(28)

Final Report on Work under

States Cooperative Assistance Program 1993/94.

Project No. 4458:- Conservation of Marine Turtles: Western Australian Region (Continuation).

This Report comprises two parts: **Part A** covers the 1993/94 season work [Information therein as per general headings specified in **Schedule 1, Item B 1** of the contract for this project, and consistent with **Action Items 12.1** thru' **12.9** of the **Project Application** annexed to contract **Schedule 1**.].

Part B integrates information derived from the main project work since inception in mid- 1986 season as per discussions between ANCA Project Officer Ms Astrida Mednis and CALM Project Officer Dr R I T Prince, having regard to content of previous reports and publications.

PART B: Final Report on Work under

States Cooperative Assistance Program 1993/94.

Project No. 4458:- Conservation of Marine Turtles: Western Australian Region (Continuation).

PROGRESS AND DEVELOPMENT OF KNOWLEDGE OF MARINE TURTLE POPULATIONS IN THE WESTERN AUSTRALIAN REGION 1986 THROUGH 1994: RESULTS FROM THE WESTERN AUSTRALIAN MARINE TURTLE PROJECT.

Project Objectives.

The Western Australian Marine Turtle Project (WAMTP) has sought:

1. To gain an adequate understanding of the distribution and abundance of the various marine turtle populations utilizing western Australian region rookeries and marine habitats, the nature of inter-relationships within species at the regional level, and between nesting and living areas of importance to the maintenance of these adult turtle populations.

2. To develop an understanding of the processes affecting maintenance and abundance of these marine turtle populations as an aid to addressing real management needs.

3. To develop appropriate management measures and interpretation packages.

Project Planning.

The paucity of knowledge of any marine turtle populations in the western Australian region was clear from the review in Limpus (1982). Once the decision to start the WAMTP was taken, this was the major problem requiring address before any of the intended work could proceed.

Marine turtles spend most of their life at sea, but the adult females are tied to land where they must come ashore to lay the eggs from which the young are hatched. The adult female sub-group of the different marine turtle populations is thus more easily accessed than any of the other life stages. Nesting areas also are generally highly localised, with many females from a wide geographic range being attracted to relatively small beach areas. However, nesting beaches are often located on offshore islands, which can be quite remote, and difficult of access. On the other hand, nesting beaches can be subject to competing, incompatible, claims for use, and the females using them are particularly vulnerable. In Australia, and other places, the adult females can be the preferred exploitation targets.

In common with many marine turtle conservation projects worldwide, there was good reason, and little other practical choice, than to focus initial WAMTP work on adult nesting female marine turtle populations in the region. The predominantly herbivorous green turtle was the species for which sufficient existing information provided focus for the first field

investigations of what was conceived as a whole of fauna program. Such program could be developed in the future as the knowledge base increased.

Questions to be Addressed.

At the simplest level, a number of tasks could be identified as basic to understanding the status and further conservation needs of the marine turtle species populations using resources within the western Australian region; viz,

discovery of major species breeding sites,

discovery of relationships between breeding sites being used, and the living areas occupied by the turtles attending each site,

definition of regional breeding groups (stocks), which should be the focus of integrated management,

commencement and maintenance at selected major species rookeries of species-specific population studies. These would be aimed at understanding dynamics of numbers, and patterns of variation in seasonal and longer term abundance,

determination of relevant biological and life history parameters of turtles within the regional populations,

documentation of aspects of the possible human/marine turtle interaction process(es) relevant to general conservation, and to sustainable use where necessary, and,

application of the knowledge generated to better management of the regional marine turtle populations and their resource base.

Having regard to:-

the extensive geographic area of interest,

the remoteness of many important sites,

the existing lack of substantial knowledge of the marine turtles in the region,

their apparent life history characteristics, plus,

likely very limited availability of resources to focus on this work,

it should be evident to the reader that choice of strategy for execution of the work to be attempted would be restricted from the outset.

Understanding of population dynamics and status of marine turtle populations in particular requires access to long time-series data sets (see) For this reason, the initial strategy choice(s) to be made could, of necessity, be expected to lock future choices available for some considerable time. The future initiation of any new work segments that might be able to be

attempted in parallel with ongoing work would depend on additional resources being secured as the project progressed.

Item 1.
Tags.

Tags are used for individual identification of adult and other turtles within the WAMTP. These tags are manufactured from titanium, and are produced by Stockbrands Co. Pty. Ltd., Perth, Western Australia. They are the large size tags as described by Limpus (1992).

Tags are project specific. Each tag has been identified by embossing with the prefix 'WA', followed by a unique four or five digit number as required.

The reverse side of each tag is embossed with the project forwarding address. Tag embossing details noted here are described in a project information leaflet available for general circulation.

The English language leaflet (Attachment) has been produced and distributed from inception of the WAMTP. An Indonesian language version has also been produced (Attachment). The Indonesian version has been distributed by Fisheries management personnel in Australian waters (Ashmore Reef, etc), and within Indonesia by several groups, including NGOs, the EMDI program administered by the Canadian Dalhousie University, visiting scientists (including Dr D J Kitchener, from WA Museum), and Indonesian turtle workers.

Results.

To September 1994, 24 350 tags within the series WA 1001 through WA25350 had been procured for use within the WAMTP. The majority of these tags were purchased from SCAP funds, but substantial numbers of tags have also been paid for from other sources in recent times (see Item 8, below).

Item 2.
Volunteer Participation: Field Work Programs.

Population studies of marine turtles require substantial sustained effort. Sampling and monitoring of the turtles attending major rookeries also requires considerable labour. Direct funding support to permit this work being undertaken by professional scientists and technicians alone is seldom available.

Anticipated maximum levels of institutional support, for the work being considered in 1986/87, certainly did not permit major planning for project work of the WAMTP to be executed by paid staff, unassisted. Apart from these considerations, it was considered strategically important to have Aboriginal resource users participate in the work where possible. Aboriginal participation is dealt with further under Item 8. It was also considered desirable to foster public participation in other circumstances.

The latter aim to obtain public involvement was met by chance from the outset in the unusual circumstances at Varanus Island (see also Item 8).

Reduction in the dedicated resources being available for the WAMTP work in 1988/89, the third project season, ran counter to planned development of the work. The conflict posed by the change in fortunes forced a decision on project structure and desired continuity that lead directly to plans for public volunteer involvement to become a major contributor to the program from the 1989/90 season onward.

Methods: Volunteer Program.

Work at the North West Cape rookery was targeted for development with major volunteer participation from 1989/90. Volunteer participation in beach work was also required at other sites.

North West Cape marine turtle nesting beaches are part of the Ningaloo Marine Park/Cape Range National Park complex. A work force engaged here would need to be able to operate satisfactorily in circumstances where public contact would be a regular feature. Primary work teams would also have to operate with minimum supervision after initial training, and continuously for extended periods in the field. Senior undergraduate, or new graduate biologists, were considered best suited to form the core volunteer group to establish the program.

Expressions of interest in the North West Cape work were sought initially via direct enquiry among people within the selected target group above. The level of response was sufficient to allow selection of those considered most suited for the job, and to proceed with implementation of the plan.

Recruitment of an auxiliary work force from among citizens from the Exmouth community was the second stage of the North West Cape volunteer participation plan to be executed for 1989/90. Recruitment of these participants was arranged on site by the project Technician. The task of training all the new volunteers, and of managing implementation of the seasons beach work program, was also the responsibility of this officer from the project management team.

Tasks assigned for beach work at rookeries are noted under Item 3 (below). One to one instruction in task work for new volunteers is supplemented by provision of printed and illustrative material for reference.

Procedures similar to the above were followed in establishing volunteer programs at other locations as necessary, and in managing continuing work.

Results: Volunteer Program.

The volunteer support for work conducted under the WAMTP has been substantial. Over the past three seasons of the WAMTP, approximately 3 to 3.5 person-years voluntary labour has been contributed to the beach work programs, mainly for the southern study rookeries. The work done could not have been attempted, let

alone executed, without this level of assistance. Volunteers have also assisted with other project work.

Discussion: Volunteer Contribution to Marine Turtle Studies.

The involvement of the wider public in the WAMTP work has enabled conservation needs of marine turtles to achieve a higher level of acceptance and support than would otherwise have been the case.

The total volunteer contribution to work under the WAMTP has, nevertheless, been restricted by the limited capacity of the small project management team to manage this effort, and by the need for the resources to provide adequate support for volunteers working in the field in remote locations. We know that many more people than we can effectively manage are willing to offer their services for this work. Proper support for the establishment and maintenance of volunteer is essential for the progress of major marine turtle investigations.

Item 3.
Nesting Female Population Studies: Rookeries.

Having decided that long overdue detailed marine turtle studies should be implemented in Western Australia, a program of on-site visits to assess feasibility of conducting this work was planned for the 1986/87 summer, anticipating that sufficient numbers of nesting female turtles would be found. The probable major breeding locations for western Australian region nesting green turtles were identified from a combination of previous formal reports, results of local enquiries, and previous personal observation. The importance of marine turtles as a traditional resource for northern Australian coastal Aboriginal communities was noted.

Means to access the Lacepede Islands, and to conduct work at Barrow Island were secured for 1986/87. Parallel arrangements were made to directly involve west Kimberley Aboriginal people in work at the Lacepede Islands. The need to individually identify turtles for future monitoring was accepted: titanium tags for this purpose (Stockbrands Co. Pty. Ltd., Perth) were purchased for use, and advice on optimum fixing of these to turtles was obtained (Limpus 1992), as was guidance on the possible range of data to be collected.

A concurrent program to gather data on nesting turtle attendances at other sites via direct inspections where possible, and from a network of interested informers as well, was planned as a guide to focussing additional species population work that would be required in later years.

Methods - Nesting Female Population Studies: Rookeries.

Rookery site work has, since 1986/87, been conducted seasonally according to work plans considered practical for the particular site, eg, seasonal sampling with target 2 weeks on site, Lacepede Islands, to seasonal sampling extended over 2 months at North West Cape.

Work parties, usually of 2 - 3 persons, patrol the focal beach(es) at night. One or more work parties may be assigned to a site. Nesting female green turtles, and/or other species females, attending the particular rookery are intercepted on beaches. Those sampled are measured (midline curved carapace length [CCL], and curved carapace width [CCW],), their activities noted, and tags applied to ensure future identification. In 1985/86 double tagging was adopted as standard practice. Since 1985/86, a combination of double and single tagging of individuals according to predetermined guidelines applicable to each rookery/species case has been the norm. Briefly, scarce species such as hawksbill and loggerhead are preferentially double tagged on first encounter, while green turtle populations have a target for $\geq$ 30% to be double tagged. Remigrant turtles when first seen also generally have a set of new tags applied alongside preexisting tags, unless those tags are judged to be secure.

Additional data on clutch size, hatching success, etc, where required have been collected from direct observation and nest excavation analysis. Numbers of turtles beaching have been estimated when sought by process of direct count, with short term paint spotting used to avoid double counting the individuals seen.

Monitoring of dispersal of tagged turtles from rookeries to home feeding grounds has had to rely to date on third party reporting of finds.

Results - Nesting Female Population Studies.

Turtles Tagged for Study.

A single hawksbill turtle only was tagged with 'WA series' titanium tags on 10 February 1986. However, the major project work supported by the States Cooperative Assistance Program was not commenced until the early part of the 1986/87 nesting season. From commencement of the work to conclusion of the 1993/94 SCAP contract period, some 14 096 turtles have been tagged in course of work of the Western Australian Marine Turtle Project. The majority have been adult females attending rookeries. These data are summarized in Table 1.

Remigrant Turtles.

Remigrant turtles were not expected in numbers before the 1989/90 season. This was the case, with a few remigrant flatbacks only being seen at Varanus Island previously. The expected increase in abundance of remigrant green turtles post-1989/90 was interrupted by the very poor nesting season in 1990/91, but since then, and with the passage of time since the first groups of nesting turtles were tagged, higher numbers of remigrant green turtles have been recorded. Frequencies of remigrant observations for other species have also increased as the project has progressed.

Six hundred and eighty-eight turtles having retained identity tags have provided single interval remigrant observations to date. Another twenty-four have provided multiple interval data. These observations are summarized in Table 2.

Individual patterns of remigration for adult female marine turtles are expected to be widely variable. Data-sets listed in Table 2 that are considered adequate for the purpose of showing this are summarized in Figures 1 - 7. These figures, plus reference to Table 1 tagging data, suggest that full sampling distributions of the individual remigration intervals can not yet have been observed for the female turtles in most of the separate species groups tagged and released via the WAMTP.

TABLE 1. SUMMARY OF TURTLES TAGGED 1986 THROUGH 1994 via WESTERN AUSTRALIAN MARINE TURTLE PROJECT: BY SITE, SPECIES AND SEASON -- ALL SEX & AGE CLASSES for ALL PURPOSES.

SITE	SEASON / SPECIES	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	TOTALS
LACEPEDE ISLANDS	G	422	1 142	931	693	222	522	555	315	4 802
	F	1	2	4	3	13	5	4	-	32
BARROW ISLAND	G	463	649	608	290	5	229	49	81	2 374
	F	2	6	1	16	26	19	7	53	130
	H	-	-	-	-	-	-	-	1	1
NORTH WEST CAPE & MUIRON ISLANDS	G	36	23	664	481	11	697	748	305	2 965
	F	-	-	-	-	-	1	1	-	2
	H	-	1	1	8	9	8	8	6	41
	L	7	3	11	20	50	137	251	190	669
VARANUS ISLAND	G	1	3	30	2		3	-	-	39
	F	11	10	9	4	4	4	5	23	70
	H	18	32	103	32	29	25	38	20	298
	L	-	-	1	-	-	-	-	-	1
DAMPIER ARCHIPELAGO: ROSEMARY & DELAMBRE	G	-	4	5	-	1	12	32	15	69
	F	-	-	-	-	13	33	58	46	150
	H	4	11	1	-	56	53	223	272	620
	L	-	-	-	-	-	1	2	-	3
MUNDABULLAN-GANA	F	6	-	26	37	45	177	110	89	490
CAPE DOMETT	F	-	25	-	-	-	-	-	14	39
DIRK HARTOG ISLAND	L	-	-	-	-	-	-	-	430	430
BROWSE I & SCOTT REEF	G	-	-	-	-	-	72	33	-	105

EXMOUTH GULF	G	-	-	-	9	112	221	92	55	489
(SANDALWOOD)	H	-	-	-	-		5	4	6	15
	L	-	-	-	-	4	19	13	26	62
		-	-	-	-					
OTHER	G	4	26	34	7	3	108	-	-	182
LOCATIONS	F	-	11	-	-	-	-	-	-	11
	H	-	1	-	2	-	1	-	-	4
	L	-	-	-	-	-	3	-	1	1
TOTALS	G	926	1 847	2 272	1 482	354	1 864	1 509	771	11 025
	F	20	35	59	60	101	239	185	225	924
	H	22	45	105	42	94	92	273	305	979
	L	7	3	12	20	54	160	266	647	1 168
GRAND TOTALS		975	1 930	2 448	1 604	603	2 355	2 233	1 948	14 096

Species codes: G = Green, F = Flatback, H = Hawksbill, L = Loggerhead. Data key: - = None tagged.

TABLE 2. Part A. SUMMARY OF REMIGRANT TURTLES OBSERVED 1986 THROUGH 1994 via WESTERN AUSTRALIAN MARINE TURTLE PROJECT: BY SITE, SPECIES AND SEASON; Part B. *RECAPTURES FOR GROWTH STUDY - EXMOUTH GULF.*

SITE	SEASON / SPECIES	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	TOTALS
LACEPEDE ISLANDS	G	x	-	-	19[4]	9[3]	190	148[4]	69[3]	435[7]
	F	x	-	-	-	2[1]	-	3[1]	1	6[1]
BARROW ISLAND	G	x	-	-	2	1	14	2	6	25
	F	x	-	-	1	1	1	-	1	4
NORTH WEST CAPE & MUIRON ISLANDS	G	x	-	-	-	-	6	6	15	27
	F	x	x	x	x	x	x	-	-	-
	H	x	x	-	-	-	-	-	-	-
	L	x	-	-	-	-	2[2]	9[1]	28[3]	39[3]
VARANUS ISLAND	G	x	-	-	-	-		-	-	-
	F	x	1[1]	2	0[2]	1[1]	4[2]	1	5[1]	14[2]
	H	-	-	-	1[1]	3[3]	8[1]	26[3]	16	54[4]
	L	x	x	x	-	-	-	-	-	-
DAMPIER ARCHIPELAGO: ROSEMARY & DELAMBRE IS	G	x	-	-	-	-	-	-	-	-
	F	x	x	x	x	x	-	4	3	7
	H	x	-	-	-	-	1	-	4	5
	L	x	x	x	-	-	-	-	-	-
MUNDABULLANGANA	F	x	-	-	1	3[1]	13[3]	23[6]	32[3]	72[7]
TOTALS [REMIGRANTS]	G	x	x	-	21[4]	10[3]	210	156[4]	90[3]	487 [7]
	F	x	1[1]	2	2[2]	7[3]	18[5]	31[7]	42[4]	103[10]
	H	x	x	x	1[1]	3[3]	9[1]	26[3]	20	59 [4]
	L	x	-	-	-	-	2[2]	9[1]	28[3]	39 [3]

PART B

EXMOUTH GULF	*G*	*x*	*x*	*x*	*x*	*x*	*8*[2]	*19*[2]	*5*[1]	*32* [2]
(SANDALWOOD	*H*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*-*	*-*
PENINSULA)	*L*	*x*	*x*	*x*	*x*	*x*	*0*[1]	*4*[1]	*2*	*6* [1]

Species codes: G = Green, F = Flatback, H = Hawksbill, L = Loggerhead. Data key: x = no turtles eligible, - = Nil observations, n = number of turtles seen in season providing single interval observation, [n] = number of turtles seen in season that have provided multiple interval observations.

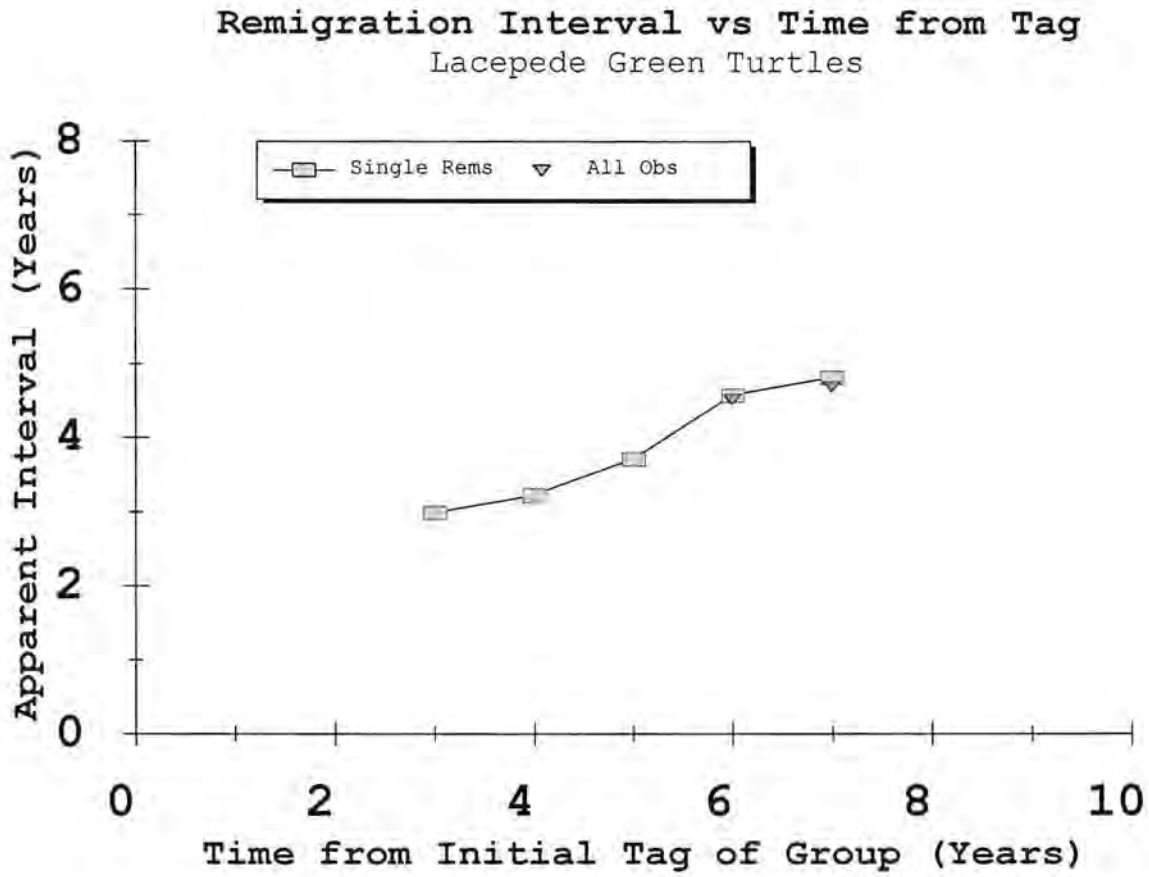

Figure 1. Lacepede Islands Green Turtles: Change in the Estimates of Average Remigration Interval for Turtles as Function of Time from Initial Tagging.

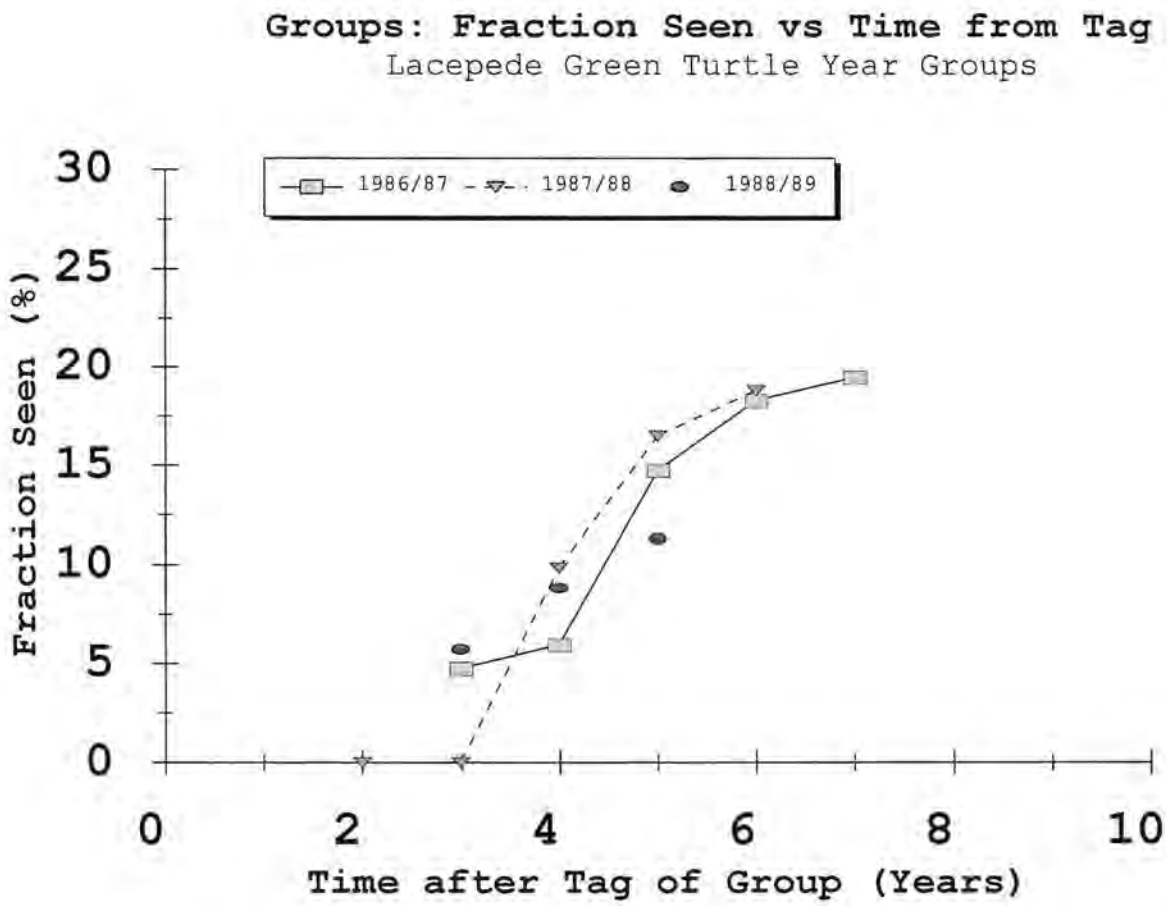

Figure 2. Lacepede Islands Green Turtles: Cumulative Proportions of the Turtles in Tagged Groups Seen as Remigrants as a Function of Time from Initial Tagging.

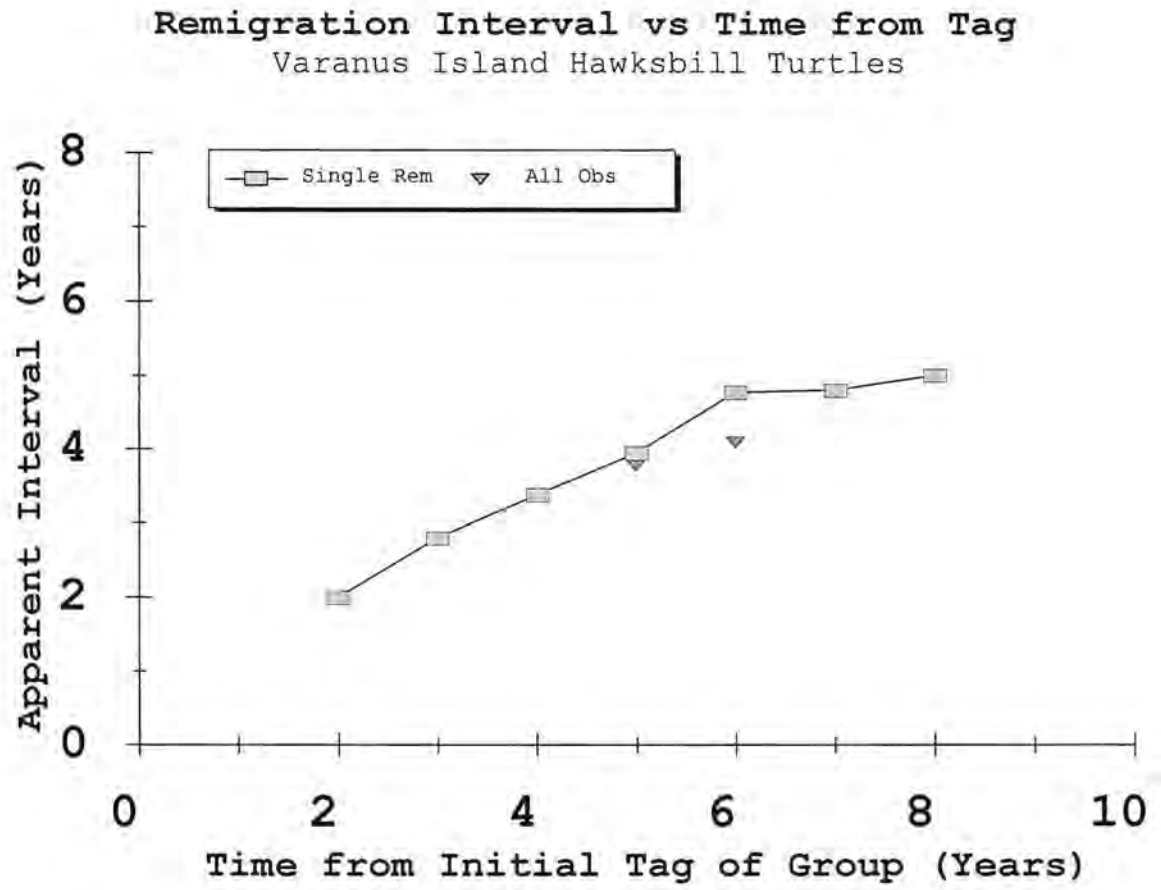

Figure 3. Varanus Island Hawksbill Turtles: Change in the Estimates of Average Remigration Interval for Turtles as Function of Time from Initial Tagging.

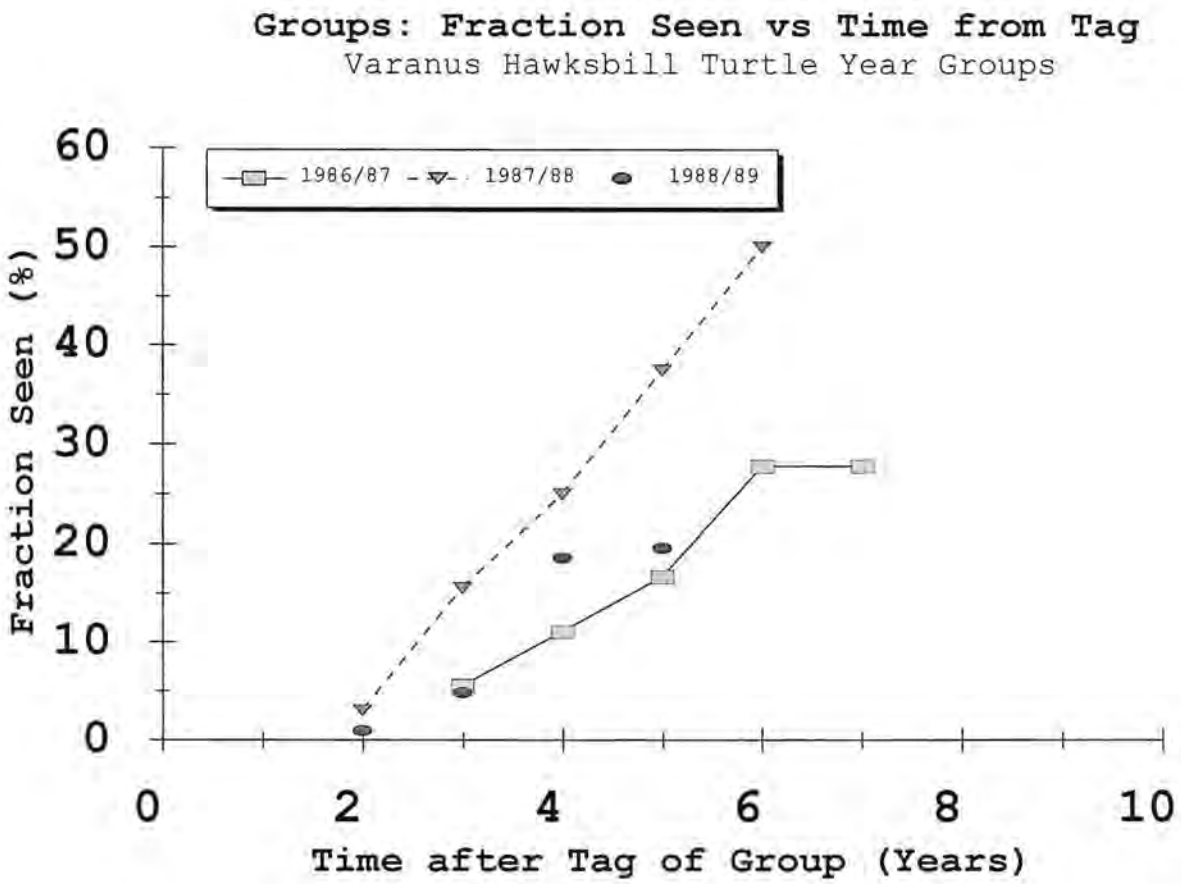

Figure 4. Varanus Island Hawksbill Turtles: Cumulative Proportions of the Turtles in Tagged Groups Seen as Remigrants as a Function of Time from Initial Tagging.

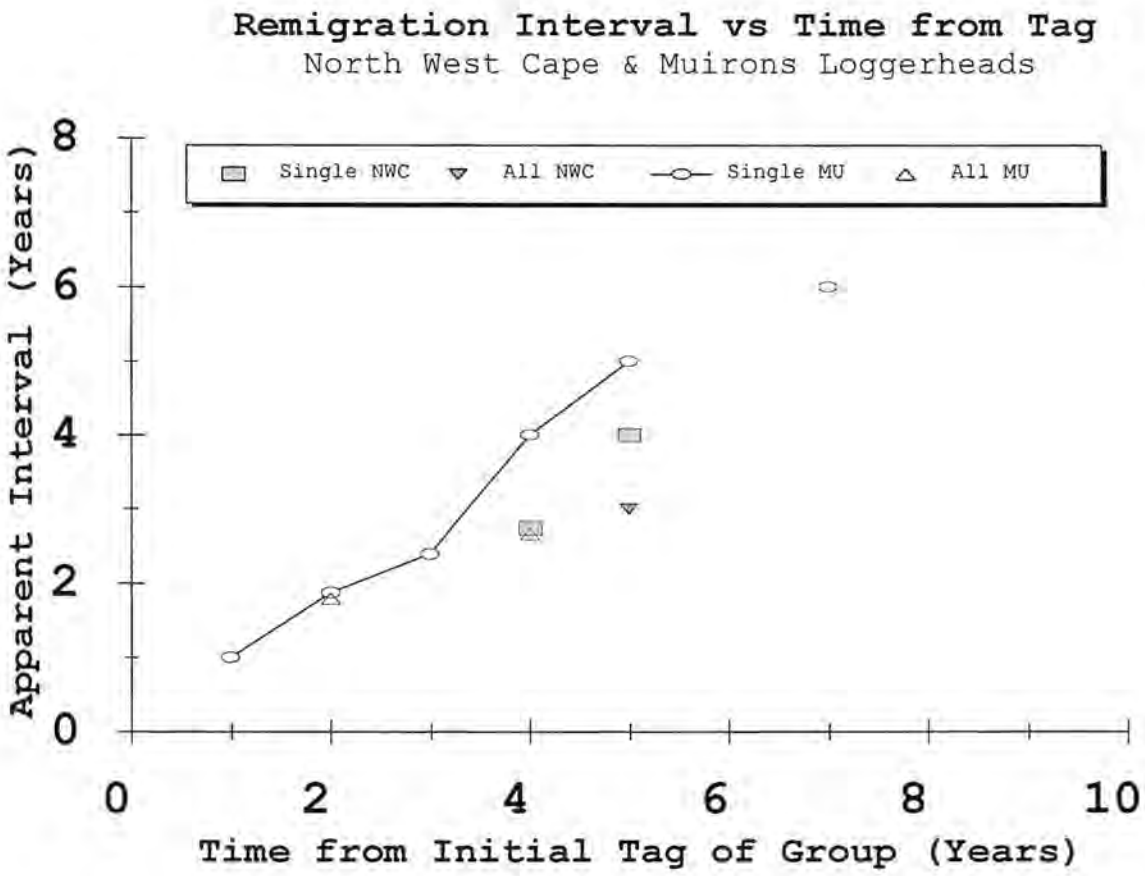

Figure 5. North West Cape and Muiron Islands Loggerhead Turtles: Change in the Estimates of Average Remigration Interval for Turtles as Function of Time from Initial Tagging.

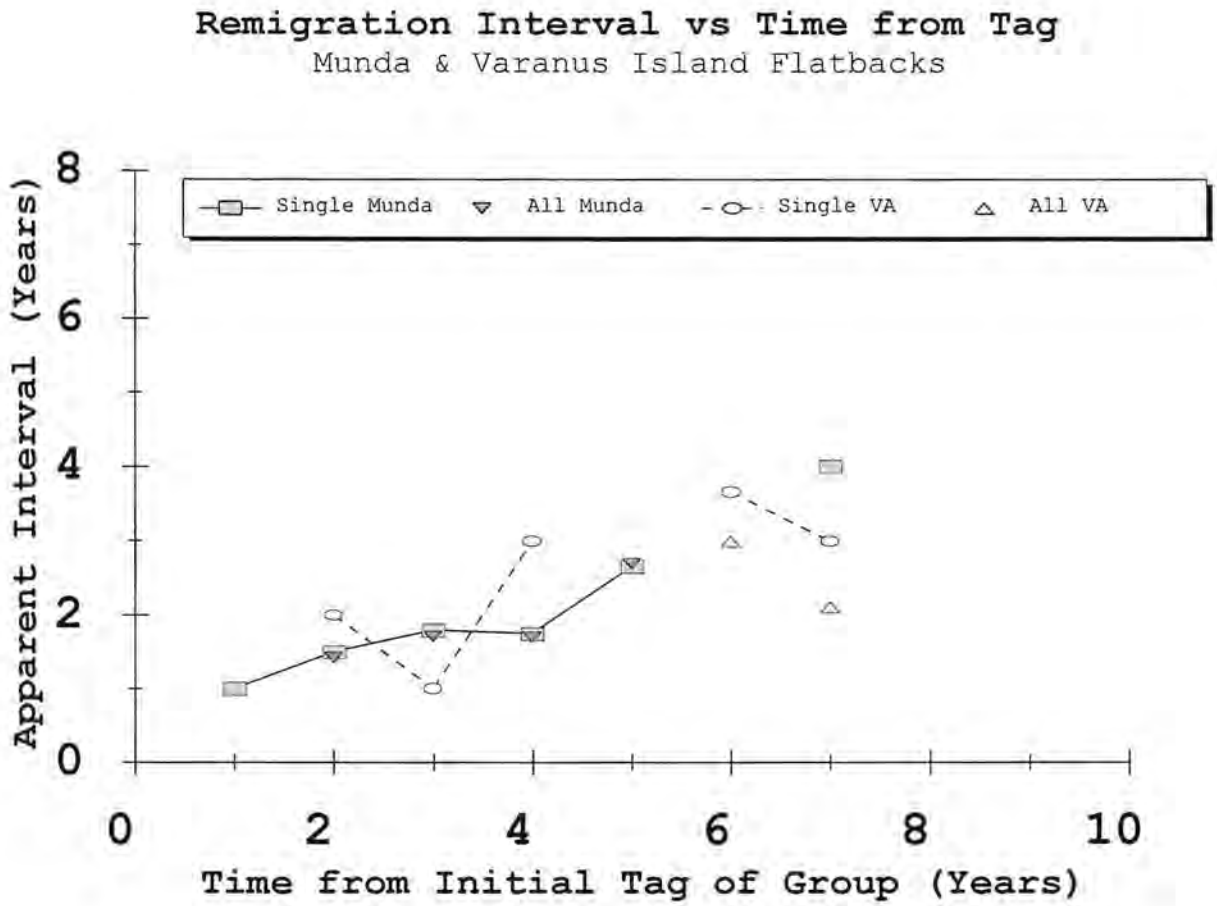

Figure 6. Mundabullangana and Varanus Island Flatback Turtles: Change in the Estimates of Average Remigration Interval for Turtles as Function of Time from Initial Tagging.

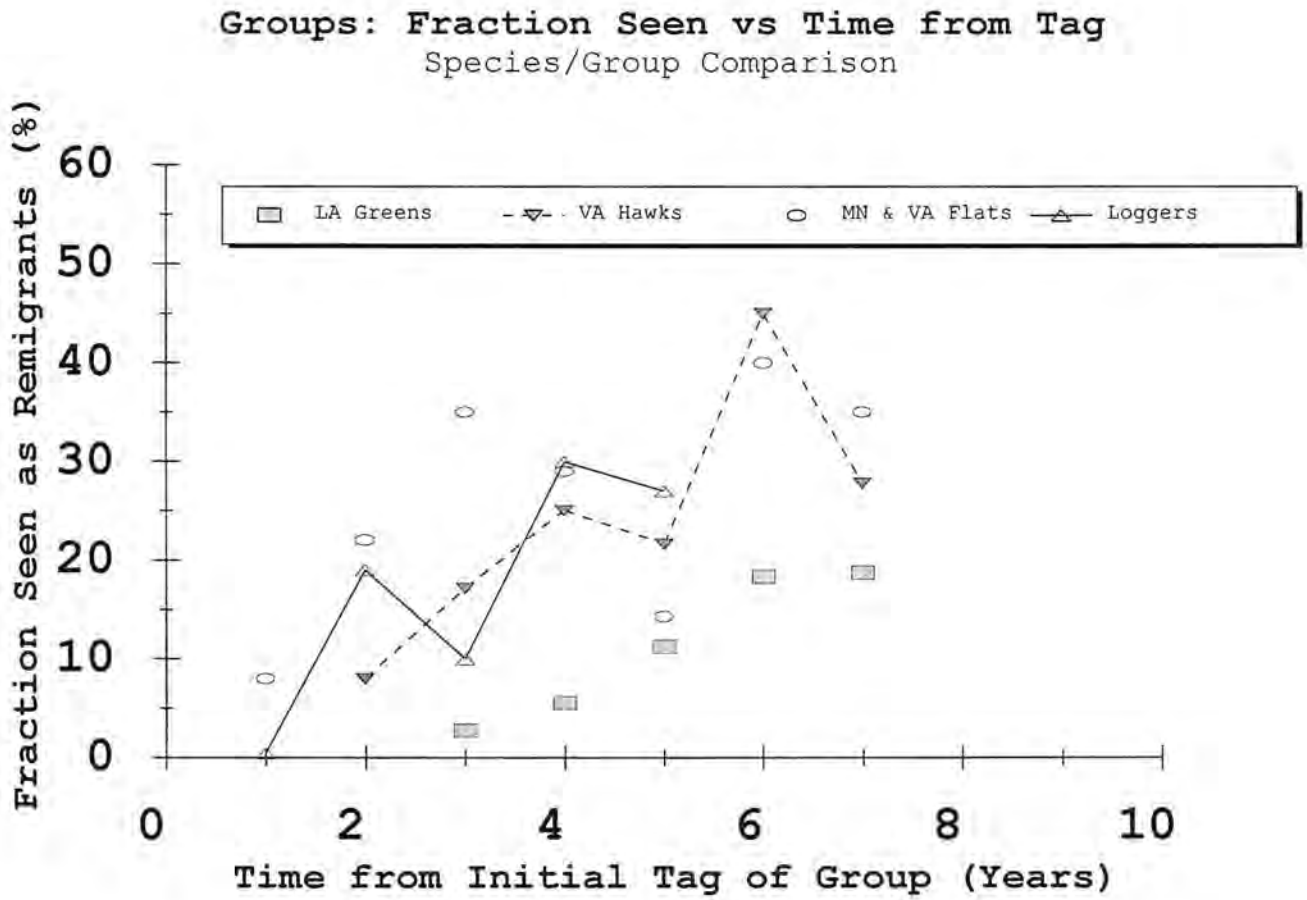

Figure 7. Comparison Between Species Groups from Different Study Sites: Patterns of Increase in Fraction of Group Encountered as Remigrants versus Time Elapsed.

The Numbers of Turtles Visiting Nesting Beaches.

There are a number of indices that might be used to estimate the abundance of turtles visiting nesting beaches during a particular season. The simplest direct indicator is nightly counts of turtles found on a nesting beach. This may, or may not, provide the most accurate estimate of the actual number of turtles actually beaching, depending on circumstances. The numbers of turtles able to be tagged for future study is also not necessarily a simple function of numbers of turtles attending a rookery. Resource availability conflicts can intervene.

Counts of numbers of turtles beaching nightly at the Lacepede Islands have been made over two to four night periods from the 1989/90 season to date. These data are summarized in Figure 8.

There is obviously an appreciable within season variation in the counts of beaching turtles shown in Figure 8. The reasons for this variation have not been properly explored. However, an approximately 15-fold difference in numbers counted beaching has been recorded between the peak (1991/92) and minimum (1990/91) seasons. Observations in the three seasons preceding 1989/90 suggested a 1987/88 peak at least as great as 1991/92, or perhaps greater, and attendances during 1988/89 nearly as great as in 1987/88. These counts represent the majority of turtles beaching on the nights involved, but not a complete tally.

Series of direct counts of turtles visiting North West Cape nesting beaches have also been made. These data will be summarized fully, and presented at a later date.

More restricted beaching count data have been obtained for other species and sites, eg Barrow Island, greens and flatbacks, Cape Domett, flatbacks, etc. These will be dealt with as for North West Cape.

Dispersal of Nesting Females from Nesting Beaches.

Dispersal data are mapped in Figure 9. Individual species accounts are summarized below.

Green Turtle.

In total, dispersal reports for 50 Lacepede Island nesting green turtles have now been received; 56% of reports from Western Australian coastal locations, 38% from northern Australian coastal locations in the Northern Territory and Queensland (Gulf of Carpentaria), and 6% (three individuals) from the Aru Islands (Indonesia). We have received multiple capture reports from five coastal Australian Aboriginal communities outside Western Australia.

Recovery reports for the 1986/87, 1987/88, and 1988/89 Lacepede season tagged groups to date account for *c.* 2.4% down to 1.4% in year order of the turtles originally tagged. Approximately 0.6% down to 0.4% of the 1989/90 through 1992/93 groups have now been reported.

Seven Barrow Island origin green turtles have been reported. Five have been taken from west Kimberley locations. These five turtles include three tagged during the 1987/88 season, and two from the 1989/90 season.

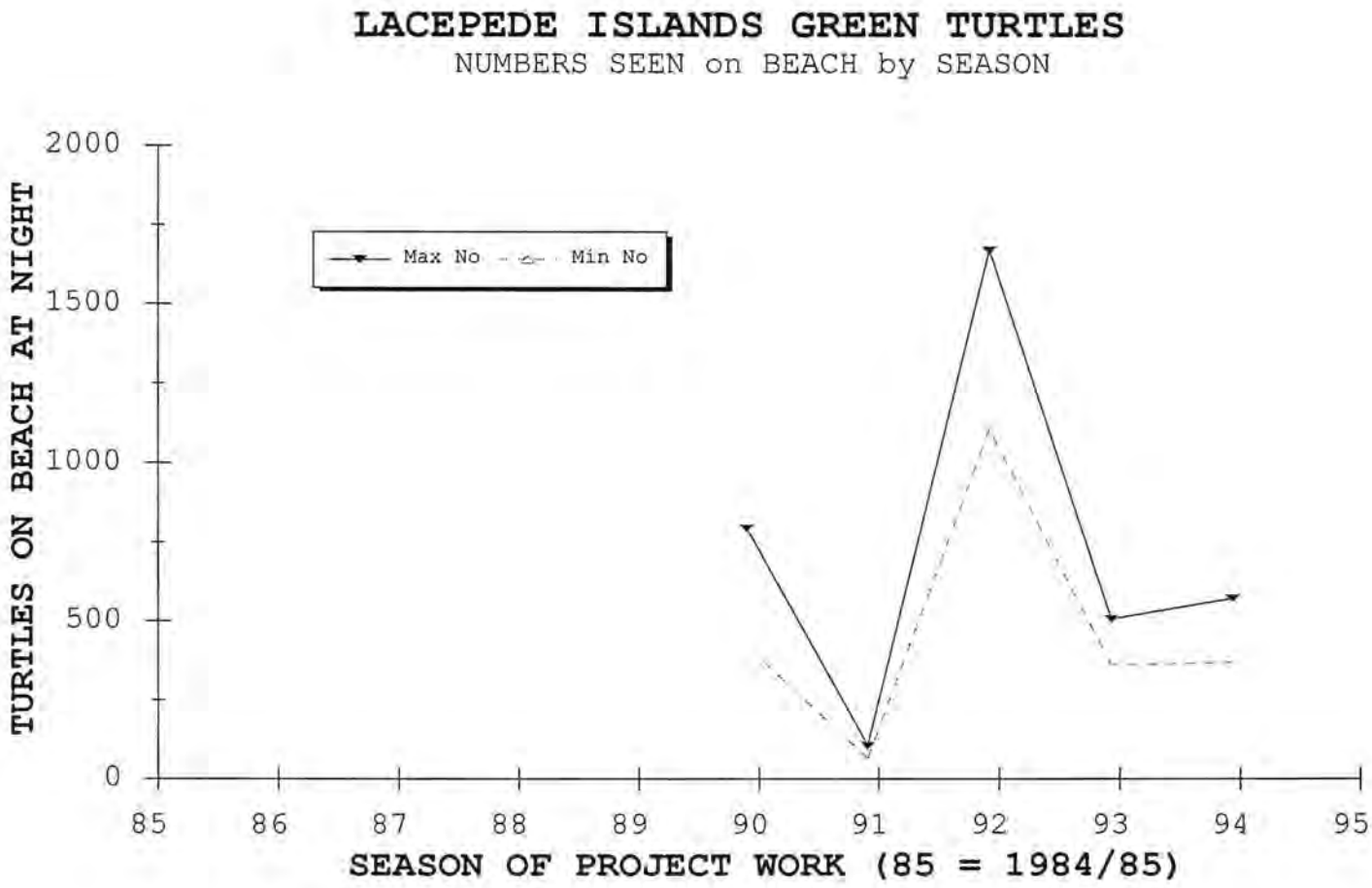

Figure 8. Variation Within and Between Seasons in Numbers of Green Turtles Beaching to Nest at the Lacepede Islands: Data for Seasons when Full Beach Counts Made.

Both of the two other Barrow Island origin turtles were from the 1988/89 nesting group. They were reported from more southerly Western Australian locations. The first turtle was found dead near Kalbarri in November 1991. The second was captured at East Lewis I in the Dampier Archipelago in September 1993.

The Barrow Island capture reports only account for 0.3 to 0.7% of the green turtles from the nesting season groups represented. We have no reports of turtles at sea from either of the 1986/87 or 1991/92 Barrow Island nesting groups. Other nesting season groups not represented here include 1990/91, when practically no green turtles nested at the southern Western Australian green turtle rookeries, and the three most recent seasons when very small numbers only could be tagged at Barrow Island (refer Table 1).

Six at sea captures have been reported for green turtles tagged at the Exmouth Gulf area rookeries: five for North West Cape users and one from South Muiron Island. All six reports are from western Kimberley locations. The turtles reported include two each from North West Cape nesters in the 1989/90 and 1991/92 seasons, one from the very few visiting in the 1990/91 season ex South Muiron Island, and another one from the 1992/93 season group ex North West Cape. We have no reports at sea of any of the numerous 1988/89 North West Cape and Muiron Island nesters. The 1990/91 nesting attendance at North West Cape was minimal.

The green turtle dispersal data relating to the southern Western Australian rookeries are much less comprehensive than those for the Lacepedes nesting groups. It is quite clear in both instances that there are substantial gaps in our knowledge of post-nesting dispersal for these green turtles. On the other hand, it is apparent that residence on distant feeding grounds is a common feature among female turtles visiting these rookeries.

Loggerhead Turtle.

Three Muiron Islands nesting loggerheads have now been reported at sea: the three dispersal points are Shark Bay, WA, Maningrida, NT, and Pulau Masalembo, mid-Java Sea in Indonesia.

Two reports of the Dirk Hartog Island 1993/94 nesters being taken and released within Shark Bay mid-1994 in course of trawl fisheries for scallops and prawns (shrimp) were received. The Muiron Island nesting animal reported from Shark Bay was also taken and released by a trawler.

Flatback Turtle.

Two flatback turtles have now been reported at sea. Both reports have been received within the past year. The captures occurred in trawl fisheries. The turtles are from the Mundabullangana (Cape Thouin area) nesting group.

Figure 9. Dispersal Map

The fishermen have also reported live release of these trawled turtles. The first turtle, captured in October 1993 in a short duration, shallow water try shot, did survive. It was seen as a remigrant nester in the 1993/94 season.

Hawksbill Turtle.

No tagged hawksbill turtles have been reported from at sea locations to date.

Morphometrics: Body Length, Width, and Weight Data.

Standard CCL and CCW measurements have been recorded for most turtles tagged. Linear equations have been fitted to some of these data sets using the methods incorporated in the QuattroPro for Windows 5 software. These analyses will be subject to more formal statistical treatment at a later date. Selected data considered representative of their group(s) are considered below.

Seasonal sample data for green turtles attending the Lacepede Islands, and the North West Cape and Muiron Islands rookeries, are presented in Figures 10 - . Equations forced through a Y = 0 intercept, as well as equations with the Y intercept being calculated, have been fitted. For the present, it is sufficient to say that the North West Cape and Muiron Islands data sets are similar, and that the measurements made at these rookeries suggest that the nesting green turtles here may be slightly more robust on average than those attending the Lacepede Islands. Maximum and minimum curved carapace lengths and widths for turtles in the groups specified are .

Body weights for small numbers of nesting turtles have also been recorded. These limited data are dealt with below in combination with information from the salvage and necropsy work (Item 4).

Clutch egg numbers.

[Hatching success.]

Item 4.
Salvage and Necropsy Program.

A general program of recording occurrences of stranded and dead marine turtles preceded work under cover of the WAMTP as supported by the ANCA/ANPWS administered SCAP program. The majority of these records were sourced from southern and south-western Western Australia (unpublished data). Some specimens were being retained for Museum collections.

Commencement of the WAMTP in quest of greater knowledge of the poorly known western Australian region marine turtle populations permitted better focus of the general program noted above. Historically, the leatherback had been considered equivalent to a threatened species under Western Australian conservation law (Wildlife Conservation Act, 1950 (as amended)). The loggerhead

data collected via the WAMTP has resulted in the recent elevation of this species to the same status (Government Gazette, Western Australia, 1994).

The recurrent pattern of occasional, but continuing, reporting of the finding, in the Perth region, of dead leatherback and loggerhead turtles in particular, prompted reassessment of what further information might be gained from these scarce specimens. Cause of death was an obvious question to address. It was also clear that there was little baseline data on matters such as patterns of heavy metals accumulation in these animals, in contrast with other larger marine vertebrates. External help to examine this question was sought and obtained.

Methods - Salvage and Necropsy Program.

Public reports of finding dead or stranded turtles are encouraged. Where possible, bodies are inspected and/or recovered to try and ascertain cause of death, and for further examination if not too severely damaged or decomposed. Standard body measurements are generally recorded where practicable, eg, CCL, CCW, Head width, Body weight. If decomposition has not progressed too far, carcases are opened for assessment of body condition at death, determination by gonad inspection of sex and state of maturity, observations on diet items, and collection of any tissue specimens required. After inspection, remains of suitable specimens are buried for later recovery of museum material.

Tissue specimens from salvaged animals have been contributed to the population genetics studies (below). The majority have been assayed for heavy metal content (Edmonds *et al.* 1994, Prince and Jones, unpublished data).

Results - Salvage and Necropsy Program.

Carcases, mainly of large juvenile (40 - 50 kg) to adult ($\geq$150 kg) loggerhead turtles, and large juvenile (>120 kg) to sub-adult (250 - 300 kg) leatherbacks, plus some juvenile (5 - 25 kg) green turtles have been found.

Stranding and Salvage.

Loggerhead Turtle.

Stranding/salvage records dating from late 1986 are available for 33 loggerheads. The exact cause of death for the majority (21) of these could not be determined.

Some bodies, obviously having been at sea for extended periods, can not be retrieved intact due to advanced decomposition. In other cases, where the bodies could not be collected for proper examination, photographs, subsequently received with formal reports of these events, have shown that inspections could have been possible. However, most reporters on site at finds, even when able to be advised direct of the information being sought, have understandably been reluctant to make any detailed inspections of the 'decomposed' bodies. Finders reporting by post, often long after making their discovery, have generally

been unaware of what signs might be looked for, and recorded, if present.

Nine of the remaining 12 animals clearly died accidentally: Four from boating collisions, three from drowning after entanglement in commercial crab nets, and two from entanglement in boat moorings. One of the other three turtles was euthanased, due to the extent of its debilitating injuries and poor body condition, after collection at sea - cause of injuries uncertain. The reason for injuries sustained by the other two animals could not be established - one carcase could not be retrieved from the surf.

Mortality data reported are summarized in Figure .

The post-mortem dissections of salvaged loggerhead turtle carcases judged suitable for this purpose have invariably shown that the animals possessed substantial body fat reserves. Observations of gut contents and fill have also suggested that the victims were feeding well prior to death.

Examination of the stomach contents has shown that diets of individual loggerhead turtles are usually restricted. Shell fragments of bivalve molluscs (*Mytilus edulis*, the edible mussel, also raised by aquaculture; *Amusium* spp., the commercial saucer scallops), and crabs (*Portunus pelagicus*, the blue manna crab; other non-commercial species), test fragments and spines of echinoderms (apparent inhabitants of seagrass beds), the occasional gastropod mollusc fragments, and the heads of ascidians (*Pyura* sp.) have been recorded. Several individuals each have been observed to have consumed prior to death diets predominantly of *Mytilus edulis*, of *Amusium* spp., or of *Portunus pelagicus*.

Leatherback Turtle.

Stranding/salvage records are now available for 32 leatherbacks. Several of these records were previously included in Limpus and McLachlan (1979, Table 4). Fifteen reports represent new records from 1986 on. Leatherback strandings, and encounters of live turtles at sea also, appear much more likely to be reported by the public than are the finding of any dead bony-shelled turtles (*cf* loggerheads data, above).

The exact cause of death for 11 of the 32 leatherbacks could not be determined. Of the remainder, 15 were drowned after entanglement in rock lobster pot lines, 3 were killed by collisions with boats, and the remaining two were also accidentally killed in commercial fishing operations

Mortality data reported are summarized in Figure .

Gut contents were generally unrecognizable, but one animal did have part digested remains of colonial ascidians (salps) present. Other animals at sea have been observed eating jelly fish (A. Cheal, pers. comm.).

Green Turtle.

Stranding/salvage records dating from 1988 are available for 26 green turtles.

The exact cause of death of 13 of these green turtles could not be determined. Of the remaining 13, the most common cause of death (8 turtles) was bodily injury resulting in loss of heads and/or flippers. Some of the injuries seen on fresh carcases were consistent with human intervention, but predators may have been responsible for the majority. Australian sea lions (*Neophoca cinerea*) may have been the cause of some (K. Marshall, pers. comm.).

Another four turtles appeared to have died of natural causes. The last turtle of this group appeared to have drowned after entanglement in monofil nylon fishing line.

Mortality data reported are summarized in Figure .

Figure . Causes of Death Summary Pies prepd.

Heavy Metals Accumulation: Baseline Study.

The results reported here are extracted from unpublished work of Prince and Jones. Samples from seven loggerhead, five leatherback, and five green turtles have been examined. Tissues sampled where available were: heart, liver, kidney, pectoral muscle, and depot fat deposits.

Screening of some of the fat samples for a range of organochlorine residues failed to detect, or detected only very low levels of contamination. These observations do not warrant further discussion here.

Other tissue samples were screened for a range of heavy metals. Only a few of the metals screened have assayed at levels of probable further biological interest. Assay results obtained have been calculated on wet/fresh tissue and dry tissue bases. These results are discussed below.

Mercury.

Only six of the 74 samples analysed had fresh tissue mercury concentrations in the range 0.5 - 1.4 mg/kg. These were mainly loggerhead turtle liver samples. The remainder of the material submitted had mercury concentrations in the range from 'limit of detection' up to *c.* 0.25 mg/kg.

The equivalent dry tissue concentrations were:
maxima of 2 to 5 mg Hg/kg,
majority in 0.05 to 1 mg Hg/kg range.

Note: NHMRC Maximum Permissible Concentrations (MPCs) Hg - wet weight basis, 0.03 mg/kg.

Arsenic.

Edmonds *et al.* (1994) have reported on the arsenic compounds found in tissues of one large juvenile leatherback turtle. Arsenobetaine was the major compound found in the heart, pectoral muscle and liver tissues examined, but significant amounts of arsenocholine and inorganic arsenate were present in aqueous extracts of the liver tissue. The first two compounds are found in other marine organisms, while arsenate is also found in sea-water.

Assay results from the leatherbacks, particularly from some of the larger loggerheads, and some of the green turtles, suggested that arsenic could be concentrated by these animals. The highest concentrations were almost invariably found in the pectoral muscle samples.

The highest arsenic concentrations found were in muscle tissues of two loggerheads: 64 and 71 mg/kg fresh tissue as submitted - equivalent dry tissue concentrations 310 and 320 mg As/kg. General concentrations found in other tissue samples were from *c.* 0.5 to 20 mg As/kg wet weight (*c.* 1 to 100 mg As/kg dry tissue).

Peak arsenic concentrations found in two of the leatherbacks sampled were 11-13 mg /kg wet tissue (*c.* 50 mg As/kg dry tissue). This was less than the minimum muscle tissue levels determined in the adult loggerheads sampled (70 - 90 mg As/kg dry tissue), and also less than the peak concentrations found in muscle tissue samples from two of the only juvenile green turtles available for sampling (60 - 90 mg As/kg dry tissue).

Note: As concs high relative to NHMRC Maximum Permissible Concentrations (MPCs) - wet weight basis.

Figure . Heavy Metals - Mercury and Arsenic prepd.

Cadmium.

The highest cadmium concentrations were found in kidney tissue samples of all species. The highest concentration found was in the kidney sample of one leatherback (92 mg Cd/kg wet tissue, 540 mg Cd/kg dry tissue). Concentrations in the 140 - 160 mg Cd/kg dry tissue range were found in the other leatherback kidneys.

The juvenile green turtle kidney sample (n=4) cadmium levels ranged from 60 - 140 mg/kg dry tissue. Four of the loggerhead turtle kidney samples fell in the range 70 - 130 mg Cd/kg dry tissue: the other three loggerhead kidney samples in the range 20 - 50 mg Cd/kg dry tissue.

Liver tissue samples from two of the adult loggerheads and one small green turtle also had cadmium concentrations in the range 40 - 100 mg/kg dry tissue. All other samples assayed were generally <20 mg Cd/kg dry tissue cadmium.

Note: NHMRC Maximum Permissible Concentrations (MPCs) Cd - wet weight basis, 0.05 mg/kg.

Copper.

Liver copper levels were generally higher than in other tissues sampled.

All the loggerhead turtle liver samples were in the range 15 - 45 mg Cu/kg dry tissue. The leatherback liver samples were in the range 25 - 40 mg Cu/kg dry tissue.

The three smallest of the green turtles had higher liver concentrations: two in the range 70 - 80 mg Cu/kg dry tissue, while the smallest animal had a much higher concentration (350 mg Cu/kg dry tissue). The two larger juvenile greens had liver tissue copper levels (20 -30 mg/kg dry tissue) in the lower half of the leatherback and loggerhead ranges.

Tissue copper levels in most other samples from leatherbacks were <15 mg/kg dry tissue. The loggerhead samples were mostly below 20 mg Cu/kg dry tissue, with the majority in the range 5 -15 mg Cu/kg dry tissue (similar to the leatherbacks). Non-liver samples from the green turtles were more variable, with copper concentrations tending to be slightly greater than, or equal to the higher leatherback and loggerhead levels.

Note: NHMRC Maximum Permissible Concentrations (MPCs) Cu - wet weight basis, 10.0 mg/kg.

Selenium.

The highest tissue selenium level was found in one leatherback liver (55 mg/kg dry tissue, 15 mg/kg wet tissue). The remaining samples were generally <35 mg/kg dry tissue selenium.

Liver selenium levels were generally greater than other tissue levels for the loggerhead and leatherback turtles, while muscle tissue concentrations tended to be lower than heart and kidney levels in the juvenile loggerheads, and more similar to the heart and kidney tissue levels in the larger animals. Leatherback muscle selenium concentrations relative to heart and kidney parallel the large loggerhead pattern.

The green turtle selenium concentration data generally fall below 15 mg/kg dry tissue, with all except one liver sample in the range 1 - 10 mg Se/kg dry tissue. Selenium levels found in tissues from the green turtles below 15 kg are generally greater than those recorded in tissues from the 20 - 30 kg size range. No larger animals were available for sampling.

Note: NHMRC Maximum Permissible Concentrations (MPCs) Se - wet weight basis, 1.0 mg/kg.

Zinc.

The majority of tissue zinc concentrations assayed fall in the range 50 - 275 mg/kg dry tissue.

The higher concentrations in loggerhead turtle samples were commonly found in heart tissues. Relative tissue concentrations in the other species samples were more variable. Interpretation of any possible tissue specific patterns of accumulation of zinc in the leatherbacks and green turtles is hampered by lack of some tissue samples from individuals within each of the small sample groups.

Zinc concentrations <<50 mg/kg dry tissue were found respectively in the muscle and liver samples from two of the loggerhead turtles sampled, and in muscle tissue of one of the green turtles. Concentrations $\geq$200 mg Zn/kg dry tissue were found in each of two heart and liver samples from green turtles, heart samples from two loggerhead turtles, and in the heart and kidney samples of one leatherback.

Note: NHMRC Maximum Permissible Concentrations (MPCs) Zn - wet weight basis, 150.0 mg/kg.

Figure . Heavy Metals - Cadmium, Copper, Selenium and Zinc prepd.

Item 5.
Methods - Population Genetics Studies.

Allozyme variation in marine turtles was expected to be restricted, but expertise for this purpose was accessible in the early phase of the WAMTP (Coates *et al.* 1994). Western Australian nesting green turtles were sampled for this purpose over the 1987/88, 1988/89, and 1989/90 seasons.

Muscle biopsy samples were obtained from adult turtles in the field by procedures similar to those outlined by Gyuris and Limpus (1986). These micro-samples were generally put into 1 ml Nunc tubes on collection, and then stored in a liquid N_2 refrigerator until analysis.

Hatchling tissue samples (including heart, liver, muscle as required) were collected by dissection following euthanasia by injection of sodium pentobarbitone solution. Where possible, live hatchlings were obtained from among the animals remaining trapped within emerged nests. Recently dead hatchlings (eg, predated) were also sampled when available. Samples were treated as for adults, above.

Blood samples being taken in recent years from adult turtles and hatchlings are obtained from the cervical sinus using an appropriate size syringe and needle combination (after Owens and Ruiz 1980). Whole blood samples, or the separated cells, have been retained at various times for later analysis. Separated cell fractions were stored in larger size Nunc tubes, and frozen in liquid N_2,as for tissues. Whole blood samples have been stored at room temperature after collection, either in a lysis buffer (method, B. W. Bowen, BEECS, U of Florida), or in 20% dimethylsulfoxide (DMSO) saturated with NaCl (after Amos and Hoelzel 1990).

Subsequent to the independent start of the WAMTP allozyme work noted above, and after discussions with Dr Colin Limpus and Dr Craig Moritz, it was agreed that Western Australian sourced samples should be contributed as part of the material being obtained for a wider regional study of the genetic structure of marine turtle populations using more advanced analytical techniques (mitochondrial DNA, microsatellite DNA, etc; see Norman *et al.* 1994, Moritz 1994). This decision has guided continuing work.

Analytical methods for the DNA work are those developed for use in Moritz laboratory (see Moritz, Norman and Limpus, Final Report to ANPWS under Research Contract , and other published works).

Results - Population Genetics Studies.

Collections of material made via the WAMTP for the purpose of genetic analysis are summarized in Table 3.

In addition to the green turtle, samples have been obtained from Western Australian nesting flatback, loggerhead, and hawksbill turtle populations. Not all samples collected have been used in analysis to date.

Table 3. Summary of Sampling Work for Population Genetics Studies: Western Australian Marine Turtle Project 1986 through 1994.

LOCATION SAMPLED	SPECIES SAMPLED (1)	SEASON SAMPLED (2)	TURTLES SAMPLED (3)	STUDY SEGMENT (4)	RESULT OF WORK (5)
Lacepede Islands	G	1987/88	23A	Nesting	Coates *et al*/Moritz group
		1988/89	31A/13H		
		1989/90	39A/ 5H		
	H	1989/90	1H		
		1990/91	2H		
Barrow Island	G	1987/88	23A	Nesting	Coates *et al*/Moritz group
		1988/89	33A		
Muiron Islands	G	1987/88	20A	Nesting	Coates *et al*/Moritz group
North West Cape	G	1988/89	30A	Nesting	Coates *et al*/Moritz group
	H	1991/92	2A	Nesting	
	L	1991/92	4A	Nesting	
Varanus Island (Lowendals)	G	1990/91	1H	Nesting	[Moritz]
	F	1990/91	2H	Nesting	[Moritz]
	H	1990/91	4H		[Moritz]
		1991/92	17H	Nesting	Broderick *et al*
Rosemary Island (Dampier Archipelago)	H	1991/92	2A/19H	Nesting	Broderick *et al*
Delambre Island (Dampier Archipelago)	F	1989/90	6H	Nesting	[Moritz]
Mundabullangana (Cape Thouin area)	F	1993/94	3A/ 2H	Nesting	[Moritz]
Dirk Hartog Island	L	1993/94	20A	Nesting	[Moritz]
Browse Island	G	1991/92	2A/25H	Nesting	[Moritz]
Scott Reef (Sandy Island)	G	1991/92	12A/10H	Nesting	[Moritz]
King Sound (N Helpman Island)	F	1991/92	3H [@WAM]	Nesting	[Moritz]
Rowley Shoals (Imperieuse Reef)	G	1991/92	5J	Feeding	[Moritz]
Montgomery Islands (reef population)	G	1991/92	10A/24J	Feeding	[Moritz]
	L	1991/92	1A	Feeding	

King Sound (Buccaneer Archipelago, incl. One Arm Point)	G H	1991/92	1A/2J 1J	Feeding	[Moritz]
Exmouth Gulf (Sandalwood Peninsula)	G	1990/91	5J	Feeding	[Moritz]
West Coastal (beached waifs, and salvage program)	L	1988/89 1990/91 1991/92	2J 32J 1A	Feeding etc	[Moritz]
	LB	1992/93	1J		

Key: (1) G = Green, F = Flatback, H = Hawksbill, L = Loggerhead;, LB = Leatherback (2) Season = 1 July YR to 30 June YR+1; (3) nA = number adults sampled, nJ = number of juvenile turtles, nH = number of hatchlings; (4) type of group sampled; (5) disposition of samples, etc.: Broderick*et al* and Coates *et al* refer to publications, other references to material forwarded to Dr Craig Moritz group at University of Queensland.

[Pt B, 2 January, 2002 10:46 hrs]

Results from the initial green turtle allozyme work were reported at the Australian Marine Turtle Conservation Workshop, 1990 (Coates *et al*. 1994).

The further work conducted in association with Dr Moritz laboratory has provided evidence that Western Australian nesting green turtles comprise two stocks for management purposes, although they also appear very closely related to other eastern Indian Ocean green turtles (Moritz, Norman and Limpus 1994).

Initial work on the hawksbill turtle has been published (Broderick *et al*. 1994). This work has also provided evidence that there are two major stocks of hawksbill turtles present in the Australian region. Western Australian breeding hawksbills comprise a major part of one of these stocks.

Loggerhead and flatback turtle samples are presently being examined in Dr Moritz' laboratory. Useful results are not yet available. Some further sampling may also be needed (Muiron loggerheads, Barrow Island and/or Mundabullangana flatbacks).

There is current agreement between relevant parties that the hawksbill and loggerhead material collected via the WAMTP, and other Australian work, should also contribute to further international study of the genetic structure of the world's marine turtle populations (via exchanges with Dr Brian Bowen, University of Florida, USA).

Item 6.
Juvenile Growth Study.

Knowledge of rates of growth and the consequent duration of different life stages of marine turtles is vital for understanding of species population dynamics. The major part of the work that has been sustained is the product of volunteer

participation with external support, and represents unpublished work.

Methods - Juvenile Growth Study.

Field Populations.

At sea studies of growth of juvenile green turtles from representative warm tropical waters and cooler more temperate waters populations were planned as part of the developing work of the WAMTP.

The warm tropical waters site selected was located in the north-west Kimberley region of Western Australia. The extensive Montgomery Islands reef complex in Collier Bay was the preferred choice. This reef was considered remote enough to be free from the impact of Aboriginal turtle hunting activity, but still reasonably accessible by small boats from the Bardi Aboriginal community based at One Arm Point. It was considered desirable to secure Aboriginal participation in this task.

Two visits to the Montgomery Islands area were arranged in August 1991. The first supervised trip (12-17 August) had the combined objectives of sampling from the feeding ground group of turtles on this reef as part of the wider population genetics studies, the checking of adult sized turtles present to see if any might bear tags previously applied at study rookeries, and to assess the overall feasibility of conducting the planned growth study.

The second Montgomery Islands trip (22-26 August 1991) was conducted unsupervised, as per an agreed plan, by members of the Bardi Aboriginal community, following success of the first trip. This second trip was aimed at increasing the numbers of turtles tagged from among the reef population.

Turtles were captured by variation of the 'rodeo' technique as described by Limpus (). They were measured (CCL and CCW standard), and tagged with 'WA series' tags before release.

The cooler more temperate waters southern study site was located off Sandalwood Peninsula, Exmouth Gulf. The work at this site is volunteer-based, being maintained by commercial fisherfolk in parallel with their fishing. Turtles are caught when they become stranded on the reef flat by falling tide after having failed to clear the obstacle posed by nets of a trap-fishing operation. The mesh of the fixed wing-net is not large enough to entangle turtles, which are also excluded from the trap itself by the narrowness of the opening. The semi-diurnal tidal regime with *c.* 2^{+} m spring range provides two opportunities daily for capture of passing turtles when the trap is being fished.

Turtles are collected from the reef flat for tagging and measurement (as above) before release.

Captive Turtles.

Post-hatchling loggerhead turtles are the only turtles of this size that are found, and often stranded on beaches of south-western Western Australian during winter and early spring.

Loggerheads of the next life stage, large juvenile (40 - 50 kg, *c.* 650 - 750 mm CCL), are resident in coastal waters of south-western Western Australia.

The finding of relatively large numbers of viable post-hatchling loggerheads in mid-1991 provided an apparently rare opportunity to observe growth in controlled semi-natural conditions of animals from a poorly known species population, and of a life stage not usually accessible to study. These animals could also be used to raise public consciousness of marine turtle conservation issues, and particularly to those relevant to the Australian loggerhead turtle populations (note 1994, p.).

A cooperative care arrangement was first made with managers of Underwater World, a commercial marine aquarium located at Hillarys Boat Harbour, Hillarys, WA. The young turtles being collected over winter 1991 by the public, and presented live to CALM, were initially held within small aquarium tanks to assess viability (water warmed to $\geq$20°C). Survivors, when judged fit enough, were transferred in small groups to larger aquarium tanks, where they remained for several months.

Later, as these turtles grew, they were moved into larger concrete holding tanks. Water provided to these concrete tanks was not warmed, being part of the sea-water supplied to the main display aquarium of Underwater World after being pumped direct from the adjacent ocean within the Marmion Marine Park.

Turtles remaining in the small experimental group were transferred from the Underwater World facility to an outdoors sea-cage located within the adjacent Hillarys Boat Harbour in April 1993, and have been held there since.

The captive turtles were first individually hand-fed a mixed diet of chopped bait-fish, supplemented with some squid and small prawns, while being rehabilitated. Food was offered twice daily according to demand. The larger turtles now housed outdoors have been fed mainly fish (WA sardines) for the greater part of their lives, with occasional supplements of shucked edible mussels. Amounts offered on a once daily basis have been adjusted according to willingness of the animals to feed.

Captive animals have been regularly weighed and measured (SCL and SCW being the only practicable carapace measurement for these small size classes). Water temperatures in the accommodation being occupied by the turtles have been monitored, along with the amounts of food being offered.

Results - Juvenile Growth Study.

Kimberley Warm Tropical Waters Study.

Eighty-nine green turtles (6 adult females, 6 adult males, and 77 juveniles) and one adult female loggerhead were captured, tagged, measured, and released at the Montgomery Islands reef in August 1991. One of the adult green females tagged migrated to the North West Cape area to nest during the 1991/92 summer.

Inability to finance continuing Aboriginal execution of the work required for this project segment, plus attendant logistic problems, has prevented further progress with this study.

Exmouth Gulf Cooler Temperate Waters Study.

The first turtle for this study was captured on 27 December 1989. To date, 489 green turtles, 15 hawksbills, and 62 loggerheads have been captured, tagged, measured, and released (see Table 1).

Growth increment data with minimum individual recapture intervals $\geq$ 250 days from initial tag date have now been obtained from among these tagged species groups for 32 green turtles and 7 loggerheads (see Table 2). The maximum interval recorded between the first tag and last capture dates is *c.* 1200 days.

Green Turtle.

Green turtle growth and growth increment data are presented in Figures aa-bb. Juvenile green turtles with CCL in the range from *c.* 400 to 700 mm only have been accessed in this study. All measurements recorded have been made by the same observers. Although there is some apparent variability in measurement data for some individuals with measurement series >2 points, the data available are generally consistent overall.

Figure . Green Turtle Growth and Growth Increments prepd.

Data in each of the Figures have been grouped by similarity in initial CCL measurements, and data for one individual in each set has been picked as generally representative and fitted with a straight line.

The data being discussed here will be subject to more formal analysis and reporting at a later date.

For present purposes, the first notable feature of the data set included in Figures aa-bb is the apparent near growth stasis exhibited by individual turtles for periods of 300 to 400 days or more (eg, 14662, 15453, 15465, 15142, 14049, 15495, 13887). The second feature is the generally low rate of increase in measured CCL among the turtles that appear to have grown. Average CCL increments $\leq$ 2 mm per month are suggested for this sub-set of juvenile green turtles. Maximum long term rates of increase in CCL are *c.* 3 mm per month.

Loggerhead Turtle.

Loggerhead turtle growth and growth increment data are shown in Figures cc-dd. The juvenile loggerheads accessed are considerably larger than the green turtles above, the minimum loggerhead CCL, *c.* 680 mm, being similar to the largest of the juvenile green turtle CCLs (see also, note re Captive Turtles study, above).

As noted for the green turtles, some of the loggerheads also appear to have undergone extended periods of growth stasis (CCL growth increments < 1 mm per month over 1 - 2 years, 15171, 15196, 15176, 15197). The few loggerhead turtles showing more consistent growth appear to have sustained average CCL growth increments in the range of 3 - 4 mm per month (turtles $\geq$ 750 mm CCL; classify either as large juvenile, or possibly pre-pubescent life stage).

Captive Juvenile Loggerhead Turtles: Hillarys Harbour.

Growth data for turtles in the captive study group retained after selection from among the 1991 winter stranded post-hatchling loggerheads are shown in Figures ee-ff. Individual growth trajectories have differed, with the smallest captives now at *c.* 4.2 to 4.8 kg being about two-thirds the bulk of the largest at *c.* 6.4 to 6.9 kg. However, the general form of these growth trajectories, and the individual patterns of growth of all these turtles are similar. Straight carapace lengths for these animals range from *c.* 275 to 315 mm.

It is clear from Figures ee-ff that all the young captive turtles when held outdoors have maintained a strongly seasonal pattern of growth stasis through winter, followed by a period of active growth through to the late-summer/early autumn period. The natural seasonal variations in water temperature in southern Western Australian coastal seas are sufficient to induce this pattern. The associated low levels of activity, poor appetite, and minimal growth through winter have occurred at water temperatures in the 15-16°C range. The periods of sustained activity, good appetite, and active growth have been associated with water temperatures 19-20°C, and greater.

Figure . Loggerhead Growth: Exmouth Gulf Growth and Growth Increment prepd. Captive CCL and Weight prepd.

Item 7.
Database.

Primary data for the WAMTP comprise the accumulated records of observations compiled in the field. These consist of completed record sheets, notebook records, and the like. These primary records are retained for further reference. Data listed in these records are extracted as required for entry to, and storage in a computer database.

The current database for the WAMTP uses Paradox for Windows software (current version 1.0, being upgraded to 1.5 soon). This database in fact is the evolutionary successor of an original, much simpler system, developed with Dbase. Paradox for Windows software allows interchange of data with some other software products including Dbase. Simple graphic presentations are provided via QuattroPro for Windows.

Apart from the file for the main data-set, which now includes nearly 23 000 records for over 14 000 turtles , the system includes other files which contain information on disposition of the tags procured for the project, the retention times for tags applied to turtles where appropriate, growth increment data with attached graph capacity, etc.

Further development to improve usability of the data-base system available, to make more efficient computer hardware use, and to more fully exploit the 'linked tables' capacity of the Paradox software, is a continuing process.

The WAMTP data-base records have potential compatability with the data-base records of the Queensland Turtle Research project lead by Dr C J Limpus (Dbase software application).

Item 8.
Other Support and Interest.

The focal management team for the WAMTP has been provided by the Western Australian Department of Conservation and Land Management. The base level operational funding permitting the project to proceed has largely been provided on a non-recurrent annual basis via the States Cooperative Assistance Program, now administered by the Australian Nature Conservation Agency. The project has been able to build additional support on this base during the course of operation, and thus increase the coverage and value of the work undertaken.

Methods.

The resources available from the two institutions noted were quite limited in context of the questions needing to be addressed (see Project Objectives, above), and did not specifically provide opportunities for Aboriginal community involvement in the work proposed, or provision of paid labour to attempt detailed population studies.

Marine turtles do, however, have their own attraction for some of the public. The experience from other marine turtle project work conducted elsewhere showed that public and community participation in such work could be obtained. Occupation by major offshore oil industry operators of land bases associated with important rookeries was a particularly important regional feature.It was also considered essential to involve Aboriginal people in the work from inception wherever communities making use of the turtle resources could realistically be expected to participate direct (see Prince 1985).

Western Australian Kimberley region Aboriginal people from the Bardi community had participated in the turtle farming experiments conducted by Applied Ecology Pty. Ltd. in the early 1970s, and were involved in investigation of dugong resource management issues (see Prince 1987) at the time the turtle project was being planned. The relevant communities had expressed their further interest in the marine turtle work being proposed.

Means to support Aboriginal participation in the Kimberley region work, and to gain and focus other potential sources of support and participation in the work were actively pursued.

Results.

Aboriginal Participation in Field Work.

Aboriginal participation in the field work at the Lacepede Islands green turtle rookery was first secured for the 1986/87 season by direct negotiation of the Project Supervisor with the Officer in Charge of the Broome office of the then Australian Department of Employment and Industrial Relations. A discretionary arrangement available to DEIR under Aboriginal training program initiatives was made.

Aboriginal involvement in the Kimberley work program for the 1987/88 season was financed from Western Australian state resources via CALM.

Continuing Aboriginal participation in the Kimberley work program for season 1988/89, and on through season 1991/92, was supported directly via the new CEPANCRM program administered by ANCA as part of the Commonwealth Aboriginal Employment Development Policy.

CEPANCRM support ceased for the 1992/93 season, but Aboriginal workers assisted with the 1992/93 season field work at the Lacepede Islands. Their participation in 1992/93 was able to be rewarded at much reduced levels with Western Australian state funds sourced from a special Social Advantage program.

No special financial support for Aboriginal involvement in turtle program field work was obtainable for the 1993/94 season. Aboriginal participants, experienced from their previous seasons work in the program, declined the invitation to offer their services for the 1993/94 season work when it became clear that there would be no alteration in these circumstances *cf.* the last minute change that occurred in 1992/93 (above). General volunteers were recruited to replace these people.

General Volunteer Program.

A major reduction in the SCAP funding offered for the 1988/89 (third) season field work, in comparison with 1987/88 season support, provided the impetus for an initial reassessment of continuing project viability. Decision to try to maintain the program as planned was instrumental in the further decision to attempt development of a general volunteer program to support work at southern Western Australian rookeries that could parallel the new CEPANCRM program support for Aboriginal worker participation in the Kimberley.

The WAMTP general volunteer participation program has been dealt with under Item 2.

Other Community and Industry Support.

Varanus Island.

The serendipitous association of a willing and available volunteer within the island workforce with the presence of nesting hawksbill turtles at the oilfield base on Varanus Island in the Lowendal Islands group was critical to the work that has been based there since 1986/87 (see Item 2 and Item 3).

The present oilfield operating company, Hadson Energy Ltd, and their predecessors, Bond Oil, have been generally supportive of the hawksbill turtle project work focussed on Varanus Island. The company has incidentally been able to gain independent industry recognition for the work.

Following retirement of Mr E. A 'Tanny' Robinson from the Varanus Island work force early in the 1993/94 nesting season, Hadson Energy provided the necessary support for an experienced general program volunteer to continue the work through the latter part of the 1993/94 season.

Barrow Island.

West Australian Petroleum Pty. Ltd. (WAPET) has provided transport and accommodation for turtle project work on Barrow Island from commencement of work there in 1986/87. Work over the first three seasons (through 1988/89) was conducted solely by CALM personnel ex Karratha.

Changed circumstances for the 1989/90 season required a new approach if work on Barrow Island was to be maintained. WAPET was supportive of an approach to seek volunteer help from among their work force on Barrow Island for 1989/90. The substantially different situation here was recognized, but success of the Varanus Island set-up provided a model.

A small core group of Barrow Island workers, assisted by many others, has participated in turtle work on the island since 1989/90. WAPET has also continued to provide support for work at Barrow Island by WAMTP personnel and associated volunteers when needed.

WAPET has received the Australian Minerals and Energy Environment Foundation 1994 Award for Environmental Excellence. In making the acceptance speech, the company's Managing Director made special reference to the volunteer involvement with the island turtle work.

Rosemary Island.

Rosemary Island within the Dampier Archipelago attracts, on current information, around 500 or so nesting hawksbill turtles annually. It is the only readily accessible site where relatively large numbers of hawksbills representative of the north-western Australian (see Broderick *et al.* 1994)/south-eastern Indian Ocean hawksbills can be tagged and released.

Work on Rosemary Island is complementary to the more detailed work based at Varanus Island. Woodside Offshore Petroleum Pty. Ltd. contributed to support of this largely volunteer executed work for the 1993/94 nesting season.

Fieldwork, Other Locations.

Arrow Pearl Co. Pty. Ltd. has assisted the Lacepede Islands program with transport of materials, access to water supplies, and other services via their farm base at Beagle Bay.

Work at Browse Island and Scott Reef was made possible by cooperation of the Bureau of Meteorology Regional Office, Broome, and assisted by North Star Charters.

The Western Australian Fisheries Department via their Exmouth office has provided assistance with transport of volunteers and equipment to the Muiron Islands on many occasions.

Ecotour Interaction.

Principals of Coate's Wildlife Tours have developed an interactive program for North West Cape in consultation with the WAMTP project management team since 1990/91. This arrangement provides tour company customers with guided, hands-on contact with aspects of the field research program. Tour participants are not required to perform any major work.

The benefit to the WAMTP arises from direct supplementary funding support provided from the tour. This assists with maintenance of the general volunteer-based work programs at the North West Cape and Muiron Islands rookeries.

Conservation Groups.

The Exmouth based group CARE (Conservation, Animal Rescue, Research, and Education) includes members who participate in the general volunteer program on North West Cape Beaches. The group has contributed funds from its own sources to assist the North West Cape and Muiron Islands work over the past two seasons (1992/93, and 1993/94).

Research Collaboration.

Collaborative work in regard to the population genetics and salvage and necropsy program segments has been mentioned under Items 4 and 5.

Staff members from the Department of Mathematics and Statistics, Edith Cowan University (Mt Lawley campus), are currently engaged in analysis of the available remigrant and recovery observation data from the Lacepede Islands green turtle data-set. The objective is to assess survivorship of tagged turtles, and the adequacy of the tagged population base as the foundation for this purpose. Edith Cowan University sourced funds are assisting with this work.

Item 9.
Reports and Papers.

Broderick, D., Moritz, C., Miller, J.D., Guinea, M., Prince, R.I.T., and Limpus, C.J. (1994). Genetic Studies of the Hawksbill Turtle *Eretmochelys imbricata*: evidence for multiple stocks in Australian Waters. *Pacific Cons. Biol.*, **1**: 123-31.

Coates, D.J., Carstairs, S.A. and Prince, R.I.T. (1994). Preliminary Analysis of Population Genetics of Western Australian Nesting Green Turtles using Allozyme Data. In: R. James (Comp.). 'Proceedings of the Australian Marine Turtle Conservation Workshop, November 1990'. Pp. 163-6. ANCA: Canberra.

Edmonds, J.S., Shibata, Y., Prince, R.I.T., Francesconi, K.A., and Morita, M. (1994). Arsenic compounds in tissues of the leatherback turtle, *Dermochelys coriacea*. *J. mar. biol. Ass. U.K.*, **74**:463-6.

Norman, J., Moritz, C., Limpus, C, and Prince, R. (1994). Population Genetics as a Tool for Managing Marine Turtle Populations. In: R. James (Comp.). 'Proceedings of the Australian Marine Turtle Conservation Workshop, November 1990'. Pp. 101-17. ANCA: Canberra.

Prince, R.I.T. (ed.). (1989). Western Australia Turtle Research Newsletter No. 1, March 1989. Western Australian Department of Conservation and Land Management (Wildlife Research Centre): Wanneroo.

Prince, R.I.T. (ed.). (1990). Western Australia Turtle Research Newsletter No. 2, June 1990. Western Australian Department of Conservation and Land Management (Wildlife Research Centre): Wanneroo.

Prince, R.I.T. (ed.). (1991). Western Australia Turtle Research Newsletter No. 3, June 1991. Western Australian Department of Conservation and Land Management (Wildlife Research Centre): Wanneroo.

Prince, R.I.T. (ed.). (1992). Western Australia Turtle Research Newsletter No. 4, June 1992. Western Australian Department of

Conservation and Land Management (Wildlife Research Centre): Wanneroo.

Prince, R.I.T. (1993). Western Australian Marine Turtle Conservation Project: An Outline of Scope and an Invitation to Participate. *Marine Turtle Newsletter*, **60**: 8-14.

Prince, R.I.T. (ed.). (1993). Western Australia Turtle Research Newsletter No. 5, October 1993. Western Australian Department of Conservation and Land Management (Wildlife Research Centre): Wanneroo.

Prince, R.I.T. (1994a). Status of the Western Australian Marine Turtle Populations: The Western Australian Marine Turtle Project 1986-1990. In: R. James (Comp.). 'Proceedings of the Australian Marine Turtle Conservation Workshop, November 1990'. Pp. 1-14. ANCA: Canberra.

Prince, R.I.T. (1994b). The Flatback Turtle (*Natator depressus*) in Western Australia: New Information from the Western Australian Marine Turtle Project. In: R. James (Comp.). 'Proceedings of the Australian Marine Turtle Conservation Workshop, November 1990'. Pp. 146-8. ANCA: Canberra.

Prince , R I T (1994c). The Western Australian Marine Turtle Conservation Project: An Update. In: B.A. Schroeder and B.E. Witherington (Comps.). 'Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation.' Pp. 139-41. NOAA Technical Memorandum NMFS-SEFSC-341.

Prince, R.I.T. (1994d). Loggerhead Turtle Breeding in Shark Bay World Heritage Area, Summer 1994 Investigation. *Marine Turtle Newsletter*, **67**:5-6.

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