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Frank BATINI

To: Dr ~~A N~~ Start.

Re: Western Australian Marine Turtle Project - Reports: 4.

A Synopsis of Knowledge of Western Australian Region Marine Turtles, and Their Conservation Needs.

Species Present in Western Australia.

A: Turtles with nesting populations in WA waters.

These species are the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*), the loggerhead turtle (*Caretta caretta*), and the flatback turtle (*Natator depressus*).

B: Turtles without nesting populations in WA waters.

These species are the olive ridley turtle (*Lepidochelys olivacea*), and the leatherback turtle (*Dermochelys coriacea*).

Distribution of Species (as above).

A: Turtles with nesting populations in WA waters.

The **green turtle** has an essentially tropical/sub-tropical distribution, with resident animals found in the shallower continental and island coastal waters in most oceans.

The majority of green turtles inhabiting the Australian coastal region are found from Shark Bay in the west, around the northern tropical coast, and down to Moreton Bay in the east.

The major nesting range of the green turtle within Australian coastal waters is more restricted, extending from North West Cape in Western Australia northward, and thence around to islands of the Capricorn Bunker group on the southern Great Barrier Reef.

The **hawksbill turtle** has a similar, but possibly more tropical distribution than the green turtle. Most are expected to be found in coral and similar hard reef habitats.

Re Nom & Julie
a useful reference
24/3

The major nesting range of the hawksbill turtle within Australian coastal waters extends to North West Cape in Western Australia, and northward around to Princess Charlotte Bay on the northern Great Barrier Reef. Major nesting sites are, however, fewer, and more widely separated than for the green turtle.

Offshore Pilbara islands in the arc extending from Karratha-Dampier out to the Monte Bello Islands are the most important hawksbill breeding sites in Western Australia.

The reason for the latitudinal difference in location of the major east and west coast Australian hawksbill turtle breeding locations is presently unknown.

The **loggerhead turtle** distribution generally extends further into sub-tropical waters than the distributions of either the green or hawksbill turtles. In Western Australian coastal waters, small numbers of large juvenile and adult loggerheads are apparently resident in the Perth region. Others may live further south. A parallel southward distribution is expected on the Australian east coast. Occasionally, loggerhead turtles are found off the southern Australian coasts, but many more are found in northern tropical waters.

The breeding distribution of the loggerhead turtle is also concentrated in the sub-tropics. Major breeding locations on the Western Australian coast are the Turtle Bay-Cape Levillain coast of northern Dirk Hartog Island, Shark Bay, and on the Muiron Islands off North West Cape. Smaller numbers of loggerheads also breed on the North West Cape coast. Occasional nesting attempts observed within the Dampier Archipelago appear to define the northern breeding limit on the west coast.

Loggerhead turtle nesting in eastern Australia is focussed on the mainland coast around Bundaberg, and extends northward offshore through the Capricorn-Bunker island groups to the Swain Reefs area of the southern Great Barrier Reef.

The **flatback turtle** is an Australian regional endemic. The distribution at sea extends to the immediately adjacent Papua-New Guinean and Indonesian coastal waters. From northern Australian tropical waters, the coastal distribution extends south to Exmouth Gulf in the west, and to the Bundaberg coast in the east.

The known breeding distribution of the flatback turtle is contained within Australian coastal waters, and covers roughly the same distribution as the animals themselves. However, the more important west coastal breeding sites are located northward from about Thevenard Island. The mainland coastal rookery at Mundabullangana station is also important because of the opportunity provided for public contact with nesting turtles (parallel at North West Cape). The northernmost major

Western Australian flatback turtle breeding site is located near Cape Domett.

Other major Australian breeding sites for the flatback turtle are found along the Northern Territory coasts, across to Cape York, within the Torres Strait region, and down to the Bundaberg region on the east coast.

B: Turtles without nesting populations in WA waters.

The **olive ridley turtle** is found in waters off north-western Western Australia, apparently in small numbers only (trawl data). There are no known breeding locations in Western Australia. The species information available for WA locations is poor.

The olive ridley turtle is also found on trawl grounds off the Northern Territory, and the Queensland Gulf of Carpentaria coasts. A sparse nesting presence has been documented in these areas.

The **leatherback turtle** has the widest seagoing distribution of all marine turtles, with the feeding range extending well into temperate latitudes where they can remain active at water temperatures around 10°C. Major nesting locations are, nevertheless, mostly tropical.

The leatherback turtle has been observed in small numbers around practically the whole of the Australian coast, with records from most months of the year.

Most Western Australian records of the leatherback turtle have been obtained from the south-western coastal area, where the number of potential observers is greatest. Seasonal distribution of these records is variable, but August is the only month for which there are no data. Similar occurrence records are available for Queensland and New South Wales coastal areas. The leatherback is also recorded from tropical Australian waters, but records are fewer.

A minor nesting presence of the leatherback turtle has been recorded at a range of Northern Territory and Queensland locations, and, recently, a New South Wales location.

There are no confirmed leatherback turtle nesting records for any Western Australian location, but isolated beachings without nesting have been noted.

Knowledge of population structure(s) within species.

Broad population structures within species are able to be defined by combination of dispersal data with analysis of

patterns of genetic variation. The process is significantly enhanced where population specific markers are found.

Analysis of patterns of genetic variation in mitochondrial DNA, and within the nuclear DNA, of marine turtle populations is of current interest worldwide (eg, Bowen *et al.*, 1992, and others).

Work on the marine turtle populations elsewhere in the Australian region is continuing, and has been an important component of the WAMTP. ANCA has also separately funded the University of Queensland laboratory work lead by Dr Craig Moritz, and through which the WAMTP samples have been channelled in accord with an independent collaborative arrangement (following from the work reported in Coates *et al.*, 1994).

The broad regional patterns of genetic variation in female **green turtle** populations, and the differences between groups using particular breeding sites, have been well covered (Norman, Moritz and Limpus 1994; see also Moritz 1994).

Green turtles breeding on the north western Western Australian coast have affinities with other Indian Ocean groups (sampled in SE Asia and Gulf of Carpentaria), but are separated from these. There are no specific markers which permit distinction between the North West Cape and Lacepede Islands breeding groups of green turtles. These are, however, distinguishable from other groups breeding in the Australian region.

The northern Great Barrier Reef green turtle population appears unique. The southern Great Barrier Reef group has affinities with other SW Pacific Ocean groups, but is distinct.

Genetic variation in mt DNA of **hawksbill turtle** populations breeding in Australian waters (Broderick *et al.*, 1994) has shown that there is separation into two broad groups, western and northeastern Australian. Further work at a regional scale is proceeding.

Sampling of turtles on feeding grounds, for both green and hawksbill turtles, has shown that these aggregations at sea commonly include mixes of individuals quite different from the groups using the geographically nearest breeding locations. This picture is supported by dispersal data derived from tagged individuals.

Green turtle data in particular do show that adult females from genetically distinct breeding groups can have foraging areas in common. Genetic separation of populations is maintained in part by the separation of mating groups prior to breeding. Mating groups assemble only in the vicinity of breeding beaches, not on the feeding grounds.

Recent work on mt DNA of **loggerhead turtles** has not detected any genetic markers unique to either the west coastal or eastern Australian breeding groups, but there are gene frequency differences between turtles nesting within these two regions.

Dispersal data from observations of tagged female loggerhead turtles have shown that they do range far from their particular nesting beaches, and may share common feeding grounds in some instances.

Analysis of genetic variation in the **flatback turtle** populations is presently in the preliminary phase. Early results suggest little mt DNA variation across Australia.

Knowledge of population abundances and trajectories.

Green turtles are the most abundant species in the Australian region. This reflects the herbivorous habit of large juvenile to adults of this species.

Current green turtle populations dependent on breeding locations in Australian territorial waters are large, but there are no clear contemporary data on trends of abundance for any of the breeding adult female groups.

Data sets now available in Australia are inadequate for the purpose of accurately assessing population trends, due to the green turtle characteristically showing substantial between seasons variability in nesting abundance (amplitude to 2-3 orders of magnitude, and with the best time series of data from field studies <1 generation length). The abundance of pre-recruits and juveniles is not known for any group.

Commercial and local subsistence exploitation of turtles from Australian breeding populations continues, however.

Harvests taken by indigenous Australian communities are generally poorly documented, but the current green turtle harvest taken in the Torres Strait region is thought likely to be unsustainable. The known magnitude of recent Indonesian commercial turtle fisheries, which have accounted for green turtles from some of the Australian breeding groups, is also apparently not sustainable.

All other marine turtles are generally carnivores through all life stages.

Populations of adult female **hawksbill turtles** nesting in Australian waters are much less abundant than green turtles. In rank order, the hawksbill lies at the lower end of the scale of abundance for Australian region marine turtles.

Nesting groups of hawksbills presently using the major western and northeastern Australian breeding sites do appear to be at least as abundant as turtles from the larger known rookeries elsewhere in the world. However, it is thought that current abundance of hawksbill turtles at many of these latter breeding sites may reflect past unsustainable commercial exploitation for the 'tortoiseshell' or 'bekko' trade. Abundance data presently available for nesting females using the main Australian breeding sites are insufficient to ascertain any population trend. Site based population studies are still in their infancy.

Nesting female **loggerhead turtle** populations dependent on east coast Great Barrier Reef region breeding sites appear to be suffering substantial continuing decline, with losses estimated equivalent to 50-80% of the initial abundance occurring over the past 10-15 years (Limpus and Reimer 1994).

The abundance of nesting female loggerhead turtles now frequenting the Western Australian breeding sites is probably less than 2 000 per annum. There are no prior data on which to judge current trends. The best information we have spans only 3 years for the Muiron Islands site.

It is clear that the main mortality factors implicated in the decline of the east coast loggerhead turtles do presently lead to death of some west coast nesting turtles. We cannot yet place these observations in context. A cautionary approach is indicated.

The abundance of **flatback turtles** in Western Australian waters is uncertain. The occurrence of flatback turtles in WA waters was, in fact, practically undocumented prior to work of the WAMTP.

There are now a number of known flatback turtle breeding sites which appear to attract at least several hundred nesting females annually. The information available for these rookeries is not sufficient to judge any current population trends. The flatback turtle is, however, the species most commonly trawled in northern Australian prawn fisheries.

Very few records only of occurrence comprise the total knowledge of the **olive ridley turtle** in Western Australian waters.

Leatherback turtles found in Western Australian waters comprise part of a group anticipated to be dependent on Indonesian breeding locations in the main part. This linkage has yet to be confirmed. The turtles also lead a predominantly pelagic life.

Documented encounter records from the past are few. The most recent records resulting from the WAMTP work comprise small

annual numbers of live at sea observations, some records of live entrapment and subsequent release from fishing gear, and records from carcase stranding reports plus salvage with the help of fishermen, and others, of some very few accidentally killed/drowned animals. Practically all the leatherback turtles I have examined have been large (140-300 kg) juveniles.

The records of leatherbacks suggest year round presence off the Western Australian coast. Data available are insufficient to properly ascertain numbers, due to inadequate knowledge of the distribution at sea relative to encounter records, and the rate of reportage of these encounters. Recent enquiries suggest that encounters may be poorly reported in some instances.

The information available does however suggest that the leatherback turtles frequenting all Australian coastal waters are an important component of their parent populations.

Records from the best known SE Asian leatherback turtle rookery in peninsular Malaysia show that this population has collapsed over the past 3 decades. The major rookery area more recently documented on the northern Irian Jaya coast is also under increasing human pressure.

Incidental losses at sea of adult and large juvenile turtles from these nesting groups due to increasing commercial fishing activity in the main are compounding the land-based conservation problems for the leatherback turtle. There is also a fishery operating in the Maluku province, Indonesia, which presently accounts for around 200 turtles annually. A small sample of these were all mature adult females with undeveloped eggs (Suarez and Starbird 1995).

Knowledge of marine turtle life histories.

The life histories of marine turtles are relatively complex, and clearly are extended in time. However, there are no direct methods for determining chronological age of juveniles and adults at sea.

Eggs laid by marine turtles **may produce young of either sex, dependent on the thermal environment of the nest** in which the eggs develop. This, of course, means that sex ratios within populations are not established in the same way as for mammals and birds. Further, climatic shifts induced by phenomena such as **Greenhouse Warming** may have more **damaging effects** on populations of marine turtles, apart from potential loss of nesting areas due to changing sea level.

Most full eggs produced by adult female marine turtles appear likely to be fertile, but not all are deposited in areas suitable for incubation. The beaches used by nesting marine turtles are also periodically vulnerable to large scale erosion due to the effects of tropical cyclones. Almost complete loss of seasonal egg production may result from ensuing beach

erosion. Predation of eggs may be significant in some instances.

Hatchling production from intact nests can range from 0 to 100%. Where eggs remain viable, development can proceed to completion in a range from a minimum around 50 days at high temperatures below lethal to over 100 days for eggs incubating at low temperatures. **Most eggs are expected to develop over periods from around 55-75 days.**

Young turtles hatching from the eggs can only make their way to the surface with the assistance of their siblings. Hatchlings may wait up to 4-5 days before coming to the surface to break out of the nest. Hatchling survival is seriously jeopardized if break-out occurs in daylight hours (increased predation risk mainly).

Groups of hatchlings leaving the nest may suffer predation losses on the beach itself, in any case. Others may be lost if they become disoriented due to **photo-pollution** from inappropriate artificial light sources in the area. Hatchlings onshore may fail to find the sea, others may be attracted back onshore, or aggregate around lighted offshore structures or moored vessels, rather than proceeding further seaward. **Effects on hatchling survival** arising from the influence of lighted structures at sea may not yet have been measured, but photo-pollution has been the cause of major disruption of sea-finding behaviour and loss of hatchlings on land in some locations.

Hatchlings making the sea face further immediate predation risks. Losses of around 10% in the nearshore environment may be common. Loss of 25% of green turtle hatchlings crossing a tropical reef has been reported.

Apart from hatchlings of the flatback turtle, which apparently remain in coastal waters, surviving hatchlings of the other marine turtles proceed further seaward after leaving their natal beach. An instinctive swimming 'frenzy' fuelled by egg-yolk reserves, plus a movement-induced sensory orientation response, combine to move the young offshore over the succeeding few days, from whence they normally commence a pelagic existence.

Small juvenile leatherback turtles appear to continue living a pelagic life while they grow to maturity.

In contrast, after completion of their pelagic life stage, small juvenile green and loggerhead turtles apparently move back into shallow continental or island coastal waters. These inshore living areas apparently can be quite remote from the natal rookery. Here, some at least of these juveniles may continue to be observed over extended periods while they continue their growth towards adulthood.

Growth increment studies focussed on these young turtles show that it can take many years them to grow to large juvenile size, and thence to maturity. Many of the larger juvenile or

sub-adult turtles do not achieve sexual maturity until much greater than minimum adult size.

Neophyte nesting green and loggerhead turtles may commonly be 20 to 30 years old, or greater (see below).

During her breeding life, a mature female marine turtle may make a number of breeding attempts spread over different nesting seasons. For example, green turtles, having survived a nesting season foray, will set out to return at conclusion of egg laying to their home feeding ground, from which location very few will again be ready to breed for at least three years. Many however do not again achieve reproductive readiness until many more years (6, 7, 8, or more) have passed.

There does not appear to be any individually fixed cyclic pattern of reproductive activity among marine turtles, rather a broad stochastic range of individual patterns.

A mature female green turtle that is ready to breed must first make a migration from her home feeding ground to the general vicinity of her chosen nesting location. In this area, she will visit some particular location where males also congregate. Here, mating occurs. This feature of reproduction in marine turtles assists in maintenance of genetic separation between groups which may share feeding grounds.

Couplings with more than one male are usual at mating, so half siblings are common among the hatchlings produced from any clutch of eggs. Sperm storage seems usual, so the hatchlings from the several clutches of eggs produced and laid through a nesting season show similar parentage. This feature is biologically significant.

The females attending a particular mating location before nesting each season do not necessarily use the same nesting beaches. Conversely, females using a nominated nesting beach can comprise animals from several mating aggregations. Further, the nesting females attending a nesting beach each season will represent variable samplings of the females from the different feeding ground populations using that rookery.

Noting the information on reproductive periodicity, and the events preceding nesting, above, **complete sampling of the female green or loggerhead turtle population visiting a major rookery may take around 10 years. Monitoring of population abundance and contemporary trends in abundance will take much longer.**

First egg laying within the nesting season will occur within a few weeks of mating. Thereafter, the female turtle will produce additional clutches of eggs. For greens, minimum intervals between clutches are usually around two weeks. Some turtles may lay more than 5 clutches within a season.

The period during which breeding females are in waters in the rookery area may therefore span several months. Hatchlings will

also be leaving the nesting beaches for some extended time after the current season nesting females have departed the area.

Thus, there is, for management purposes, no simply defined, short 'nesting season' period applicable to a marine turtle population.

Reproductive patterns for marine turtles apart from greens are similarly organized to that described above, but not necessarily identical.

Knowledge of habitat use at sea, and related matters.

Patterns of habitat use by marine turtles at sea vary according to the species and life stage, plus the current activity mode, for the animals in the group being considered.

Further seaward dispersal is the first major at sea event in the subsequent lives of most marine turtle hatchlings, once they have survived the hazards of the beach and nearshore shallows and reefs. Flatback turtle hatchlings are the apparent exception, as noted above.

Photo-pollution hazards for hatchling marine turtles from unsuitable artificial lighting in the onshore, and immediate offshore environment have been mentioned previously.

Seaward dispersal routes being followed by the young hatchling turtles moving away from the shore can reasonably be expected to be determined by sea conditions in the area, modified by the instinctive active behaviour of the hatchlings. Thus, dispersal will be channelled in particular directions in each case, rather than being random and diffuse. The activity of these hatchlings is also generally confined within the upper layer of the sea (from 0 to 30-50 cm below the surface).

The consequences of this seaward dispersal mode are that the **young turtles chances of encounter with floating pollutants such as oil, and other industrial sourced bouyant debris such as polystyrene particles, will also be raised.**

The **particular seaward dispersal routes** followed by hatchling marine turtles leaving the **major Western Australian breeding locations are presently unknown.** Likewise, **the areas at sea where the survivors will commence their further growth and development are also unknown.**

The **pelagic life stage** of young **green turtles** in the sub-tropics appears commonly to last **around 4 to 6 years**, but may be longer for many. This life stage for young **loggerhead turtles** apparently follows a different course, and quite likely takes much longer time. **Around 8-10 years** minimum seems likely.

The **small juvenile** life stage **green turtles** found in the shallow waters around island reefs, and in and around mangrove communities, or over seagrass beds, are in process of making a fundamental change in lifestyle. These animals are converting to a predominantly herbivorous diet, as well as settling down in a different location. Some obviously experience difficulty in this regard, judging by prolonged periods of growth stasis observable in the field. Those successfully negotiating this change commence their further growth toward maturity.

Growth rates measured over extended periods in the field are quite slow. Long term averages of less than 2 mm per month increment in carapace length are common (unpublished WAMTP data, and others).

Juvenile green turtles growing at around 2 mm per month in CCL increment will take about **another 20 years at least from the time of their return onshore before they reach minimum physical size at which sexual maturity may be attained.**

The physically larger, and older, juvenile loggerheads first found in coastal waters continue as carnivores, and remain so throughout their later life. Foraging mode must change, however, as their diets shift to predominantly benthic organisms such as crabs, molluscs, urchins, and similar.

Juvenile loggerhead turtles in coastal waters also grow relatively slowly toward a mature size similar to adult green turtles.

One large (80 cm CCL) juvenile loggerhead studied on the Great Barrier Reef (Limpus and Reimer 1992) required a further 8 years from first encounter before being judged sexually mature, but did not recruit to the breeding adult group for another 5 years.

Age at recruitment to the adult breeding group for both **green** and **loggerhead turtles** does seem likely to be similar. In Australian sub-tropical waters ages of **20-30 years or greater** appear most probable.

Because of dietary differences, **the foraging areas used by** the growing **juvenile green and loggerhead turtles will** generally **differ. Specific data on these foraging distributions in Western Australian waters are not available.**

Generally, it is thought that juvenile green and loggerhead turtles will grow to maturity in the coastal area in which they may be first discovered. However, no-one has yet followed any green turtle through the full period of juvenile growth. (Limpus and Reimer 1992) is the most complete information yet available for a loggerhead turtle.

Studies of breeding adult turtles of both species also suggest that individuals do generally occupy and use known home feeding grounds during the remainder of their life post-maturity, but some may wander.

The means whereby a breeding group of adult turtles, having individuals with home feeding areas spread from near-rookery locations to places far distant, **can maintain recruitment processes and their integration as a breeding unit are still not properly understood.**

Adult turtles within a breeding group spend the majority of their life foraging 'at home'. **Periodically, some** of the **females within a feeding ground population** will **attain physiological readiness to breed. Those that reach** and hold **this peak condition are** 'pre-programmed', ready **to undertake a reproductive migratory excursion to the area** within which the nesting beaches **from which they originally came,** are located. **Some** individuals may be required to **make quite short journeys** for this purpose. **Others may** have to **travel several thousand kilometres. Coastal or open sea journeys may be required.**

Whatever the case, **the female turtles,** and most probably, males also, first **travel to mating areas at sea,** but **within range of the** females 'chosen' **breeding beach.** Numbers of specific mating areas may be found in a region.

As noted before, **mating aggregations are not specifically associated with any particular nesting beach.** The female turtles found together mating at sea may disperse to several nesting sites, and the females using a particular beach may be drawn from several mating groups.

Major activity at **mating aggregations** will **precede** the time when the females of a particular species commence their **egg laying for the season. Timing** of these events **will depend on species and location.** Hawksbill turtle breeding activity in Pilbara coastal waters of Western Australia does commence well in advance of that for other species in the same area.

Species mating groups may be noticed at sea from a month or so before egg laying commences. **There are no data on the locations at sea, or of the relative importance of particular mating aggregations for any of the Western Australian nesting marine turtle populations.**

Nesting female marine turtles commonly lay multiple egg clutches during a breeding season. **Laying of the first clutch for the season can be expected 2-3 weeks post-mating.** Over the intervening period mentioned, the female turtle will be (re)establishing her association with the nesting beach and its environs, and completing development of the first eggs to be laid. The **turtles ready to lay will be found close by the nesting beach** in the day or so before going ashore. Many will require more than one trip ashore to complete their initial task.

Female turtles, having completed laying a clutch of eggs, but with more eggs to be produced and laid later in the season, will move away from the nesting beach front.

Green turtle females apparently seek a refuge area where they can rest relatively undisturbed while fasting and shelling up the next batch of eggs to be laid. Female loggerheads may move further seaward offshore at this time, and thus have to complete a more substantial journey back to the beach before the next laying event.

The anticipated **internesting refuges or possible seaward internesting ranges of any of the female marine turtles** visiting the major Western Australian rookeries **have yet to be defined.**

Conservation Risks for Marine Turtle Populations.

Current conservation risks for marine turtle populations largely reflect consequences of human population growth and increased economic/industrial activity in tropical areas. Recreational activities can also pose particular hazards.

The substantial use of marine turtles and/or their eggs for food, or as items of commercial trade, have, in the past, lead to elimination of some major breeding populations (eg, Grand Cayman Island green turtles), and are presently contributing to probably unsustainable pressure on some quite recently documented breeding populations (eg, Irian Jaya leatherbacks), and to the continuing substantial depletion of some of the better known SE Asian green turtle populations (Limpus 1994).

The collapse in recent decades of the formerly substantial leatherback turtle population nesting on the east coast of peninsular Malaysia is also well documented, as is the case of the Caribbean endemic Kemp's Ridley turtle.

Within Australian jurisdiction, the current decline of the Great Barrier Reef nesting South Pacific loggerhead turtle population presents a special case, reflecting apparently unsustainable indirect commercial activity impacts arising from professional fisheries. The sustainability of indigenous harvests of green turtles being taken in the Torres Strait region is also doubtful, as previously noted.

The Western Australian licenced commercial green turtle fishery of the 1960s - early 1970s period was also likely to prove unsustainable if continued.

Further to the matters discussed above, the continuing development of major new industrial facilities and recreational establishments within the beach areas used by the nesting turtles, or within the neighbouring areas from which the associated potential hazards may still affect these turtles, is assuming a greater conservation significance. Chief among the potential or actual risks posed are photo-pollution, physical injury/death risks arising from increased boating and fishing activity, greater disruption of activities of the turtles on land, or at sea, and the increased likelihood of beach and coastal waters pollution.

In the longer term, the consequences of anticipated Greenhouse Warming may have substantial impact.

The Appropriate Management Framework.

The appropriate focus for management of marine turtles is at the level of regional species breeding populations. The minimum geographic area over which management measures must apply is set mainly by the dispersal of feeding grounds occupied by the members of each breeding population. **Seldom**, if ever, **will these populations fall within a single administrative cover.**

Historic records of **elimination of major marine turtle breeding populations** suggest that the process **is essentially irreversible** over periods >500 years. The expanding population genetic data base now available for marine turtles also suggests that **the process of natural rookery extinction and recolonisation has a time frame of thousands of years.**

The means whereby established breeding groups of marine turtles maintain their populations are not well understood. Some essential knowledge of the recruitment processes and turtle behaviour is not available. **There are** also **no means whereby captive breeding programs can be considered viable conservation measures.**

The preceding information clearly suggests that **conservation programs for marine turtles must aim at maintenance of natural populations**, and that **these programs must be based on the precautionary principle.**

Conservation: Western Australian Region Marine Turtles.

A) Western Australian locations.

Data now available for western Australian region marine turtle populations do not allow any informed decision to be made about the proportion of the turtles within any particular species breeding population that may remain wholly **within Western Australian state territorial jurisdiction.** It is, however, clear that **rookeries of international significance for maintenance of these populations** are present.

Breeding sites for marine turtles are restricted in distribution, and **of critical importance** to the dependent populations. In recognition of this fact, all **the major Western Australian breeding locations for marine turtles should preferably be recognized for their conservation value, and accorded the highest tenure status possible (Class A), with primary management control vested in the NPNCA** (CALM is the management agency).

Presently, **only some of the known major Western Australian rookeries are covered by the appropriate preferred reservations and vestings.**

There are **no appropriate reservations for**: the largest Western Australian **loggerhead turtle rookery on northern Dirk Hartog Island, Shark Bay**; the mainland **flatback turtle rookery on Mundabullangana Station westward of Cowrie Creek** (see Wilson Report, , 1994); and the **flatback turtle rookery extending from The Needles towards Cape Domett** at the eastern head of Cambridge Gulf (see Wilson Report, , 1994).

Very few of the more important **rookeries are covered by Class A reservations for conservation**. Barrow Island itself is an exception.

Other rookeries are covered by a variety of reservations of lesser stature. These should be reviewed, with a view to improving their conservation status, and the possibilities for exercise of better management control by CALM.

For example, the main North West Cape Jurabi Coast rookery beach complex (main use by green turtles, also some loggerheads, and occasionally hawksbills) is excluded from the adjacent Ningaloo Marine Park, and outside the Cape Range National Park. Current status is , with .

The Muiron Islands group, which contains the second ranked loggerhead turtle breeding location (of only two known) in Western Australia, and is also used by numerous green turtles, are currently a Class reserve for , with vesting .

The Lacepede Islands group, which contains the largest regional green turtle rookery, and is also used by small numbers of flatback and hawksbill turtles, is currently a Class reserve for , with vesting .

The **turtle rookery beaches** can periodically be disrupted by tropical cyclones, but usually are later renewed by natural processes. However, the **sand supply** in most cases appears **limited, and natural rates of accumulation small. The fouling of these beaches by oil must generally be avoided at all times.**

Oil spills at sea approaching toward turtle nesting areas at times **when concentrated reproductive activities are occurring pose additional problems**, even when it is not likely to come ashore on the nesting beaches. **Potentially at risk are turtle mating aggregations, groups of females in internesting refuge areas, and hatchlings proceeding seaward. Presently, we have no substantial data to identify particular locations at sea where these risks may be acute.**

Photo-pollution arising from residential, industrial and recreational facilities, and inappropriately controlled patterns of human activity, **can adversely affect turtle reproduction**. The photo-pollutant sources may be located on land or sea within the nesting region.

Chief among the noticeable **effects of photo-pollution** is **disruption of sea-finding behaviour of hatchlings on beaches,** and **their unnatural aggregation around artificial light sources**

located at sea. Unusual increased hatchling mortality has been detected in these circumstances, but quantitative effects on the process of recruitment to adulthood have not been reported for any population (for obvious reasons, eg appropriate time series data plus lack of full understanding of the normal recruitment process). **Adult nesting female turtles can** also **be deterred from nesting** in some circumstances.

Chronic and increasing photo-pollution of turtle nesting areas should be prevented, or ameliorated to the best practicable extent **whereever turtles may be at risk**. Measures should be based on the most up to date knowledge of turtle behaviour in response to particular light emission spectra.

Relevant considerations are: the needs for lighting of facilities being used, or of necessary activities; the availability of particular types of lights suitable for the purpose(s); and the placement, design, and management of lights and their use.

Vehicle traffic on beaches above the high water mark inland to the limit of turtle nesting activity **should generally be prohibited at all times**. Compaction of nests can decrease hatchling production, and emergent hatchlings can be channelled in wheel ruts while attempting to move across the beach to the sea. Night-time traffic will also exacerbate disturbance and photo-pollution problems while most turtles are using the beach.

Where managed beach use may be acceptable, and visitors will travel to the access points by vehicle, parking facilities and the like should be designed with photo-pollution risk in mind.

Turtle watching on beaches **during the nesting season** is an activity that **provides opportunities to increase public awareness of marine turtles and their conservation problems**, as well as the turtles providing an attraction on their own. **Normal behaviour patterns of the nesting turtles are however, at risk**. Beach emergence patterns, nest site selection onshore, and the energy cost of nesting attempts can be adversely affected.

Turtle watching activities must be carefully managed in accordance firstly with the needs of the turtles if they are to be sustainable. Major **tourist contact areas should be defined within part of a rookery only.** Where large tourist groups can become involved, **the person/turtle interactions should be constrained according to the number of turtles available** for acceptable contact. The size of a **group viewing** any turtle **should be restricted to that which can ensure meaningful observation for all, and** the group **managed by an experienced guide.** Oral presentations will be made on site.

Suitable signage for general information should be provided at all contact sites. Printed material of professional standard incorporating biological and conservation messages should also

be produced, and made readily available. This will provide reinforcement of the experience for the visitors.

General problems for management of onshore locations of importance to marine turtles have been dealt with above. Some of the seaward risk management problems related particularly toreproductive activities, and oil, and photo-pollution effects have also been noted.

There are **further management risks**, of importance to conservation, that **are encountered at sea**, where marine turtles spend most of their lives. The most immediately appreciated of **these are: commercial and recreational boat traffic, and particular commercial** (and occasionally similar recreational) **fishing activities.** Leaving aside directed exploitation, and harassment, the potential management problems involved here occur incidental to the primary activity.

Boat traffic can kill turtles on collision, and also interfere with normal behaviour patterns. This does occur in coastal waters of Western Australia. The risk can be expected to be the greatest where boating activity is concentrated, and turtle activities maximize potential conflict. **Turtles in feeding groups and reproductive aggregations may be involved.** Feeding loggerhead and leatherback turtles are killed by boat strikes in Perth region waters, and collisions have been reported elsewhere (eg, Shark Bay, the Ningaloo Marine Park, and the Pilbara coast).

Management of boat traffic within areas occupied by turtle mating aggregations, within internesting refuges, and in the offshore waters adjacent to nesting beaches requires specific attention. As noted in regard to oil spill management problems, specific information on the location of mating aggregations, and internesting refuge areas is presently unavailable.

Fishing activities can also kill turtles after entrapment in fishing gear. This risk is greatest for turtle species which share their foraging areas with, and also feed on species being targeted by the particular fisheries. Trawls, gill-nets, and bottom fished traps with surfaced buoyed lines are methods of prime interest.

Loggerhead, flatback, and olive ridley turtles are the species most vulnerable to fishery capture in Australian waters. **Leatherback turtles are a special case.** Their wide ranging active foraging mode maximizes their exposure to risk of entrapment. **Green and hawksbill turtles are less vulnerable,** but can easily be caught in gill nets set in their foraging areas.

A greater range of specific quantitative data are needed on current turtle/fishery interactions within Western Australian waters. Reconstruction of past history within some fisheries may also be needed before current observations may be properly interpreted. **Continuing liaison with fisheries and their operators is required as part of this process. The achievable**

goal is minimization of risk to turtle populations arising from fisheries by-catch.

Aboriginal Australians are legally permitted to exploit marine turtle populations for food only. **There is need for greater awareness of the magnitude of this harvest, and the factors important for continuing sustainability. This work can succeed only if done in cooperation with the Aboriginal people.**

The success of continuing management of the Western Australian nesting populations of marine turtles, including the further conservation measures recommended, can only be determined properly by future history. This process will be greatly enhanced by the availability of suitably comprehensive time series of quantitative data for each of the major population units identified, and necessary additional research, particularly at sea.

The Western Australian Marine Turtle Project has established a firm foundation for this work. The Project should be continued to meet the needs as stated.

B) Within the population range.

Turtle populations comprising the Western Australian nesting groups can include many individuals residing in places elsewhere.

It is clear that some of the green and loggerhead turtle populations fall within this class. Other Australian states, and Indonesian territory, are within their normal range. There is evidence that some Indonesian nesting green turtles also move into Australian coastal waters in Western Australia and the Northern Territory.

The foraging ranges for Western Australian nesting hawksbill and flatback turtle populations are, respectively, presently unknown, and poorly known. There is also a minimum knowledge of these populations themselves.

The leatherback and olive ridley turtles found in Western Australian territorial waters are members of populations nesting elsewhere. Indonesia is the suspected origin of the leatherbacks. The source of the olive ridleys is presently unknown.

From the above, **it is obvious that comprehensive conservation measures for these marine turtle populations can only be formulated and applied with the cooperation of all the relevant national and international conservation authorities.**

Recognition of the joint state/national component of this equation was a major factor in establishment of, and support for the Western Australian Marine Turtle Project. This focus was reinforced separately in the process of convening of the Australian Marine Turtle Conservation Workshop 1990 (ANPWS, now

ANCA ,and QDEH joint initiative), and in the published proceedings of that meeting.

ANZECC, the peak Australian governmental conservation forum, has, more recently (1993), reinforced this need for national integration of marine turtle conservation measures.

The **necessary discussions have not yet occurred. This omission should be rectified as soon as possible.**

The Australian Government, through its conservation agency, ANCA, has also entered into cooperative arrangement with South Pacific island nations through SPREP as a partner in the RMTCP (Spring 1994). Further **discussions with Indonesian authorities concerning** cooperative arrangements for **conservation of marine turtle populations in the north-western Australian/Indonesian region are in progress.**

Western Australia is a major stake-holder in this regional context, having territorial responsibility for a substantial part of the national marine estate, and **being the custodian of the major south east Indian Ocean breeding locations for the regions nesting marine turtle populations**. Western Australia is also undoubtedly host to some substantial part of these populations.

Western Australia must insist that it is recognized as an important participant in the development, and conclusion of necessary regional agreements. Western Australia must also remain an active participant in regional research and management of these particular marine turtle populations, for which a substantial base has already been established by the joint CALM/ANCA sponsored Western Australian Marine Turtle Project. This Project also has international recognition within the marine turtle conservation community.

Anticipating future progress towards the objectives outlined above, **Western Australia should seek presently at the national level to further participate in appropriate joint research and management work within northern Australia**. The most immediately relevant work would focus on Aboriginal harvest of stocks which include Western Australian bred turtles, and in aspects of fisheries interaction with these same turtle populations.

This proposed work would require cooperative involvement of Aboriginal people from near source and distant user communities, and fisheries operators respectively. Field projects would be managed within an acceptable interagency project framework.

Other national cooperative work of current relevance has been part of the Western Australian Marine Turtle Project to date.

Development of more formal links with Indonesian workers will depend on the outcome of discussions yet to occur.

Western Australia should ensure that it is assigned an active role in any work that might flow from conclusion of any international agreement aimed at conservation of the regional marine turtle populations.

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