TURTLE FARMING PROJECT IN NORTHERN AUSTRALIA

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TURTLE FARMING IN NORTHERN AUSTRALIA

REPORTS ON THE ORGANISATION, MANAGEMENT AND MARKET PROSPECTS AND ECOLOGICAL IMPLICATIONS

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Dear Senator Willesee,

We forward herewith our *Report on an Inquiry into Ecological Implications of a Turtle Farming Project.*

In the report we have endeavoured to limit our comments and recommendations to the terms of reference provided. In this letter of transmittal, however, we have taken the liberty of going a little beyond our terms of reference to comment on one or two other matters that seem to us important. In making these comments our hope is that in all future dispensations affecting the turtle farms the well-being, dignity and peace-of-mind of the Islander and Aboriginal farmers will continue to be a prime consideration.

On ecologic and conservational grounds we consider it unlikely that the present project will prove suitable for expansion as the whole or even the principal economic support of the Torres Strait Islanders. We therefore suggest that other appropriate occupations that will allow these deserving people to remain in their island communities be sought.

Besides the obvious need to find ways of protecting the people in the event that the turtle project should not fulfill the high hopes that are held for it, we see a need for vigilance regarding two other possible repercussions.

One is a decline in the nutrition of the islanders that their new stewardship for the turtle resource may bring. Although the eggs and flesh of sea turtles have traditionally been important in the Torres Strait diet we were told by some Islanders that they no longer eat turtles because 'they are worth money.' Having elsewhere seen nutritional degradation occur when a 'turtle- people' stopped eating turtles and started selling them – it happened dramatically among the Miskito Indians of the Caribbean when freezing plants were built there during the past two years – we urge that the Torres Strait people somehow be shielded against this eventuality. If there is any justification for the exploitation of the diminishing sea turtles of the world it is to nourish seaside people who have always depended on them as a source of protein.

Another possible disruption of the welfare of the islands could come from increased visitations by outsiders admitted under special licence. We have in mind not only commercial agents exploring for sources of turtle products but also the more casual visitors who will be attracted by the novelty of the turtle farming enterprise. It even seems likely that the immense scientific interest of the peculiarly divergent island populations of hawksbill turtles will inspire awkward numbers of people to wish to visit

the islands. We suggest that this possible side effect of the new exposure the turtle farm project is bringing to the islands, might be made known to the appropriate authorities who might otherwise not foresee it. We are particularly sensitive to the injury that any sizeable influx of people could do in the small island communities, and we trust that admission into the area will be carefully regulated.

Yours sincerely,

A.F. Carr

A.R. Main

Senator the Hon. Don Willesee,
Special Minister of State,
Parliament House,
Canberra A.C.T. 2600

ACKNOWLEDGMENTS

The success of this investigation has depended on the help and co-operation of a large number of people.

We wish to acknowledge the assistance we have received from the Department of the Special Minister of State where all the arrangements for the investigation were made. In particular we acknowledge the help we have had from Mr P.J. Lawler, O.B.E., the Secretary of the Department.

We are also indebted to other agencies of both Federal and State Governments for advice, information and assistance.

Our investigations in Torres Strait were greatly facilitated by Captain H.G. Chesterman, Master of the M.V. *Cape Moreton* who took his ship into unfamiliar waters with skill and unfailing good humour.

Our thanks are due to him and to the able crew of the *Cape Moreton*

The Representatives of the three Island Groups in Torres Strait, Messrs Tanu Nona, Getano Lui and George Mye, were unfailingly co-operative and understanding in helping us to fulfil our aims, as were the Chairmen of the individual Island Councils. The turtle farmers both in Torres Strait and in Western Australia were invariably helpful, and provided us with much useful information.

To all the above we are grateful for whole hearted assistance that made a complex expedition pleasant and profitable.

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1. INTRODUCTION

Terms of Reference

1.1 Terms of reference for the inquiry were as follows:

'To study the turtle farming project which has been initiated in Northern Australia and to report by 1 Nov to the Special Minister of State on the following matters:

(a) the implication, if any, of the turtle farming project for turtle populations in their natural state;

(b) the effect of the turtle farming project on marine ecological systems in the area where farms are located and, more generally, in the waters of Northern Australia as a whole;

(c) the effects on turtles of the methods of husbandry which are practised at present.

To consider and make recommendation in the light of these studies on whether any modifications to the turtle farming project are desirable and also on whether any further studies of the issues involved should be made.'

1.2 Turtle farming has been introduced as a government-sponsored occupation for the people of the Torres Strait area, at Mornington Island in Queensland and at Cape Leveque in Western Australia. In the limited time available the entire field party did not attempt to visit all these areas but concentrated its investigation in Torres Strait where turtle farming was first introduced and where the majority of the farms are located. The party visited all but two of the islands in Torres Strait where turtle farming is in operation and this constituted the major part of the field investigation. After completion of that inspection Carr made a brief visit to the farms of the Bardi Aboriginal people in Western Australia.

Procedure

1.3 The Torres Strait farms were inspected between 2 and 7 October 1973. The party proceeded from island to island on the M.V. *Cape Moreton,* making the following landings: Kubin Village; Moa Island; Badu Island; Sue Island; Yam Island; Cocoanut Island; Yorke Island; Maer Island in the Murray Island group; Darnley Island; with a second stop at Yorke Island on the return trip. At each island all farmers were interviewed and their holdings inspected, a total of 100 interviews being held. These were necessarily brief and rapport with especially shy individuals was difficult to establish in the time available. Both sexes were about equally represented among the farmers. Interviews were materially helped by the presence of both the Group Representative for the Island group concerned, and the chairman of the local Island Council. Dr Robert H. Bustard of Applied Ecology Limited accompanied the survey party and was available for questioning at all times.

1.4 The course taken by the M.V. *Cape Moreton* is shown at Appendix A.

Material Available

1.5 The principal written material at our disposal was the Preliminary Draft Impact Statement prepared by Applied Ecology Limited and the attachments thereto. No other written material of a scientific character has been presented to us.

1.6 By 'impact statement' is generally meant a written demonstration, by supplicants for either government support of permission for a proposed action, that they recognise and have taken into consideration in a rational way all the possibile ramifications and effects of the proposed action. To dignify a prospectus of that nature by the title of impact statement seems to us to invite well-written but glib presentations which skirt, gloss over or direct the attention of reviewers away from possible effects that are difficult to resolve. In the present case, we found the Draft Impact Statement to be not commensurate with the complexity of the enterprise proposed.

1.7 Because of our opinion of the inadequacy of the Preliminary Draft Impact Statement we have considered it appropriate to provide a somewhat lengthy and detailed report, in the hope that by so doing we could bring out some of the complexity of the project. Furthermore, in order to assist others who may have to prepare the full statement that should precede any future expansion of the project, we attach at Appendix B a list of headings and topics which we believe ought to be considered if a useful and realistic evaluation is to be made of the probable ecological ramifications of any proposed manipulation that concerns the environment.

2. THE TURTLE FARMING PROPOSAL

Aims

2.1 The aims of the turtle farming project are set out in the Draft Impact Statement referred to in 1.5 – 1.7. According to para. 12 of that document an aim is to make 'a major contribution to wild turtle conservation by:

(a) Rigorous protection of our own wild turtles, and

(b) putting turtle farming on a sound scientific basis.'

2.2 It is stated that 'there is little scope for sustained exploitation of wild adults.' (*ibid.*, para. 7). However, whereas 'in most areas of the world turtle farming must produce all its own eggs from a captive breeding stud... the situation is totally different in Australia where natural populations occur in many areas where destruction of eggs by subsequent nesting turtles is enormous. In such circumstances it is perfectly appropriate to remove a proportion of wild laid eggs – which are going to be destroyed anyway – for utilization in managed farming.' (*ibid.*, para. 11). The project utilises 'a very small proportion of the wild eggs and raises these to turtles of a commercial size'. (*ibid.*, para. 8).

2.3 The Impact Statement gives no explanation as to how the farming is to proceed. However, Attachment 5 to the statement explains that:

> 'Farms are individual Islander owned farms operated by an Islander and his or her family. Islanders enter the scheme and receive a training allowance when they have at least 150 baby turtles. During the first three months they are required to increase this number to at least 250'. (*ibid.*, para. 2) '.... the farms operate on the green sea turtle and the tortoiseshell turtle, details of the conservation picture of which are provided in the Environmental Impact Preliminary Draft Statement.' (*ibid.*, para. 4). 'At present all turtles are penned in pools and trays on the land. They grow exceptionally well under battery farming techniques. They are fed fish and vegetable

matter.' (*ibid.*, para. 7). 'The future programming of the scheme involves the building up in the current financial year of two or three large fattening pens located in the sea. At the same time it is essential not to lose the cottage industry type aspect of the farming which is so important to the indigenous people. The fattening pens will be owned and operated by Islanders but it is anticipated that many will still prefer to produce smaller turtles on their own individual farms for sale to the fattening pens.' (*ibid.*, para 9).

2.4 It is stated that the scheme 'employs entirely indigenous people who have no other employment opportunities'. (Preliminary Draft Impact Statement, para. 14b).

2.5 Conservation of wild green turtles is to be achieved as follows:

'. . .in return for the wild eggs which it utilizes, the scheme liberates 10% of the hatchlings at the age of one year. This factor alone is a major contribution to conservation since turtles at this age have a high probability of surviving to breeding size'. (*ibid.*, para. 14a).

2.6 Extension of the farm project is to be made from the green turtle to the greatly endangered hawksbill and work in Torres Strait has shown that 'the tortoiseshell turtle can be farmed exceptionally well and grow extremely fast'. (*ibid.*, para.15). Production from these farms would 'move rapidly to destroy the current demand for wild, mounted tortoiseshell turtles by supplying a much superior product from the Torres Strait farms at an age of six to ten months'. (*ibid.*, para.15).

2.7 Sale of the following products is planned:

(i) Green turtle

(a) Curio mounted turtles.

(b) Meat (highly nutritious for local consumption in the protein hungry world as well as a valuable export. Steak from a three-year old farmed turtle fetches £1.50 per pound on the London market).

(c) Soup.

(d) Leather.

(e) Oil (*ibid.*, para.16)

(ii) Hawksbill or tortoiseshell turtle

(a) Six to ten month old turtles mounted as curios.

(b) Tortoiseshell, with the expectation that the project will supply the commercial demand starting 18 to 24 months from now (*ibid.*, para.14d, dated 20 August 1973).

3. FARMING PROCEDURE

Species Farmed

3.1 Although three species of sea turtle, the hawksbill (*Eretmochelys imbricata*), the green turtle (*Chelonia mydas*), and the flatback (*Chelonia depressa*) occur and are locally abundant in Torres Strait, only the hawksbill and green turtle were being reared on the

farms. Hawksbills were seen at Kubin on Moa Island and on Badu, Sue, Yam and Cocoanut Islands. Both green turtles and hawksbills were in the Yorke Island tanks. Only the green turtle was being farmed at Maer and Darnley Islands, where farming has been in progress longer than in the west.

Procurement of Turtles

3.2 When islanders were interviewed, one of the standard questions asked related to the procedure followed in taking the eggs from which the farm stock was derived. It appeared that two methods are employed as follows: (1) When a clutch is known to have been freshly laid it is marked and dug up at a time coinciding with the anticipated emergence of the hatchlings. When nests are not abundant, some of unknown age are partly excavated and, if the eggs are about to hatch, these are removed. (2) In places that are distant or difficult to visit, freshly laid clutches may be removed immediately and reburied on the farmer's island, where they are surrounded by wire mesh and left to await emergence of the young turtles. No precise figures on the losses attending each of the above procedures were available though it was said to be low in all cases. Some consequences of these two methods for conservation are discussed in Section 5.

Husbandry

3.3 The structure of the sheds covering the tanks and containers in which the turtles were held showed considerable variation (see Appendix C: figs. 1–8 and 14-15). Some were of sawn timber partly beach derived; others were of mangrove poles; on the volcanic islands of Darnley and Maer, locally grown bamboo was used. Roofing was frequently of galvanised iron, in some cases insulated with thatch or other material, and some of the shelters were also partly walled with galvanised roofing. At other places palm thatching was used for roofing. This was said to last about three years before needing replacement. The walls of some sheds were of woven palm leaves, or of pandanus leaves woven into wire netting. One shed on Darnley Island had walls of hessian over wire netting.

3.4 A variety of containers were in use for holding turtles; plastic wash bowls; aluminium pots; bathtubs; 4-, 5- and 44- gallon drums, split lengthwise and painted; wooden trays; old bathtubs; old refrigerator liners; shower-floor trays; trays constructed from 6' x 4' galvanised iron; and concrete tanks of various sizes. Generally there was a progression from the makeshift containers of new or aspirant 'farmers' to galvanised iron trays, and finally to concrete tanks amongst established farmers. Even in the case of the concrete construction there was a readily detectable trend from small, economical structures to bigger ones with drains, and finally to very large, deep pools as at Darnley Island and Maer Island, where several years of experience had allowed development of more advanced structural standards.

3.5 Invariably, water was said to be changed after feeding, both morning and evening. The labour involved in this chore, without the mechanical aids (semi-rotary hand pumps, old bilge pumps or pumps driven by petrol motors) used at a few of the farms, was considerable and severely limited the number of turtles that could be tended. Buckets, empty five gallon kerosine drums and large garbage cans were frequently used for carrying water. Not all farmers kept precise account of amounts of water carried, but figures of up to 16 garbage cans or 40-50 five gallon drums, morning and evening, were frequently cited.

3.6 The tanks and containers used were occupied by turtles of different sizes and ages. Some appeared crowded and this may have contributed to the cases of flipper damage observed. In crowded containers young turtles were seen to bite one another. For maximum survival and growth it seems clearly desirable to accumulate records to use in establishing optimum density for the various ages in the growing tanks.

Disease*

3.7 The farms were inspected for evidence of disease. A malady common among pen-reared sea turtles is a fungus that invades breaks in the skin caused by nips and abrasions, produces spreading lesions, and often invades the mouth and respiratory system, killing the turtle. The world over, whenever young turtles are kept in numbers in enclosures this fungus is a major problem. Though present in many lots of turtles in the Torres Strait farms, the farmers appeared to have it under fairly good control with applications of gentian violet, the standard remedy for the disease. An antiseptic preparation containing hexachlorophene was also being used in some cases, but we do not know what results it produced.

3.8 Another trouble noted but not widespread was a tendency to abnormal buoyancy in the hind parts of hatchlings. This common ailment of pen-reared sea turtles hinders diving for sunken food, retards growth, and in late stages is often accompanied by swelling about the anal region. The cause of the trouble is not known, but it has been suggested that in feeding on floating food the hatchlings take in excess air, and that this accumulates and makes buoyant bubbles in the lower digestive tract. The only other unhealthy condition noted was injury produced when the turtles nip each other, especially on the neck and back fins. This not only spreads fungus infection but also reduces the suitability of the young turtles for use as stuffed specimens.

3.9 In sum, disease seemed at this stage not to be a seriously adverse factor at the turtle farms inspected.

Feed and Feeding

3.10 In the Western and Central groups of islands, mullet, mackerel, rock fish and blue fish were fed to turtles, while in the Eastern group mackerel and sardines were the principal feed being used. In the absence of any records of weights of the food offered, precise figures could not be obtained, particularly for the Western and Central groups. Questions there concerning amounts of fish used were answered with such estimates as; 6 fish per day for 148 turtles 3-4 months old; 2-3, 2½ foot mackerel morning and evening for about 400 3-4 month old turtles; 5-6 large mackerel for 117 turtles 16 months old; 3-4 mackerel for 215 turtles 16 months old. However, on Darnley and Maer islands the situation was different and the greater experience of these farmers and the ease with which amounts of sardines can be measured allowed more precise statements of the turtle feed used. Sardine quantities were cited in the following units; flour bags; 2-gallon plastic buckets; rice bags; 5-gallon drums; and garbage cans, which we established as containing approximately 25 pounds, 50 pounds, 60 pounds and 100 pounds respectively after some sardines were caught, measured into containers and weighed. Using this very approximate scale, and converting the units given by the various farmers, it seems that on Darnley the farmers could use at least 1700 pounds of sardines per day in feeding their turtles; while

* See addendum to report at page 41.

on Maer, which has more farmers and turtles than Darnley, but fewer large turtles (2½ to 3 years of age) at least 2200 pounds of sardines per day could be consumed as turtle food.

3.11 The imprecise measurement of food consumption and the difficulties discussed in the following paragraph relating to crowding, precluded the making of reliable estimates of optimal feeding regimes for maximum growth and survival.

3.12 Only a little information on survival under the present conditions of feeding and husbandry could be gathered and all that came from Darnley Island. The reliability of even that information is questionable, since the commencing dates and original hatching numbers could not be checked in the short time available, nor could even the numbers being held at present be verified in all cases. However, accepting the information given by the Islanders, it appears that with hatchling numbers of the order of 100, there is little mortality when the turtles are well tended and mortality in batches of 250 can be as low as 18% or 32% after 30 months. Six farmers reported survival of about 50% of the original turtles after 6-8 months. Some of these were new farmers, but a few experienced farmers also reported high mortality. A major cause of loss of turtles was the inadequate shelter from the sun provided by a few of the more inexperienced farmers. Some mortality was also apparently associated with over-large initial lot numbers, with resultant crowding and malnutrition. In a few cases flipper damage was reported as a cause of death. Information on mortality rates was plotted semi-logarithmically in the hope that such a plot might indicate the form of a survivorship curve. There is some suggestion that it may be diagonal. However, in view of reservations about causes of death, crowding and husbandry practices, it would be unwise to conclude more than that ideal conditions of husbandry are not reached by some farmers.

Crawls

3.13 According to Attachment 3 of the Impact Statement there are already 112 turtle farmers in the Torres Strait islands. From our inspection it is clear that turtles to be reared to large size and held for two or perhaps even three years, will soon have to be transferred to large, walled or palisaded growing pens in the sea. These are the enclosures euphemistically referred to in the Impact Statement as 'fattening pens'. The term obscures the enormous effort required in building and maintaining these structures and in caring for the turtles during their stay in them. In the present report we will use the West Indian term, 'crawl'. According to the Islanders, their present intention is to begin the construction of crawls gradually and in an experimental way. On Maer and Darnley islands, however, there are already about 2000 turtles of one or two years of age. Some method of holding these as they reach even larger size must be found at an early date.

3.14 During our visit it was repeatedly put to us that raising turtles to commercial size would be done in the sea, but that the details of the sort of structure in which this would take place would be worked out by experimentation. Various kinds of structures were mentioned as possibilities. At Badu, mangrove palisades were being considered. At Yorke Island a pen of fishnet supported by pipes had been partly constructed; although some Yorke Islanders said that they would not leave their large turtles in such a structure because sharks would break through the netting. On Darnley Island, floating pens of steel mesh buoyed by steel drums were being built. These were to be anchored in deep water and the turtles fed wholly on fish. Although one of these pens had been completed, it had not been placed in use. On Maer, it was proposed to build as a trial a small,

concrete-walled enclosure in shallow water inside the reef. Should this be successful larger crawls would then be built.

3.15 Crawls enclosing extensive sea grass pastures should be tested wherever this vegetation occurs in continuous stands. Wild green turtles graze extensively and it seems likely that they may need vegetable material for maximum growth. In any case it is important that this resource be exploited as a way of conserving the fish stocks that otherwise are used as feed. Because of the large size of older turtles now being held on some of the farms, the designing and construction of crawls has become urgent.

3.16 Providing pens for large turtles, both green and hawksbill, as they approach market size, is a major technological problem confronting the farmers. Both species will have to be held until they weigh at least 100 pounds and preferably heavier. At such size the space required is great. Ideally, the green turtles would be held on turtle-grass flats, where natural vegetation would furnish most of the feed required. The feeding area needed to support a green turtle is not known, nor is anything known of the regenerative capacity of heavily grazed, underwater vegetation.

3.17 Moreover, to fence in any area of water on an exposed shore, whether the enclosure be a fenced pasture or a live-car (floating pen), is technically very difficult. To build enclosures of any kind that will resist the occasional heavy storms that drive seas over protecting reef is, though obviously essential to the future development of the project, not an undertaking that the people can be expected to work out for themselves. When the farmers undertake this task they will need engineering advice. Fencing possibilities include driven piling of mangrove poles and boulder-wall enclosures similar to the Darnley fish-weirs – or the latter with an inner fence of plastic-coated wire mesh to keep turtles from crossing the wall. Another possibility is a huge live-car of mesh fencing buoyed by framed blocks of plastic foam, making a floating enclosure that is solidly floored to prevent loss of feed but has open sides through which water movement prevents pollution. This problem of crawl construction seems likely to be solved only by centralisation of the final stage of the husbandry in one or a few propitious places within each island group. We strongly advise against any plan to build onshore pens for big turtles. The experience of Mariculture Limited, a large turtle farm in the Caribbean, has shown this to be an enormously expensive undertaking.

3.18 We are unable to say what would be a reasonable density for turtles held in a crawl. We emphasise that the ideal is enclosed natural pasturage. Enclosing such pasture grounds would be very expensive however, and if it should prove impracticable, a strong effort should be made to develop ways of harvesting turtle grass as a supplementary feed.

3.19 Should both enclosing sea grass pastures and harvesting significant quantities of sea grass prove impracticable, then as suggested elsewhere (5.19, 5.20), fish for feeding the turtles may prove limiting. It can be assumed that each year each farmer produces 50 turtles that must be held until they reach saleable size. These will have to be held in crawls for at least two years and, if growth is slow, for 3 years. Making the further assumption that the total number of farmers is 120, then if turtles reached saleable size after two years in the crawls, the crawls would have to be large enough to contain 12,000 turtles (120 x 50 x 2). On the assumption that turtles had to be held another year, the crawls would need to hold 18,000 turtles and the annual turnoff would be 6,000 turtles. When one thinks of the size and space requirements of a sea turtle weighing 120 pounds

or more, the problem of housing and feeding 12,000 of them appears imposing. To avoid ultimate disappointment to the Islanders, the problem should be very realistically considered.

4. SEA TURTLE BIOLOGY

A Resume of Sea Turtle Life History

4.1 In this section we briefly review the status of knowledge of sea turtle biology as it relates to the Torres Strait project and then proceed to discuss research that is needed if the Torres Strait project is to develop upon adequate grounding.

4.2 The species of sea turtle involved in the Torres Strait farm project are widely distributed in tropical seas of the world. Although much has been learned of the ecological, geographical and behavourial aspects of the biology of marine turtles in the last four years, there are still important gaps in our knowledge of the life cycle. These hinder any effort to manage or farm the species, or to forecast probable ecological repercussions of any culture project.

4.3 The basic features of the breeding ecology of all marine turtles are similar. All go ashore to nest, all require friable, well-drained, moist beach sand as a medium and open access from the sea. Most sea turtles visit the nesting beach at intervals greater than one year. While there, they lay a hundred eggs – more or less – on from three to seven nesting emergences that occur at about fortnightly intervals. The eggs of all species take about 60 days to hatch. Predation on eggs and hatchlings is enormous; the survival rate has been variously reckoned at from one in one thousand to one in ten thousand. The hatchlings of all species disappear from view for a period of about one year. This period is known among sea-turtle specialists as the 'lost- year mystery'.

4.4 Differences in the ecology of the hawksbill and green turtle are mainly associated with the herbivorous diet of the latter. After passing its first year the young green turtle becomes essentially vegetarian and is then, except for the dugongs and manatees, the only vertebrate animal important as human food that grazes on the vast expanses of submerged spermatophyte plants that grow in the shallows of the tropical littoral. In regions where pasturage is good and where they have not been decimated by overexploitation, green turtles gather in loose aggregations, moving away each day from the coral ledges and caves where they sleep and grazing on grass flats.

4.5 Because turtle-grass grows only in protected water, while good nesting beach is built only by ocean surf, the nesting and feeding grounds of a green turtle are usually widely separated – in some cases by as much as a thousand miles or more. This has been proved by tagging research at several different rookeries. A strong homing sense and site tenacity for the ancestral nesting beach have also been demonstrated. Travel to the breeding beach occurs every two, three or four years (only very rarely after a one-year interval). Both sexes make the trip, and mating occurs off the rookery. This periodic migration clearly requires of the members of some colonies an advanced navigation mechanism, and though this has been investigated it has not been explained.

4.6 At the end of the 'lost' first year, the young turtles do not go directly to the paternal

resident ground. Instead, they appear to pass through a developmental migration that places different age-groups in different localities, often far away from both the breeding and feeding grounds of their population.

4.7 The above short resumé of green turtle habits should make it clear that the life cycle is fundamentally complex and that any projected management program faces a number of unknown problems and factors.

4.8 Less is known of the behavioural ecology of the hawksbill. The species retains the juvenile carnivorous habits and is less generally gregarious than the green turtle both in its feeding range and at the nesting beaches. In both mature and immature stages it forages on reefs and rocky bottoms and feeds mainly on sponges and bryozoans; exploiting, however, any available source of animal food and occasionally eating marine plants and shoreline debris. This species has been very inadequately studied. Except for work at one beach in Costs Rica, almost no tag-return data are available.

Needs and Opportunities for Research in Torres Strait

4.9 In Torres Strait and in northern Australia generally, no sea turtle research, beyond the preliminary nesting reconnaissance, has been done. The sea turtle colonies of northern Australia are virtually isolated from those of the rest of the world and they appear to rank with the most populous anywhere. Certainly the density of hawksbill nesting reported to occur on Long Island in the central islands is nowhere equalled, and other colonies in Torres Strait are apparently nearly as large. The opportunities for basic research in the area are therefore very great. In the case of economically important species, basic research automatically becomes applied research. People interested in the management, protection and farming of sea turtles are hungry for reliable data on the natural life cycles of all the species. A protracted and systematic program of censusing, seasonal monitoring and tagging at breeding grounds is basic to both the development of turtle farming in the area and to successful management and protection of the natural stocks there. Actually such research ought to have preceded establishment of the Torres Strait project and should have furnished the material for the Ecological Impact Statement for the undertaking. Whatever the destiny of the farming scheme may prove to be, the research ought to be done and should have strong government backing.

4.10 The first research requirement in the area is a detailed, island-by-island, survey of the distribution, density and seasonality of nesting of green turtles and hawksbills in Torres Strait.

4.11 Such a survey is requisite to the rational scheduling of any harvesting of eggs for farms and to determine the numbers that could be taken with the least damage to each colony. This kind of information ought to have been required in the original prospectus for the project and is wholly essential to any further growth of the scheme.

4.12 In order to fill the above gap in our knowledge of the distribution of sea turtles within the Torres Strait region, we asked each farmer, each island Chairman and each of the three Group representatives to list the known nesting sites used by each species of turtle. We were further assisted in this effort by Mr R. Yarrow, Manager, Queensland Department of Aboriginal and Island Affairs, Thursday Island, who provided us with several maps on which breeding places were marked in accordance with information received from Islanders. These sites are shown on the sketch map at Appendix A.

4.13 From the information obtained, the distribution was plotted of the three species that occur regularly in Torres Strait – hawksbill, green turtle and the flatback (the last is not cultured on the farms). The flatback, hawksbill and green turtle range together as far east as Cap, Bel, Sue and Poll islands, although in the last three the flatback and green turtle have a minority breeding only. The range of the hawksbill extends no further east than Stewart Reef, where it has only a small breeding colony. Darnley and Maer islands and the other islands and cays in their vicinity have breeding colonies of the green turtle only.

4.14 Another obvious need is the types of biological information yielded by a tagging program. In this kind of investigation, durable tags (inscribed with a return address and with the offer of a reward for their return) are fastened to the flippers of female turtles when they go onto the beach to lay their eggs. The turtles are measured and the precise site of emergence is recorded. Subsequent contacts with these tagged turtles yield life-history data of several different kinds. Long-distance recoveries show the location of the resident ground and, as they accumulate, build a picture of the routes and schedules of migratory travel. In most green turtle nesting colonies some or all of the nesting turtles are recruited from across international boundaries. Protection and management therefore requires the co-operation of countries other than that in which the nesting ground is located. It is necessary to find out from where a nesting colony comes in order to know to what exploitation it is being subjected. The prevalence of this habit of long-range travel suggests that the technique of 'free-range farming' sometimes proposed as a culture procedure, could be far more complex than might appear at first glance.

4.15 Besides the yield of these distant tag recoveries, much can be learned from recoveries of the tagged turtles at the nesting beach itself. These are of two kinds: *renestings*, or repeated emergences during a single breeding season; and remigrations – migrating returns to the nesting place in subsequent seasons. Renesting returns yield data on variation in the inter-nesting interval, on total number of nestings that occur per season, and on size of egg-complements as related to the age of the turtle, the stage of the season, and the island population involved. The Torres Strait region is an especially suitable place for the study of such variables. The bearing the data has on all aspects of the farming project and especially on any programme for improving domestic stocks, is obvious.

4.16 Records of the remigratory returns of the turtles to nest in later seasons provide a different kind of insight into the ecology and demography of the colony. If records are kept through several years it becomes possible to determine the relative proportions of two-year, three-year and four-year cycles characteristic of the colony and to see whether a given female has a fixed cycle or can change her period from one to another. By analysing the cycle-changes associated with subsequent specific long distance tag recoveries, it becomes possible to make reasonable deductions as to what resident grounds turtles with characteristic cycle-periods come from and what the ecological causes of any peculiarities in breeding rhythms may be. Understanding this variability in the frequency of the breeding migrations is basic to an understanding of the population dynamics of a colony. A population that breeds every year and one that breeds every two, three, or four years will have very different reproductive potential and, by implication, different hatchling mortality rates.

4.17 Another yield of a tagging program is information on the growth of the females after they reach sexual maturity. Yet another, as important to sea turtle management as any of the rest, is to reveal the fixity and precision with which the females return season after season (also of course in their repeated returns in a given season) to nest on the same island or same extent of beach. Research elsewhere suggests that though there is some geographic variation among colonies in this respect, homing is quite, though by no means completely, precise. The implication of this is that the turtles are returning to breed where they themselves hatched out, although the technical difficulty of tagging hatchlings for recovery as breeding adults precludes definite proof of this.

4.18 This tendency to return to an ancestral nesting beach must be reckoned with in any program of free-range farming or colony-restoration, and also in evaluating the practice of returning a percentage of pen-reared young turtles to the sea, proposed as one of the conservation justifications of the Torres Strait project.

5. SOME RELEVANT PRINCIPLES OF POPULATION ECOLOGY

Populations and Exploitation

5.1 Natural populations are never constant and fluctuations in size and abundance are to be regarded as normal. Regardless of abundance or rareness, a population will persist if over the long period each female of one generation replaces herself by another female before her death. It is a characteristic of species that some are short- lived and others long-lived. These different patterns of death are characteristic of each species. Generally speaking, short-lived species can recover from a population decline more quickly than long-lived species. Regardless of whether species are short-lived or long-lived, all species do not follow the same pattern of death. The pattern is established by following a group of young of the same age, a group usually called a cohort, through life and recording the time of death of individuals in the cohort. The results of such a study can then be plotted graphically and when this is done the results will fall into one or the other of two characteristic curves. The first is characteristic of animals, such as man, where few young are born. There is little juvenile mortality and most deaths occur at the end of a relatively long life. Such a curve is called a physiological survivorship curve and death of old animals is assumed to be related to physiological old age. A second pattern of death is that common among insects, marine fish, crabs and other crustacea and marine turtles. These animals produce a very large number of eggs and mortality among the juveniles and pre-reproductive stages is high. However, once the animal reaches sexual maturity, survival may be long and the individuals die of old age. The plotted curve of such a pattern of death is the mirror image of the one discussed above. The above two types of survivorship curves encompass most of the animal species in the world. However, there is another group in which mortality is not related to age at all. In such animals death is a chance event and the chance of death is equal at any stage in the life. Examples are birds and reptiles.

5.2 Only under special circumstances can the type of survivorship curve be established by sampling a population. The more usual way is by measuring the survivorship of a group or cohort of animals born at the same time and counted throughout their life.

5.3 The survivorship curve of any species is a characteristic of that species. The fact that there is a high juvenile mortality is in no way related to whether the species is well adapted or ill adapted to survive and persist as a population. In a general sense, if juvenile mortality is high, juveniles can be extracted from the population without effect because by so doing, we might merely divert part of the total mortality from being natural to being man-induced, without changing the overall or total mortality in any cohort.

5.4 Exploited populations may have survivorship curves of any of the above three sorts. Since we cannot measure the survivorship of a cohort, we can only anticipate that a population will persist by measuring some characteristics which do not depend on either total counts or the survivorship of a cohort.

5.5 A fishery is a characteristic exploited wild population. The population being fished is called the stock. In such exploitation it is assumed that the fishing activity is random with respect to the stock and hence, with the exception that net mesh may let some animals escape, the population or stock will be constantly but randomly sampled while fishing proceeds. With such a method there are several ways of measuring whether the population is changing in nature. First, if it takes longer to catch an equivalent amount of fish we might assume that the population is reduced in size – this is referred to as the change in catch per unit of effort. A further indication of changed status is afforded if a wider search has to be undertaken to obtain the same amount or size of catch and a similar indication arises if technological improvements in fishing practice are necessary. A further indication of change in the status of the population comes when the length frequency of the randomly caught fish changes, the distribution of size trends towards smaller fish and, or in extreme cases, no adult or reproducing fish are caught. It is clear that, in such a case, the prime requirement for population persistence – namely that females replace themselves in their lifetime – cannot be made. In none of the above cases are numbers of animals actually known.

5.6 Two ways in which turtle populations have been exploited are by killing the adult females coming to breed and thus preventing the laying of eggs; and by removing a high proportion of eggs laid. In the first instance it is not possible to measure the change in population by any length frequency analysis, because all the females will be adults and, because of the spacing of egg laying (4.3, 4.5), the females caught are not a sample of the whole population. The change in catch per unit of effort will, however, measure the change in abundance of the population. But because of the longevity of the turtles and the spacing between breeding, such a measure is too insensitive for use as a regulating device, because the population will be on the point of collapse when the catch per unit of effort falls dramatically.

5.7 In the event of a proportion of the eggs being removed from circulation by human exploitation, we are merely diverting mortality from that naturally induced by weather and wild predators to mortality caused by human interference and, provided a good proportion of the eggs is left, it should have little effect on the population.

5.8 Exploitation of fish is, of course, an entirely different sort of exploitation. Except where the largest fish are exploited, as especially when fish are caught by spearing, the classic fishery operates when we are fishing by hand lines or if nets are used, as with mullet or sardines. However, in all these cases, if catch per unit of effort is measured, or

the length frequency distribution of the fish caught is established, it should be possible to establish any trends in age structure of the population which would indicate a likely collapse or a change in total abundance.

The Nature of the Torres Strait Turtle Resource

5.9 The turtle resource in Torres Strait has two interlocking elements. First is the series of rookeries from which the eggs or hatchlings are obtained. Any exploitation of these will divert mortality as explained above. The other aspect of the resource has two parts – the seagrass, and fish stocks that will be used as feed for the farm-held turtles. The pressure on this resource will depend upon the size of the turtle farming project, on the number of turtles being fed, and particularly on the amount of food consumed by very large turtles.

5.10 As explained elsewhere, the fish resource is not equally distributed throughout the islands. Sardines, which we have tentatively identified as the Spotted Herring *(Harengula koniqsbergi)* and Hardy-head *(Pranesus ogilbyi)* (which has to be scaled before being fed to turtles), occur only in the east. In the west and central group either mullet, rockfish or mackerel are exploited. For each of these the measurement of catch per unit of effort and change in the length frequency of the population would have to be established independently for each island.

5.11 From our inspection it is clear that the hawksbill turtles from different islands will not be equally acceptable commercially, principally because of marked differences in shell colour and pattern. Because of this the hawksbill stock cannot be considered homogeneous and it is likely that exploitation may be concentrated at a few rookeries. Some of these will be large – for example, that on Long Island – but others may be small. Until eggs are derived from domestic turtles, tolls of eggs taken for the farms should be carefully adjusted to the size of the rookeries.

5.12 Another element in the present resource is the potential for artificial hybridisation and selection among the various island types of hawksbill turtles to produce a fast growing, commercially acceptable for shell type from truly domestic turtles. Such selections may also be possible with green turtles grown for meat. This part of the resource can only be developed if large sea pens or crawls can be constructed.

Size of the Resource

5.13 The above elements of the resource are complemented by the size of the natural turtle stocks themselves. We have no way of reasonably estimating the numbers of turtles present in Torres Strait or based on the area as a breeding place. In addition, since juvenile animals are lost during the period from hatching to the end of their first year of life, we cannot make any estimate of the natural mortality during this period, because the cohorts cannot be traced. However, from the distribution as shown on the map at Appendix A, it is clear that the resource must be very large and widely distributed on numerous breeding islands.

5.14 The size of the fish resource cannot be estimated at all, from our investigations, and the Queensland Fisheries authorities have not yet attempted an inventory. The distribution and abundance of fish species vary from one part of Torres Strait to another and we were given to believe that mullet, rock fish and mackerel are widespread. Of the

sardines, *Harengula* occurs only in the eastern area while the Hardy-head, *Pranesus* is of more general occurrence. It was the general impression of the Islanders that fish are abundant and that the status of fish population could not be changed regardless of the intensity of exploitation. This idea merely reflects past experience, in which no shortage of fish has ever been known to the people of the islands. Nevertheless, there are severe doubts whether the fish resource can feed an expanding human population and an increasing turtle-farm project; and certainly there is no reason to expect that it would support these and extensive commercial exploitation as well. The amounts of fish likely to be required to feed turtles are discussed in 3.10 and 3.11.

5.15 To date there has been no use of the turtle-grass resource. Its potential importance, however, as feed for the crawl-penned 100 pound turtles is great and a quantitative survey of submerged vegetation among the Torres Strait islands should be an intrinsic part of the development of the programme.

Limits to Production

5.16 The Islanders naturally see turtle farming as an expanding industry. However, there are readily perceived limitations to the size that the industry could, or should be, allowed to attain.

5.17 As discussed in 3.5, the labour of emptying and filling ponds and tanks morning and evening is intensive and many farmers are at present occupied for a good part of the day with the chore of changing water by hand. Since each farmer has other tasks to perform, the amount of time available limits the number of turtles to be tended.

5.18 In 3.5, it was mentioned that some farmers already had hand pumps or petrol pumps. For some islands, a reticulation system – consisting of windmills pumping sea water to an overhead tank from which water could be run to the tanks – has been proposed. Clearly, such a system would provide more time in which fish for more turtles could be caught and prepared.

5.19 Despite the fact that easier watering (referred to in 5.17) would make it possible for each farmer to tend more turtles, such expansion would soon be limited by the amount of fish required to feed the turtles, especially when large ones are being held in crawls. That limitation will have two aspects; first, the physical labour and time to catch and prepare fish; and second, the problematic capacity of the fish stock to sustain increasing and continuous levels of exploitation.

5.20 Elsewhere (3.13 – 3.19), when discussing the sizes and construction of crawls, mention was made of the very large number of turtles that would have to be held in them if there should be a total of 120 farmers and if each produced 50 turtles per year that must enter the crawls. Assuming that the most favourable saleable size is reached after 2 years in the crawls and they house 12,000 turtles, the fish required to feed them would weigh approximately six tons. Clearly, with our present state of knowledge we cannot say whether this intensity of exploitation is ecologically feasible.

5.21 If domesticated strains should be developed, the limitations imposed by the size and vulnerability of the natural egg source would be removed. This can only come about after the problems of sea-crawl construction and captive breeding have been solved. Even then, the limitation imposed by the number of egg-producing turtles that can be held will be added to the other limiting factors already discussed.

6. CONSERVATION OF THE EXPLOITED RESOURCE

Turtles

6.1 One is often impressed by the great mortality among the very young or juveniles of animal species. When it is realised that species have persisted in the face of such mortality, one is led to wonder how this can occur. In the case of turtles, much of the mortality is of the following sorts:

(i) Disturbance of each other's eggs by females nesting in large colonies.

(ii) Destruction of nests or killing of eggs by high tides, storms, floods or droughts.

(iii) Destruction of eggs by predators.

(iv) Killing of hatchlings on their way down the beach to the sea and for a while thereafter.

6.2 In the case of (i) above, site fixity for one beach by a great number of turtles has led to a shortage of space for nests and this expresses itself in nest destruction. If this were serious it should depress recruitment and over a period of years reduce the population of laying females using the beach.

6.3 Destruction of nests by environmental factors cannot be anticipated by the egg laying female and the strategy which mitigates against any female losing all her eggs is to distribute the total egg laying in numerous clutches over a laying season. A population can of course use a somewhat similar strategy for ensuring some recruitment by distributing the egg laying of many females over the egg laying season, so that some lay their clutches early in the season and others late. Compared with the green turtle in Australia, the hawksbill, which breeds over the whole year, shows this strategy to an extreme degree.

6.4 Predators operate in regulating a population by hunting single individuals. If more individuals are present the predator can only take one and any given individual has an enhanced chance of escaping. With aggregations the relative chance of an individual escaping is improved.

6.5 The mortality induced by factors discussed under 6.1 and 6.2 can readily be diverted to man-induced mortality without reducing the proportion of turtles available for recruitment to the population. However, it should be noted that hatchlings removed from their natural nest at about the time of emergence have survived the dangers listed under 6.1 (ii) and such removal should be equated with the mortality caused by beach predators, fish and sharks. Furthermore, if the emerging hatchlings are too reduced in numbers and predation is still intense, the relative chance of an emerging hatchling escaping predators is reduced.

6.6 We would conclude on balance that, as long as the turtle farming project remains small, operating under the labour limitations of husbandry and feeding and with only modest technological assistance for watering the tanks, the wild turtle stocks would be secure, except where many eggs were derived from small rookeries.

6.7 In the event that particular rookeries provided turtles with high favorable commercial properties we would suggest that the removal of eggs be timed to correspond to a carefully determined optimum season.

6.8 Establishment of a domestic breeding stock would obviously remove pressure from wild populations.

Fish

6.9 It has previously been explained that the fish stocks used as turtle feed are complementary to the turtle stocks in developing the proposed industry. It may be that the fish resource is quite large. We know very little about its size, however, and this unknown factor requires urgent investigation and assessment.

7. PROSPECTS FOR ACCEPTANCE OF THE PROJECT BY WORLD CONSERVATION ORGANISATIONS

Conservation Claims for the Project

7.1 Besides the economic benefit to the Torres Strait people visualised for the farm project, it is described as a conservation exercise (2.1). It is in fulfilling this promise that the project faces perhaps its gravest uncertainties. In order to become economically viable the enterprise will have to sell its products on an international market. World conservation organisations are very sensitive to the exploitation of populations of rare or declining species and, unless they are satisfied that the proposed exploitation is not harmful, they are likely to lobby for the banning of international trade in the products involved. The ultimate success of the project will therefore depend on whether it shows promise of improving the chances for both local and worldwide survival of the exploited species and on its ability to convince international conservation groups of this potential.

7.2 One of the ways in which the project is said in the Ecological Impact Statement to contribute to conservation is through 'head starting' (see 2.5). The proposed conservation benefit is to be achieved by the releasing, as yearlings, of ten per cent of the turtles reared from each lot of eggs taken from wild colonies. This procedure has not been subjected to experimental testing. It is one used by Mariculture Ltd, the heavily capitalised turtle farm on the island of Grand Cayman in the Caribbean. As alleged justification for licences to take eggs from various turtle sanctuaries for commercial rearing, a percentage, set by a somewhat dubious demographic calculation, is put back into the sea as yearlings. Mariculture calls this practice 'head-starting' and regards it as a conservation move. The claim may, of course, be valid and the practice has been uncritically adopted elsewhere. Its validity remains wholly unproved, however, and the burden of proof of its effectiveness would seem to rest on those petitioning for access to protected egg sources. What is required before a released, pen-reared turtle can realistically be regarded as a viable reinforcement of a colony – as the demographic equivalent of some given number of eggs that a mariculturalist proposes to take away – is a pilot research program in which pen-reared yearling turtles are tagged and released in a designed pattern of localities. The program determines whether they are actually able to survive in the natural environment and whether, on reaching sexual maturity, they rejoin the breeding colony from which they have been taken or merely wander away somewhere.

7.3 The life cycle of a sea turtle is complex and it is possible that pen-reared turtles lack some of the instinctive or learned behavioural equipment for survival. Although there has

been no investigation of the ecologic geography of the sea turtles of Torres Strait, research elsewhere has shown that they undergo extensive migrations and developmental shifts in habitat.

7.4 The green turtle, especially, is a long-range periodic migrant, commuting between a specific nesting shore and a distant year-round feeding ground that often lies hundreds of miles away. Before taking up residence on a home pasture ground, the young turtles disappear completely for about a year. They then evidently move from station to station as they reach increasing size, gradually abandoning their juvenile carnivorous diet for the herbivorous habit of the adult. On reaching weights of around 125 pounds they begin to adopt the grazing habit of maturity. It is into this complex life cycle that a head-starting program proposes to inject pen-reared recruits for green turtle populations. While successful head-starting no doubt circumvents the heavy predation on hatchlings, releasing young turtles, that for the first months of life have been hand-fed on strange food in restricted quarters, cannot be accepted as sound conservation until it has been statistically tested by recoveries in careful tagging-and-release experiments.

7.5 Another justification cited for the Torres Strait program as conservation is that it will flood the market with turtle products and thus reduce turtle hunting and poaching, which throughout the tropical world is exhausting sea turtle resources and degrading the survival outlook of populations and species.

7.6 The rationale for this claim will be examined separately in the economic report. It can be said here however, that to try to forecast the commercial outlook and vicissitudes of the diverse products here involved – some of them destined for the curio trade, some to become gourmet items and some with strong potential as a staple meat supply – would appear to be a difficult economic prediction. Meanwhile, unless the enterprise involved becomes a monopoly able to operate at any price level and market size, the alternative to market-flooding would simply be stimulation of new markets and higher prices. This would encourage both legal and illegal turtling everywhere and surely produce a disastrous increase in the world-wide pressure on sea turtle stocks.

7.7 A third conservation benefit cited for the project is the prospect that the successful spreading of cottage-industry farming by the Islanders would bolster the determination of State and Commonwealth agencies to deny access to the region to outside turtle-culture enterprises. Obviously, no evaluation of the validity of that prospect is possible or appropriate in the present report.

Possible Obstacles to World Acceptance

7.8 Although both the hawksbill and the green turtle range widely through the tropical seas of the world, they both have been seriously depleted by combined overexploitation and loss of habitat. In its 'Red Book', the International Union for the Conservation of Nature lists the hawksbill as an endangered species and the green turtle as seriously reduced. If trends, rather than absolute population numbers, are used as criteria, both of these species are obviously endangered. They are a diminishing resource that is being subjected to growing exploitation for international trade.

7.9 Accordingly, the eyes of conservationists are on them closely and any new threat to their status, actual or potential, is likely to evoke the intervention of such organisations as

the IUCN, the Survival Service Commission, the World Wildlife Fund, the Fauna Preservation Society and a number of others.

7.10 Since large nesting colonies of the hawksbill and green turtle were discovered in Torres Strait a few years ago, the area has attracted international interest as an important asylum for these diminishing species. It can therefore be expected that every aspect and implication of the turtle farm project will receive close international scrutiny.

7.11 The conservation claims made for the undertaking will inevitably be examined and disputed. For example, world opinion as to the validity of head-starting is mixed. Some people consider it is at least worth trying out; others regard it as merely an expensive way to kill turtles. The market-flooding and price-lowering function promised for the enterprise will also receive vigorous criticism. Critics are predisposed to look with suspicion on all claims of this kind.

7.12 There appear to be good reasons to doubt that markets for high-quality turtle products can readily be flooded. Some factors involved are discussed at length in the separate economic report on the project.

7.13 The subject is one of great concern to conservationists. They recognise two opposing theoretical possibilities for stemming the decline of species that are being exploited by international commerce. One is by massive, widespread farming that might saturate world markets and discourage both poachers and legal hunters. While species-survival people are willing to give prospective farmers of wild species the benefit of the doubt, in the case of sea turtles they have been predisposed against commercial farming by Mariculture Ltd, which after promising to flood markets, is now doing just the reverse – purveying turtle meat through American supermarkets to housewives who never saw it before; and injecting new vigour into previously undersupplied markets for oil, calipee, skins and green turtle shells. In other words, the world's only currently operating turtle farm is actively expanding its market, raising prices and exacerbating the predicament of wild sea turtle stocks. If the Torres Strait project is to avoid a poor reception by conservationists, it will somehow have to inspire confidence in its ability to avoid such developments as mentioned above.

7.14 An aspect of the Torres Strait project that seems sure to draw adverse attention is the sale of young turtles as curios – that is, stuffed objects to hang on the wall. Besides the inevitable uncertainty concerning the ability of the farms to flood the market for such objects, there will very likely be widespread emotional reaction against both killing young turtles and hanging them stuffed on the wall. Unfortunately, at the present stage of its development, producing and preparing these small turtles as curios or as educational material would appear to be the one aspect of the enterprise that is beset with the fewest technological problems and is most practicable as a commercial venture.

7.15 The criticism and opposition of conservationists could, to some degree at least, be avoided if five moves were made as follows:

(i) Present the project to world conservationists as an effort to maintain the economic and cultural integrity of a group of native people – not as primarily a commercial venture. It should never appear that the native people are merely labourers in someone else's enterprise. This possibility can be most readily precluded by placing most of the responsibility for running the organisation in the hands of the Torres Strait Islanders.

(ii) Initiate a program of crawl breeding of mature turtles to produce all eggs used on the farms, making public this program and a firm schedule for its development.

(iii) Undertake and publicise a vigorous, scheduled program for the artificial selection of truly domestic breeds of turtle.

(iv) Make it an aim of this breeding program to produce a strain of turtles which, in the desirable economic characteristics that are bred for, will be so distinctive that it cannot be confused with wild-bred stocks, either in the market or if accidentally released into the sea.

(v) Ensure that all eggs for the farming project come from domesticated turtles, and make public a schedule for achieving this aim.

8. DISCUSSION

General

8.1 In planning this inquiry and in gathering data and preparing the report we have interpreted the terms of reference as requiring answers to the following questions:

(a) Is the Ecological Impact Statement furnished by the management of the turtle farm scheme an adequate document and is the project being developed in accordance with it?

(b) To what stage has the project developed and what is the current condition of the farms?

(c) In its present stage of development is it proceeding without evident injury to either the environment or the wild sea turtle populations of the region?

(d) As it moves into projected full-scale commercial operation, producing meat, oil, skins and shell as well as yearling turtles for the curio trade, what new problems of husbandry can be predicted?

(e) At that stage of full operation, what effects can be foreseen on fish stocks exploited as turtle feed and on the turtle colonies from which eggs are taken?

(f) What problems can be anticipated for the time when slaughter-sized turtles must be moved into extensive sea-crawls (turtle pens)?

(g) What assessment can be made of the conservation benefit that has been visualised for the operation, both locally and with respect to its effects on wild sea turtle populations?

(h) What reactions can be expected from organisations concerned over the diminishing of sea turtle stocks throughout the world, when word has spread that young Torres Strait turtles are being shipped and sold as curios, and that the international market is to be supplied, and perhaps stimulated to growth, by a new source of turtle meat, oil, skins and shell?

8.2 In the body of this report we have provided answers to some of these questions. While our hurried visits to the islands were too short to obtain a detailed knowledge of conditions at each, the very rapidity of the visits and the focus afforded by plying each

farmer and Island Chairman with a standard questionnaire gave the survey a sharpness, immediacy and perspective that otherwise would have been hard to achieve.

8.3 An outstanding impression from the survey was the resourcefulness and initiative that the Islanders have displayed – both the supported farmers and those hopeful of being accepted as farmers in the future. The dedication and good sense that they are putting into the project is one of its main assets. Their co-operative reaction to the inspection was also impressive. Despite our intrusion as alien people asking a rapid series of what must have appeared odd questions, the people all answered to the best of their ability and with unfailing good humour.

8.4 All the Island Chairmen made sincere efforts to understand what we were trying to do through our questionnaire, which was designed to anticipate the limits to the size of the farming project, to establish the sources of turtle eggs and feed and to judge whether supplies of fish or other food available for growth were sufficient. It was clear from talking with Mr Gaetano Lui, Mr Tanu Nona and Mr George Mye that they had never conceived of fish stocks as exhaustible, but they now realise that to establish the size of fish stock to be used as feed is as important as good husbandry to the welfare of the turtle farming project.

8.5 It seems clear that the management of the industry should not ignore the fund of common sense and native ecological knowledge that the Islanders have. The best use of this asset could be made by having representatives from each island group in the Company and by holding the meetings of the Company in Torres Strait – and we recommend accordingly.

8.6 Mr Lui repeatedly made the point that there had been little supervision of the farms beyond laying out the original guidelines. He suggested that no one really knew how to farm turtles and said that the people had had to feel their way, to try things out and to share their knowledge with each other. He personally had visited many farms and had tried to advise the best type of farm for conditions on Yam Island.

8.7 From the diverse array of pools and tanks in use on the farms, it was clear that nearly any sort of container will do to hold the turtles. However, it was not possible to establish the optimum volume of water for turtles of various sizes. One hundred and fifty hatchlings up to a month old appeared adequately housed in trays made from 6' x 4' sheets of galvanised iron. At ages of 5 or 6 months only a dozen to twenty turtles could be held by such trays. Diversity in the sizes of the concrete tanks used precluded our gaining any impression of the numbers and sizes of turtles that ought to be held in a given volume of water. However, it did appear that yearlings, especially green turtles, were in nearly every case overcrowded in the size trays (approximately 6' x 6') in which they were held.

8.8 It seemed probable that overcrowding, coupled with abnormal or inadequate feeding, caused the turtles to bite each other's flippers. It appeared that turtles of different ages could not successfully be held together in a single tray or tank.

8.9 Because records were not kept of the quantity of food given morning and evening, nor of the growth rate (length and weight gain) of the turtles being fed, we are unable to say what would be a favourable density and feeding regime for maximum growth. We recommend that such research be commenced on each island. Records should be kept separately for turtles hatching from eggs from each source. Project Officers should be instructed to undertake or supervise such research.

Geographic Diversity of the Farming

8.10 A feature of the turtle farm project that requires consideration in any future planning is the geographic spread and heterogeneity of the operation. Because of the great distances that separate the farms – they extend from Murray Island at the top of the Great Barrier Reef to One-Arm Point in northern Western Australia – the scheme is not a single enterprise, but a number of different projects that vary widely in their problems and resources.

8.11 The islands differ in many ways. Physiographically some are continental, some volcanic and some of coral origin. One series of farms, those of the Bardi people at One-Arm Point, are not located on an island, but on a peninsula in the Indian Ocean. At Murray, Darnley and Stephen islands, the eastern Meriam-speaking group, sardines are available for feeding turtles, while elsewhere reef fish, pelagic, cursorial species, or mullet must be caught. In some places, eggs for stocking the farms are available a mile or less away; in others the farmers travel as far as 20 miles to get them. On some of the islands only green turtles are reared, because only eggs of that species are available; other islands stock only hawksbills and still others grow both species. In the case of the hawksbill islands – those of the Western and Central groups in Torres Strait – there are differences in ease of access to stocks with good shell characteristics and thus in marketability. Disparity in other resources – boulders and cobbles for crawl construction, for example; mangrove piling for palisade crawls; or extensive ancestral stone weirs for trapping fish for feed – give some of the islands advantage as sites at which big turtles could be held for further growth when they have outgrown the tanks of the small farms. Variations in fresh water supply, in fertility of the soil, or in the productivity of nearby trochus-shell beds, give the islands different potential for producing supplementary feed for crawl-penned turtles, as they outgrow the fish supply that sustained them as juveniles. Beds of turtle-grass are extensive at some of the islands and restricted at others. If a way to harvest submarine turtle-grass is devised, differences in its availability will make for more local disparity in the capacity of the islands to hold big herbivorous green turtles. The presence of offshore reefs protecting areas of shallow water is requisite to development of good grass pasturage; the reefs also increase the practicability of installing crawls that storm seas will not carry away. Besides such local differences in resources, the varying distances of the islands from a shipping centre or an air-strip produce further inequality, making some farm sites more suitable than others as places at which to locate crawls. The many local social and demographic differences among the separate settlements may prove to constitute one of the important variables in the undertaking. The turtle farm project is, thus, a number of different enterprises which though they share a source of support and an ultimate market, vary widely in their problems and assets.

8.12 *If a technology of crawl and sea-fence construction can be worked out and turtles* are induced to nest on artificial beaches, the important goal of developing domesticated turtle strains can probably be realised. For a turtle culture project to deserve the name 'farm', it should not take eggs from natural wild colonies but from pen-reared breeders that nest on artificial beaches. This development not only ensures a stable egg supply as wild turtles dwindle, but offers the opportunity of emphasing desired commercial qualities by artificial selection.

8.13 Besides improving marketability, establishing modified, truly 'domestic' breeds of turtle would bring another benefit to the project. It would calm the concern of conservation organisations and species-survival people who see farming as just a factor which in several different ways hastens the decline of natural species. Once a well-marked domesticated animal had been derived, the farmers would not only be free of conflict with conservationists, but also would have reinforced their counter-claim that their 'improved' product decreases the exploitation of wild sea turtle populations.

8.14 Torres Strait appears to be an exceptionally propitious place for the experimental selection of sea turtle strains. Northern Australia may be the largest remaining reservoir of the hawksbill, while at some of the green turtle colonies there and in the Lacepede Islands northeast of Broome, nesting may be as heavy as anywhere in the world. There is thus an ample supply of wild material for artificial breeding of green turtles for meat quality and oil production, of hawksbills for thickness and pattern of shell and of both species for hardihood and full, fast growth.

8.15 The hawksbill colonies of the area present a truly extraordinary opportunity not only for the artificial selection of whatever characteristics should eventually appear most desirable, but also for basic field studies in genetics and micro-evolution. During our inspections of the farms, where hatchlings from separate islands had been kept in separate tanks, we repeatedly found cases in which lots of turtles derived from different island nesting colonies showed strong divergence in pattern. The differences involved both pigmentation and marking, and in some cases were so clearly evident that the separate island strains in a mixed lot could be sorted out as fast as they could be picked up. The Islanders spoke also of difference in size, in growth rate and in the thickness of the shell that they had noted among different island populations. Especially distinctive patterns were observed on shells of hawksbills from Crab, Jackson, Poll, Sue, Long and Cap islands.

8.16 This marked tendency to vary from island to island would seem almost entirely genetic – that is not associated with any direct effect of the environment or with treatment of the eggs after being collected, but inherited as a special trait that has originated under partial isolation at separate island rookeries because mating is concentrated there. If this is indeed the case, the variability offers a palette with which artificial selection in pen-reared stocks could produce a shell-pattern that would best satisfy the world market or any of the regional preferences in that market. Two ways in which this can be done are:

(a) breed only from fast-growing, well-coloured animals from a preferred stock

(b) produce a desirable animal by taking advantage of the already distinctive genetic differences in the various island populations by breeding between stocks and so rapidly developing a distinctive 'domestic' type turtle. The process would be analogous to that of producing hybrid corn, but the stock so produced could be self-sustaining under domestication.

8.17 This benefit could of course be realised only after a breeding program had been established and pen-reared turtles were mating in enclosures and nesting on artificial beaches.

8.18 Besides the advantage as material for artificial selection, the island-related variation could, by using techniques of discriminant analysis, be used as a sort of natural tagging

system by which the turtles derived from the various island rookeries could be recognised when found elsewhere.

8.19 Although a clearly necessary part of a realistic plan of turtle mariculture, egg-producing and experimental breeding and selection present the same feeding and penning problems that attend the holding of turtles for meat and shell production. Perhaps even more space would be required to encourage development of natural breeding behaviour. In addition, a breeding crawl must have access to a stretch of beach suitable as a nesting medium.

8.20 Once these proper facilities were provided, a period of several years would be required for selection of the desired traits through a few successive generations. It is not clear how a long-term purely developmental exercise of this kind would fit into the budget and organisation of the existing turtle farm project, but the work nevertheless seems altogether essential and in the long run it could prove to have been one of the most important aspects of the whole program.

8.21 The existence and the practical and scientific significance of the distinctive island strains emphasises the need for caution in making use of head-starting as a management procedure. The discrete populations can only be accounted for by supposing that:

(a) the female turtle has the ability and tendency to return to the island on which she was hatched

(b) there is a tendency for male turtles to mate only with females from the island of their origin and

(c) the sensory basis of this site tenacity is an imprinted or learned process beginning at the time the hatching turtle enters the sea.

8.22 It is possible that older turtles cannot be thus imprinted. In the event that much older turtles (the 10% of yearlings proposed as a conservation measure, para. 14a of the Impact Statement) are placed in the sea at their home island, they may be too old to absorb the sensory record that will enable them to return. Should they be merely placed in the sea somewhere away from their home island and survive to adulthood, they would have no way of knowing the island of their derivation. So, on maturing, they would presumably mate randomly and breed on any island. Should this happen, the extraordinary island races would be rapidly destroyed and no possibility would remain of studying an incredibly interesting scientific phenomenon, in which recognisably different races have arisen in populations separated only by a few miles, even though the individuals of the population could range far beyond the distances separating their breeding sites. This is discussed further in 7.3 – 7.4.

8.23 We recommend that nothing be done by way of either too-heavy egg harvesting or releasing head-start turtles that could jeopardise the island hawksbill races of the Strait.

9. THE FARMS OF THE BARDI ABORIGINAL PEOPLE AT ONE-ARM POINT

9.1 The Bardi farms are so far removed from those of Torres Strait and the conditions under which they are operating are so different, that special attention is given them in the

following report of observations made during a visit to One-Arm Point after the main survey had ended.

9.2 Travel to One-Arm Point from Derby was made by aircraft in the company of Mr David Drysdale, who has been associated with the turtle project and is the Secretary of the Bardi Tribal Council.

9.3 At One-Arm Point we were met by Mr Michael H. Capelle, a Canadian anthropologist who has been recruited by Applied Ecology Limited as project officer with the Bardi people.

9.4 The Bardi community consisted of 176 people and there are two other communities of similar size nearby. Mr Capelle said that when he arrived seven months ago there was only one farm at One-Arm Point, with a total of 28 turtles. At the time of our visit there were three farms and six farmers, three of whom had not yet got their own farms, but would shortly do so and were being paid at the full training rate.

9.5 The farms were located behind a thin mangrove fringe along the shore of a lagoon. The tanks in use were all children's swimming pools lined with plastic and surrounded with galvanised iron. Water was being delivered to the tanks from the lagoon by a petrol pump. The main feed used for the turtles was mullet, caught communally with a seine and said to be available at all seasons.

9.6 Only green turtles were being cared for by the Bardi. Most of these were about four months old, although there were some one year old turtles. Generally, these were in good health and were comparable to those of the better Torres Strait farms. A few seemed slightly undergrown. There were signs of flipper damage and fungus infection was being treated and evidently controlled with application of gentian violet.

9.7 The people appeared to co-operate freely in the work of fishing and said they regularly looked after each other's farms when necessary. The Bardi women were not involved in the farming; only men were engaged in the work.

9.8 The project had access to a 16-foot dinghy powered by an 18 h.p. outboard motor. This had been supplied by the AAPA of Western Australia following the recommendation by Mr Bramley, a Fisheries Officer, who had been sent to help the Bardi people by the Western Australian Director of Fisheries.

9.9 According to Mr Capelle, the Bardi were going to receive two additional dinghies with 10 h.p. motors from the AAPA. He said that three farmers had also applied for Commonwealth Government loans to purchase boats but had not yet had replies to their applications. A 22-foot plywood launch with inboard motor, given to the Bardi by Mr Drysdale, was being refitted and repaired by them under Mr Capelle's direction.

9.10 According to Mr Capelle, the Bardi people did not wish to concentrate on turtles. They were also interested in crocodile farming and fishing. He shared this interest and was particularly anxious to set up a pilot experiment in the culture of mud crabs which are plentiful in the area.

9.11 The general condition and potential of the Bardi farms seemed good. The people are intelligent and, with the motivation the farm project gives them, appear resourceful and industrious. As with the people of Maer, turtles are a traditional part of the Bardi culture. Special assets of the locality are a reliable mullet supply, protected bay water, and the mangrove piling that should facilitate crawl construction.

10. FINDINGS

10.1 Even limiting our appraisal strictly to the terms of reference for our survey, we find this project to have complex ramifications and caution against simplistic or wishful thinking in assessing its achievements and in planning for its future. Solutions for several fundamental problems cannot now be seen and these impart uncertainty to the outlook for the enterprise. The key problems are:

(a) devising a technology for penning turtles for further growth as they approach weights of a hundred pound,

(b) achieving self-sufficiency in egg production and thus relieving wild populations of the egg-tolls now being taken,

(c) developing a selected strain or strains of each of the farmed species,

(d) conducting experiments to test the efficiency of head-starting as the basic conservation claim made by the project,

(e) managing production and marketing so as to avoid stimulating new markets and thus causing heavier pressure on natural stocks,

(f) winning the confidence of world conservation organisations in the validity of the conservation claims made for the project.

In the face of these complications and unpredictable factors, the future of the project is not easy to forecast.

10.2 In its present form, however, the project is not adversely affecting the wild turtle populations.

10.3 Small turtles are being successfully reared and mounted for sale. The taxidermy is excellent. However, even this stage of the proposed production cannot be greatly expanded as long as wild-bred eggs are used. Moreover, this part of the project will probably receive especially unfavourable attention from world conservation organisations.

10.4 On the whole, little adverse effect of the husbandry procedures was observed, although some stunting of growth was apparent, especially among turtles older than one year.* We obviously are unable to comment on the condition of turtles that, prior to our visit, may have died on the farms through either overcrowding or inadequate shelter from the sun. Some flipper damage from mutual nipping was apparent, especially among green turtles held in high density. Because of a lack of quantitative records for each farm, conditions for maximum survival and growth could not be determined. Such records should be required of all farmers.

10.5 The next stage in the development of the undertaking, the rearing of turtles to the large sizes at which they will produce meat and tortoiseshell, poses serious problems. Sound technical advice will be needed before the Islanders can hope to build crawls and sea-fences for large turtles.

10.6 The chief conservation benefit claimed for the project – the proposal to increase natural stocks and pay for the taking of wild eggs by releasing pen-reared yearling turtles representing ten percent of all eggs taken – is an untested procedure, the value of which is seriously questioned by some biologists and conservationists. Its worth can only be

* See addendum at page 41.

determined by a careful tagging program in which pen-reared turtles are marked and systematically released, with the patterns of recoveries critically evaluated. In the case of distinctive island populations of the hawksbill turtle that occur in the Torres Strait, even if released yearlings survive, they would eventually cause the loss of the genetic distinctiveness among the various island populations, unless all those released should invariably breed with turtles from their island of origin.

10.7 A proper understanding of the ecology and population dynamics of both the hawksbill and the green turtle can be gained only by carrying out marking programs at the various nesting grounds. The help of the Torres Strait Islanders should be counted on as a strong asset in the development of these tagging programs.

10.8 If the farm project should be allowed to expand, wild-caught feed, especially fish, could become limiting. Accordingly, before growth is encouraged, the sizes of the fish stocks of the area should be determined and these should subsequently be regularly monitored to avoid the possibility of over-exploitation.

10.9 Until techniques of crawl and sea-fence construction are worked out, it is not possible to say whether tracts of submerged vegetation can be utilized in their natural state as enclosed pasturage, or whether some method of harvesting may be necessary. In any case the distribution and area of the turtle-grass pasturage available at the various islands should be determined. Although sea grass is less likely than fish stocks to be limiting, it may prove to be an important factor in any future development of the farms.

10.10 Several years' research in the Torres Strait area should have preceded establishment of the project on a production basis. Further growth should be held back until such a research program has provided answers to some of the biological and ecological uncertainties that make controlled development impossible.

11. RECOMMENDATIONS

11.1 Because there has been no adequate impact study on which to ground the commercial turtle farming enterprise in northern Australia, we propose that if the effort is continued it should, for the time, be kept small and be regarded as a pilot, experimental project in which research is emphasised.

11.2 We recommend that data derived from the above pilot study be used as the basis of a new Ecological Impact Study which should constitute a minimum requirement for any future growth.

11.3 We recommend that in the new Ecological Impact Study the diversity that exists among the separate islands as regards both assets and problems be recognised and that a separate analysis and project plan for each island or island group be required.

11.4 We recommend the immediate initiation of a long-term tagging program, staffed by Islanders, in which female green turtles and hawksbills are marked on the nesting ground as a way of determining ranges, migrations, feeding habitat, breeding-site fixity, reproductive rhythms and population structure.

11.5 We suggest the mounting of a program of from three to five years' duration to test the validity of head-starting by releasing lots of tagged pen-reared green turtles in a pattern

designed to reveal their subsequent fate or movements. This programme should not be extended to the hawksbill turtle because of the risk to the genetic integrity of the island strains.

11.6 Experimentation should begin at once with the construction of crawls and sea-pens.

11.7 Pilot studies should be made of the space and feed requirements of large turtles kept in crawls and in fenced submerged pastures.

11.8 We recommend the quantitative surveying and subsequent monitoring of fish stocks used in feeding turtles.

11.9 Experimentation in the use of turtle-grass as feed should begin in order to determine carrying capacity, effects of over-grazing, and yield under artificial harvesting.

11.10 As an appropriate crawl is developed, a breeding program should be organised in which pen-reared turtles nest on artificial beaches and produce all eggs used by the farms.

11.11 When penned turtles are regularly mating and nesting on artificial beaches, a program should be established of artificial selection to establish distinctive strains with traits favoured in the market.

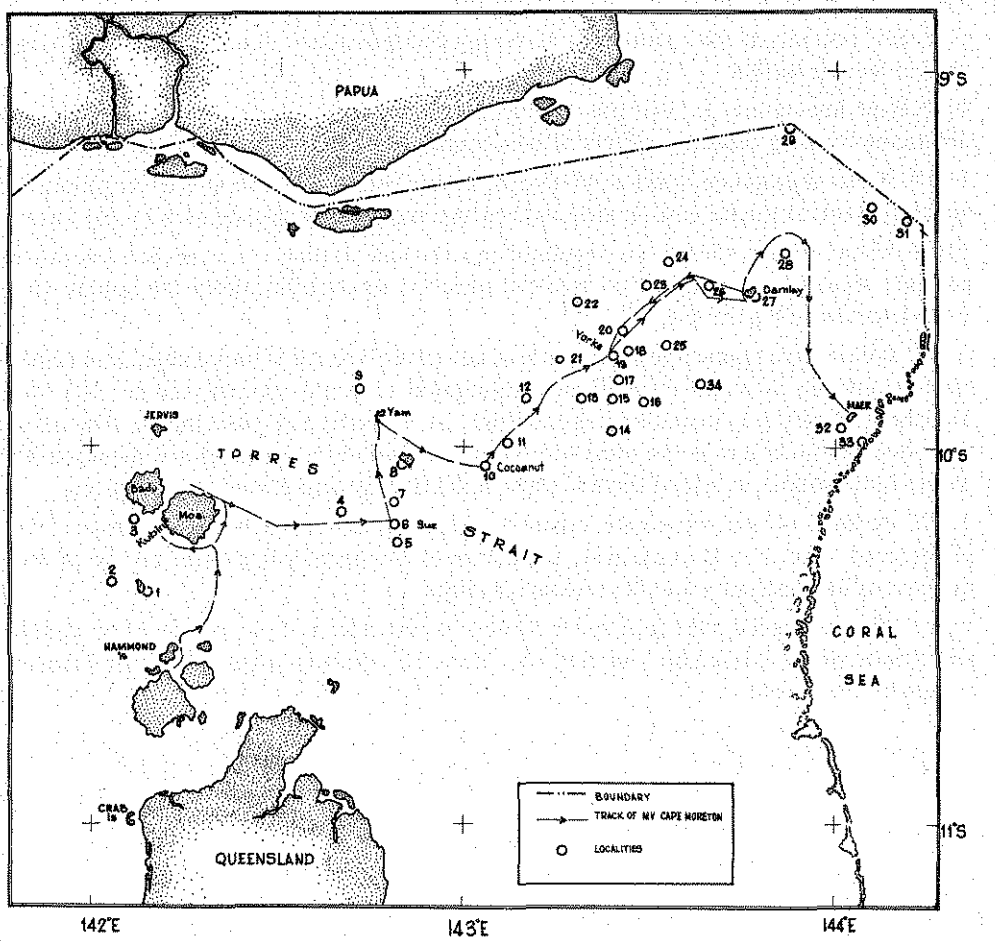
11.12 Before development toward commercial self-sufficiency is undertaken, immediate steps should be taken to forestall any stimulation of world markets and to allay the uneasiness of world conservation organisations, by adapting and publicising a trade mark that identifies products as the yield of a group of small farms manned and managed by Torres Strait people, as one of the few ways in which they can remain self-supporting.

11.13 Because of the extremely complex problems associated with the project, we recommend that if it is continued, there should be periodical general review of the progress of the husbandry and the research findings.

11.14 We recommend that each turtle farmer be required to keep records of all details and results of his husbandry and that the farms be regularly inspected by an Islander chosen by the people.

APPENDIX A: SKETCH MAP OF ISLANDS OF TORRES STRAIT VISITED FROM 2 OCTOBER THROUGH 7 OCTOBER 1973, SHOWING THE COURSE OF THE M.V. *CAPE MORETON.*

The list of breeding sites was compiled by asking the Islanders at each of our stopping places to name all the local breeding grounds of sea turtles. Presumably other rookeries are located at greater distance from track of the Cape Moreton.



—— Sketch Map = TORRES STRAIT ISLANDS——

APPENDIX A1: LIST OF ISLANDS NAMED AS TURTLE BREEDING SITES BY TORRES STRAIT ISLANDERS 2 – 7 OCTOBER, 1973

Number on Map		Name of Island	Comment
	+	Jackson	Islands known to the Western Group: Located between Jervis in North, Naghir in East, Hammond in South and Badu in West.
2		West	
1		Hawkesbury	
		Yore, Tukupai	
3		Green	
		Christmas, Zurat, Kulbai Kulbai, Kanig, Tuin, Murbar, Fruit, Pumpkin, Zagasup, Aim, Mukunab (Trocas), Surag, Nelgie, Sunsweet, Dadalai, Gitalai, Kanig No 2, Sarbie, Youl, Nur, Aiah, Gainaualai.	
4		Saddle	Islands used by the Central Group
5	+	Poll	
		Poll Bank (? = Fall Bank)	
6	₡	Sue = Warrabur	
7	+	Bet	
	₡	Bet	
8	+	Long	
10		Cocoanut	
		Pol, Bank between Bet and Long	
9	+	Cap	
11		Dove	
19		Yorke	
12		Arden	
13		Layoak	
20		Keats	
18		Kadau	
15		Aukane	
17	*	Kabbikane	
16	+	Bourke	
14	*	Mimi	
21	*	Rennel	
22	*	Dalrymple	
		Maer = Murray	Islands used by Eastern Group
32		Dowar	
33		Waier	
31		East Cay	
		Eur Cay	
30		Anchor Cay	
29		Bramble Cay	
28		Underdown Islet	
27		Darnley	
26		Nepean	
24		Stephen	
23		Campbell	
		Tobin Cay	
34		Hannah Bank	
		Benefit (near Hannah)	
		Raine (11° 36'S 144 E)	
25		Kos = Stewart Reef	

₡ Not readily distinguished
* Eggs said not to be collected from these Islands
\+ Cases in which hawksbill turtles said to have originated from specified islands were readily distinguishable from those of other islands.

APPENDIX B: SUGGESTED HEADINGS FOR ENVIRONMENTAL IMPACT STATEMENT TURTLE PROJECT IN TORRES STRAIT ISLANDS

SECTION 1. SUMMARY

- 1.1 Title
- 1.2 Authority proposing action
- 1.3 Authority of action
- 1.4 Authority to receive statement
- 1.5 Proposed action
- 1.6 Possible adverse environmental effects
- 1.7 Alternatives considered
- 1.8 Qualifications for authority issuing statement

SECTION 2. PROPOSED ACTION

- 2.1 Objectives
- 2.2 Proposed action
- 2.2.1 Production
  - Holding of farmed turtles
  - Feeding of farmed turtles
- 2.2.2 Processing and marketing
- 2.2.3 Maintenance of field population
  - Control and monitoring of Wild population
- 2.3 Justification for proposed action
- 2.3.1 Economics
- 2.3.2 Environment
  - Reefs
  - Beaches
- 2.3.3 Infrastructure
- 2.3.4 Timing of the project

SECTION 3. CHARACTERISTICS AND CONDITIONS OF THE EXISTING ENVIRONMENT

- 3.1 Climate
- 3.2 Resource use
  - Land
  - Reef area
  - Fish stocks

SECTION 4. IMPACTS OF PROPOSED ACTION ON THE EXISTING ENVIRONMENT

- 4.1 Amenity and conservation
  - Islands
  - Turtles
  - Fish

APPENDIX C

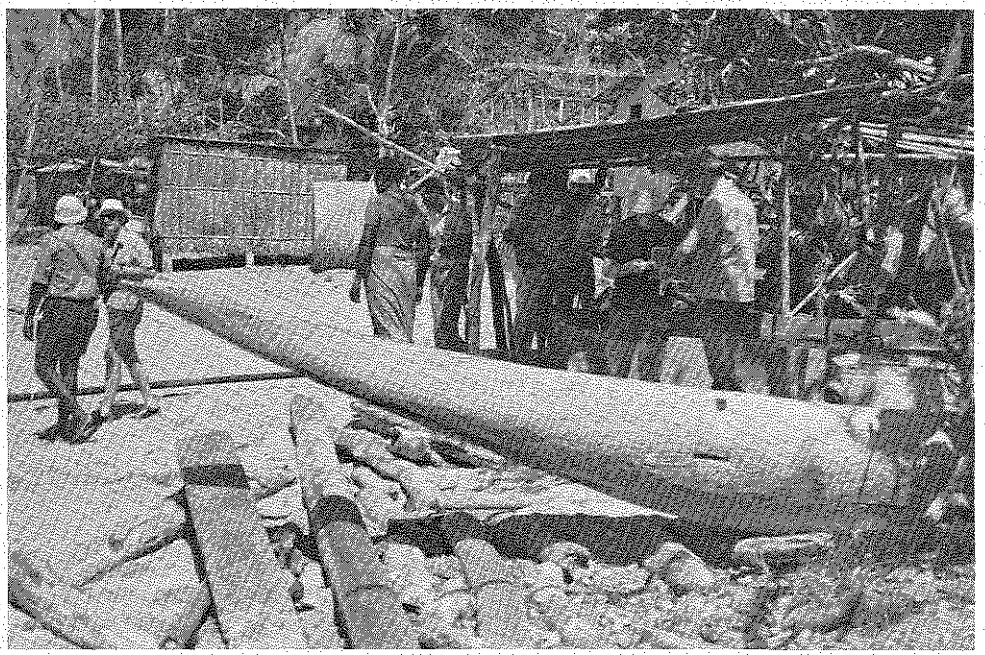


Fig. 1. Darnley Island, showing distribution of turtle farms along the shore. The low, roofed structures are the farm buildings.

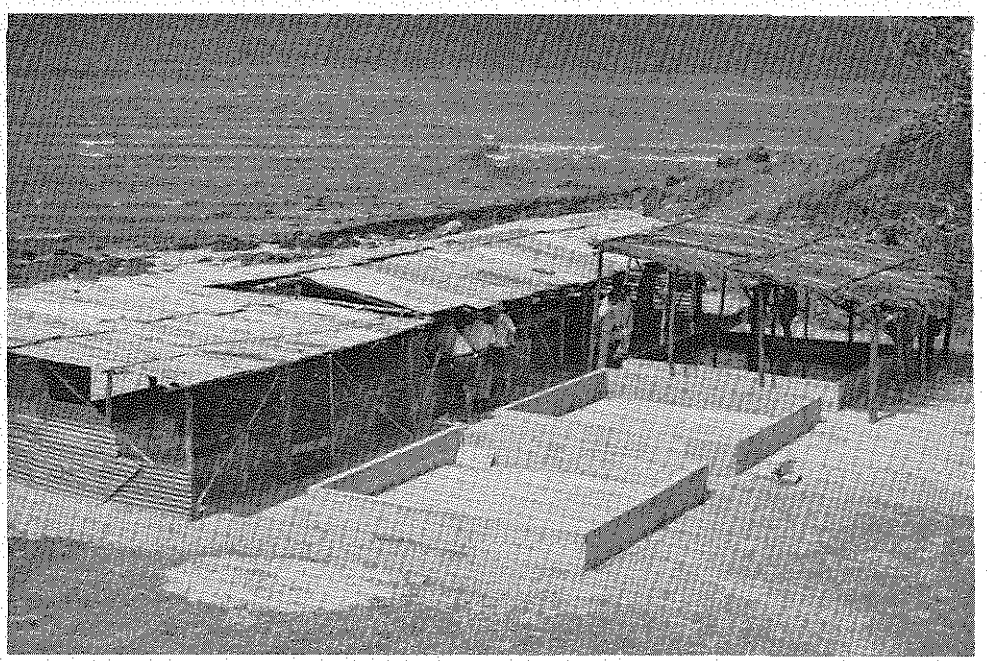


Fig. 2. Communal turtle culture on Darnley Island. The shed in the view houses three farms belonging to a collaborating family group. Note the new concrete tanks in construction on right.

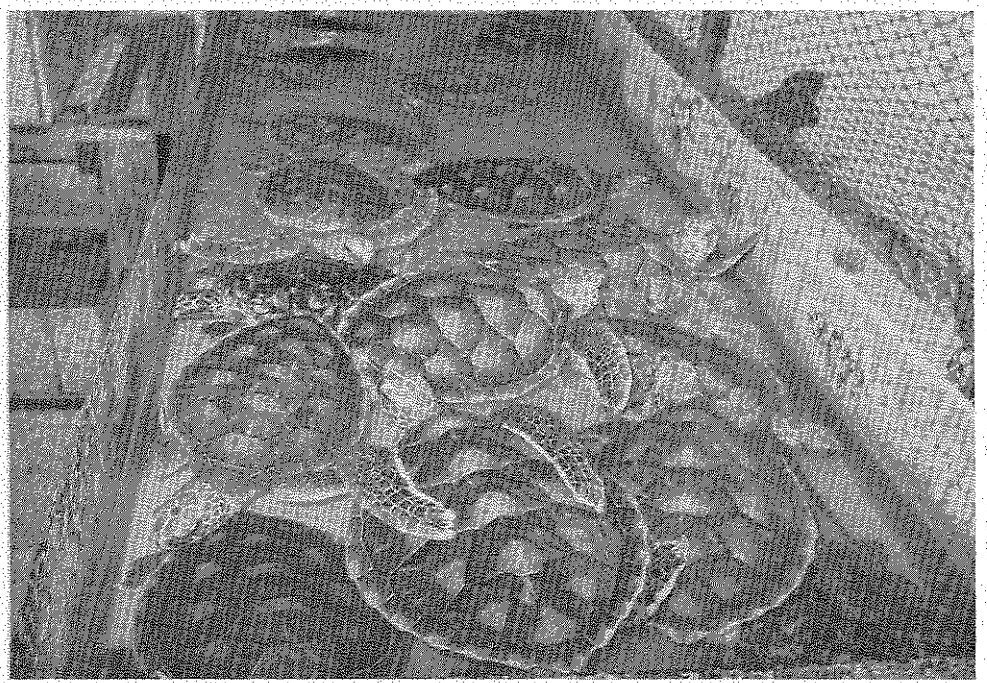


Fig. 3. Darnley Island: eight-month-old green turtles in galvanised iron rearing tanks.

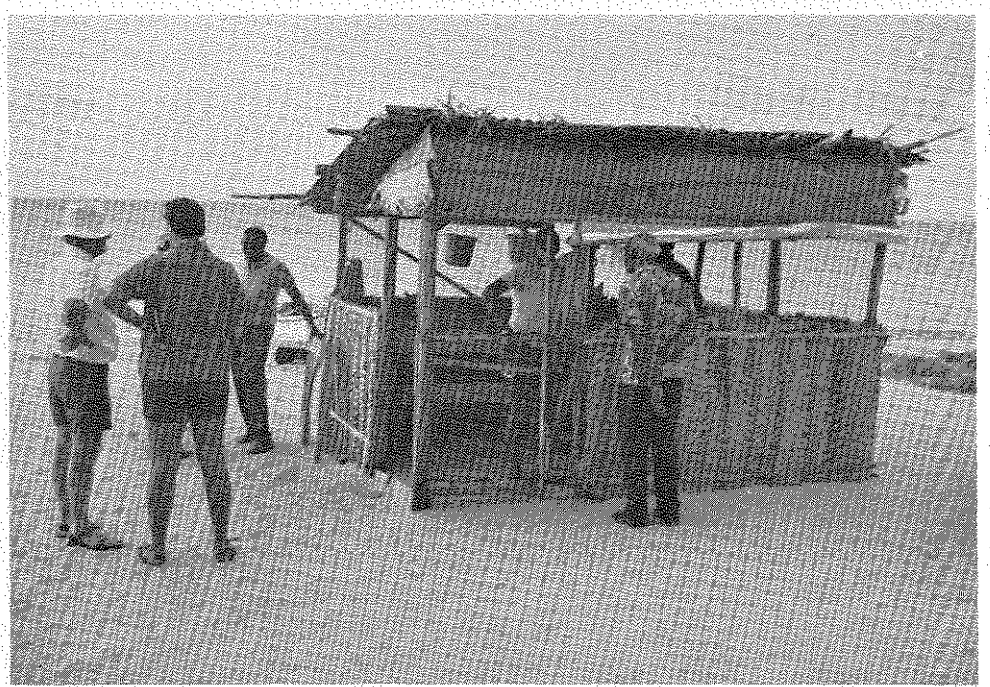


Fig. 4. Darnley Island: farms of bamboo-and-palm-thatch construction.

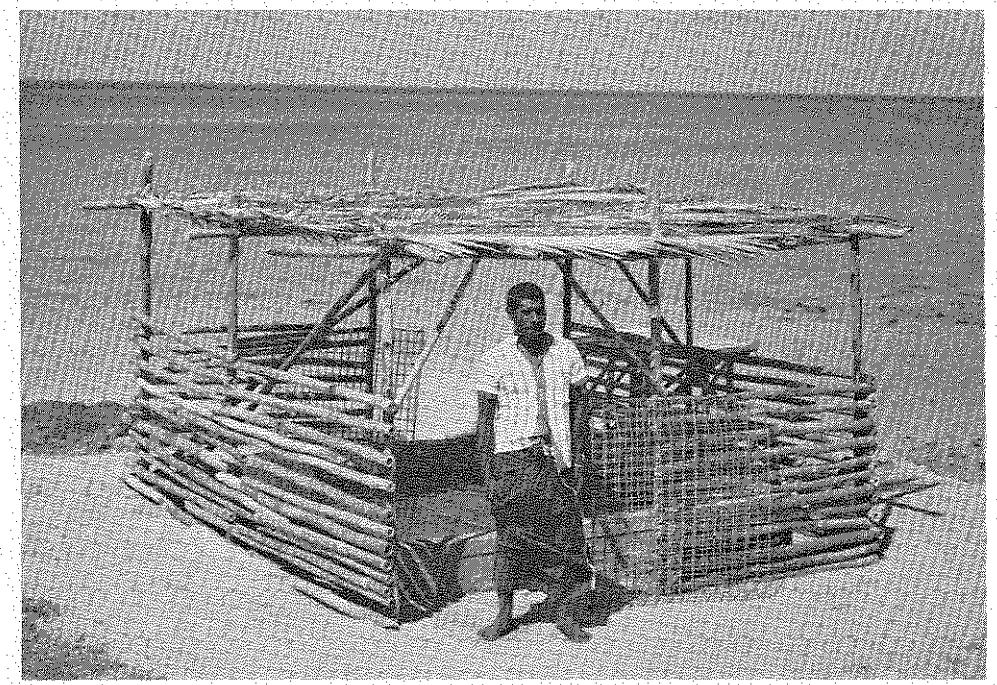


Fig. 5. Coconut Island: farm shed with walls of woven pandanus leaves.

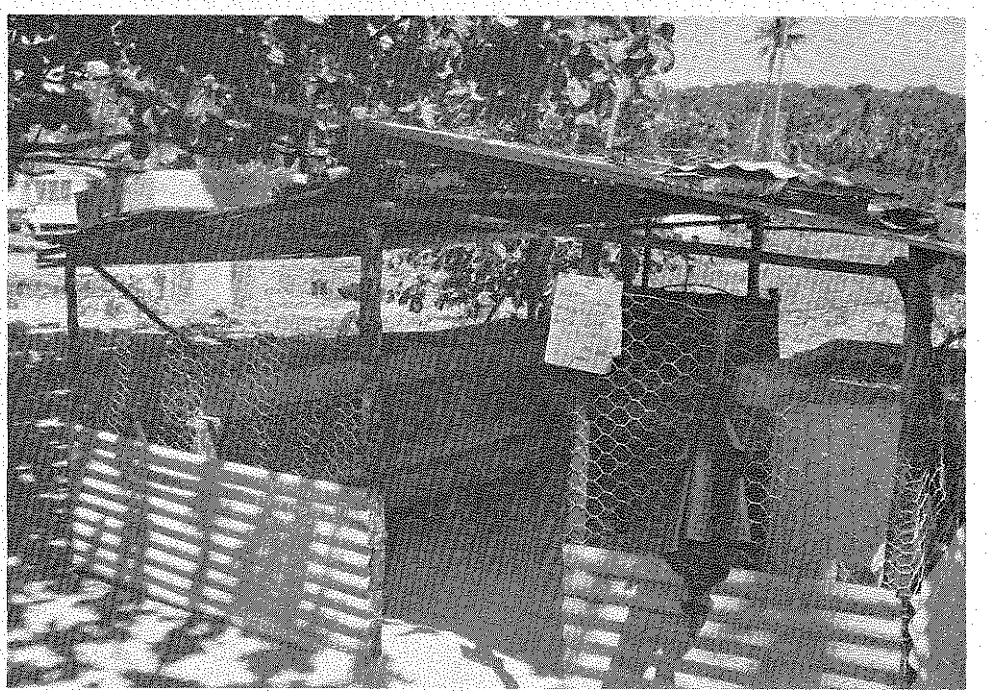


Fig. 6. Yam Island: farm of galvanised iron and poultry-wire construction and with tanks of galvanised iron.

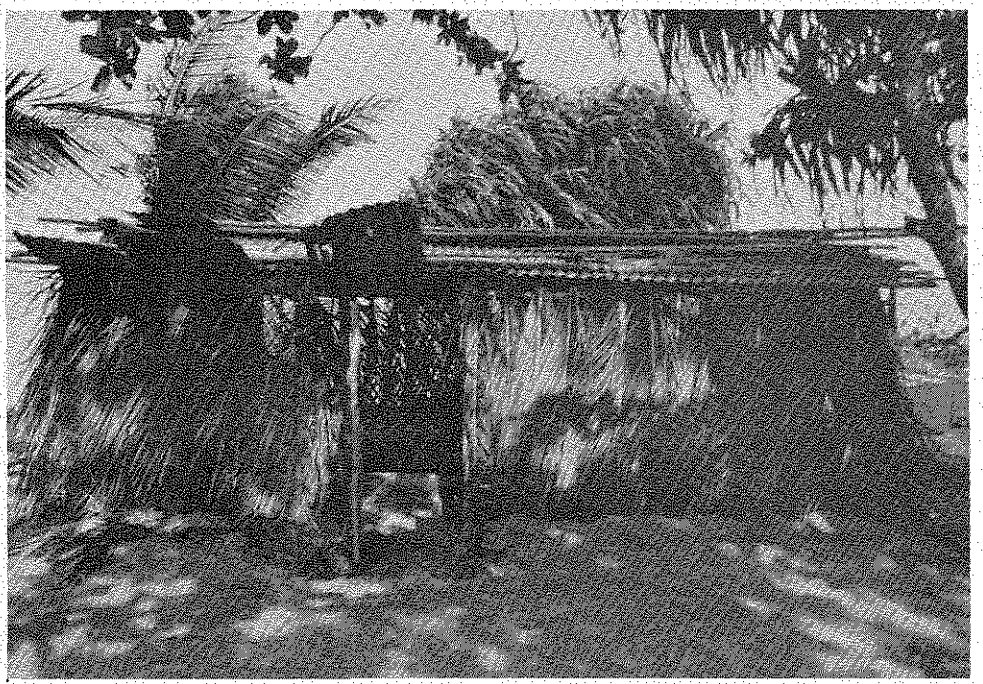


Fig. 7. Maer Island: farm with palm-thatch walls and metal roof.

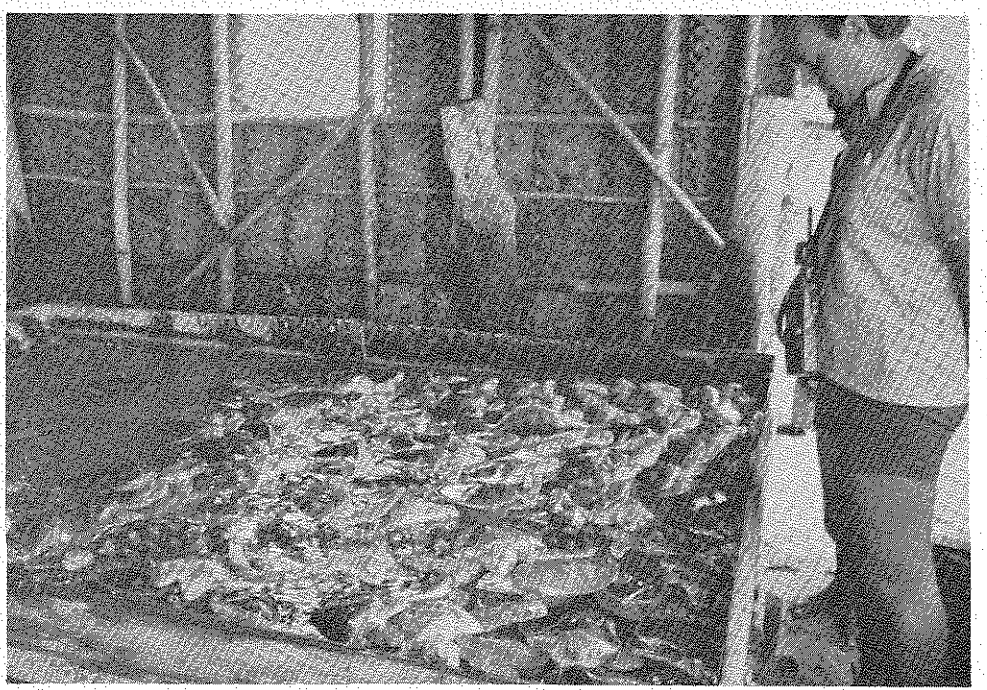


Fig. 8. Maer Island: six-month-old green turtles eager to be fed.

Fig. 9. Maer Island: girl throwing cast-net for sardines in front of her turtle farm. The ship on the horizon is the M.V. Cape Moreton which transported the survey party.

Fig. 10. Sardines used as staple turtle feed on Maer and Darnley Islands. Upper, spotted herring, *Harengula konisgbergi;* lower, hardy head, *Pranesus ogilbyi.*

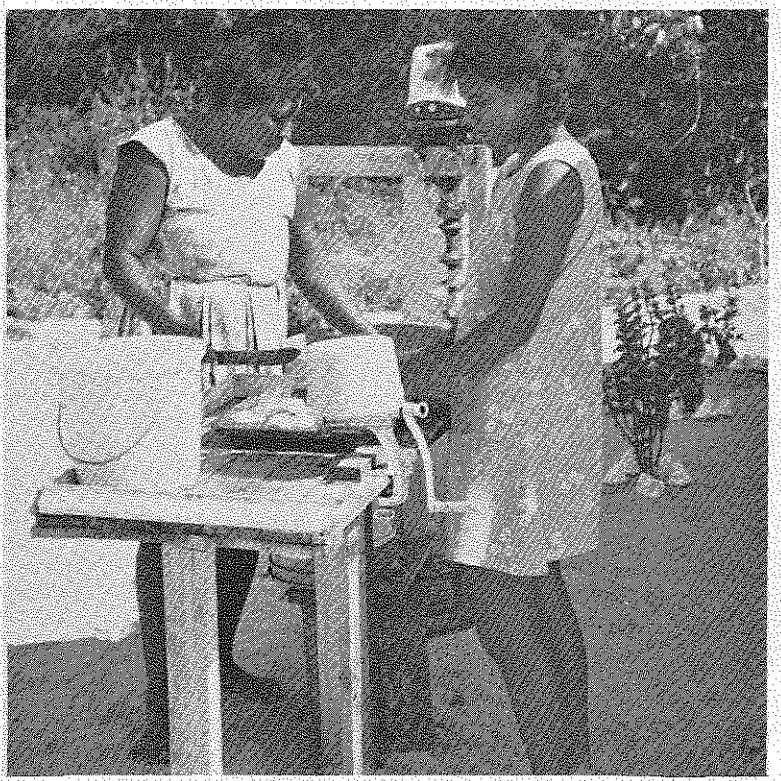


Fig.11 Farmers cleaning various species of reef fishes to be ground (in the chopper at centre) as turtle feed.

Fig.12. Stone fish weir, Darnley Island. These ancestral structures, which are still in use, not only help provide turtle feed but also may serve as models for construction of sea-crawls on the islands at which boulders are available.

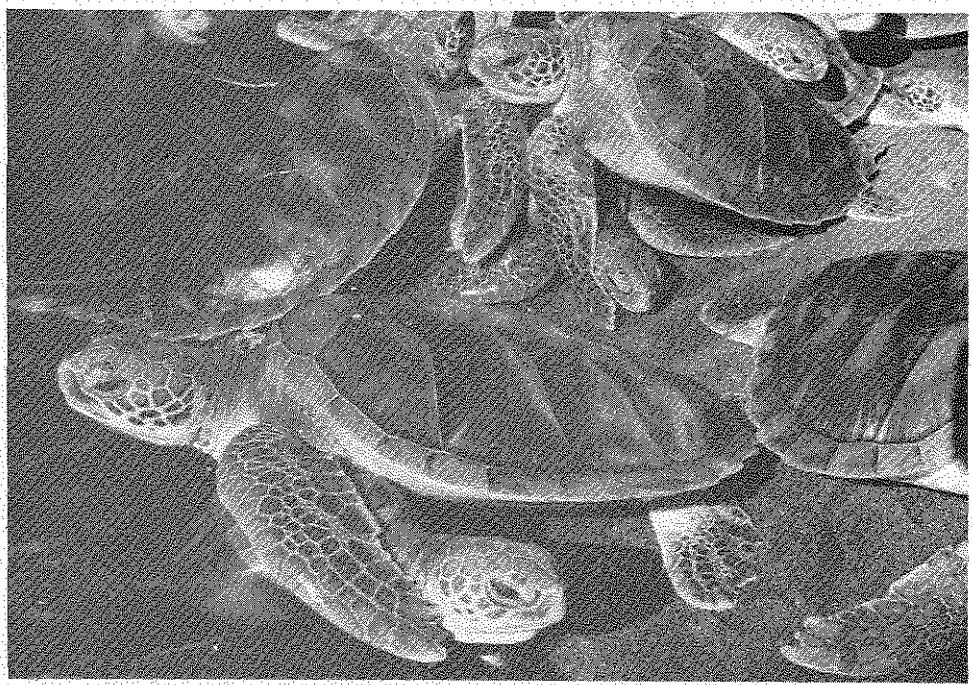


Fig.13. Yearling green turtles at a farm on Yam Island. Note at lower centre the scalloped back edge of the hind flipper on the turtle which has been nipped by tank mates.

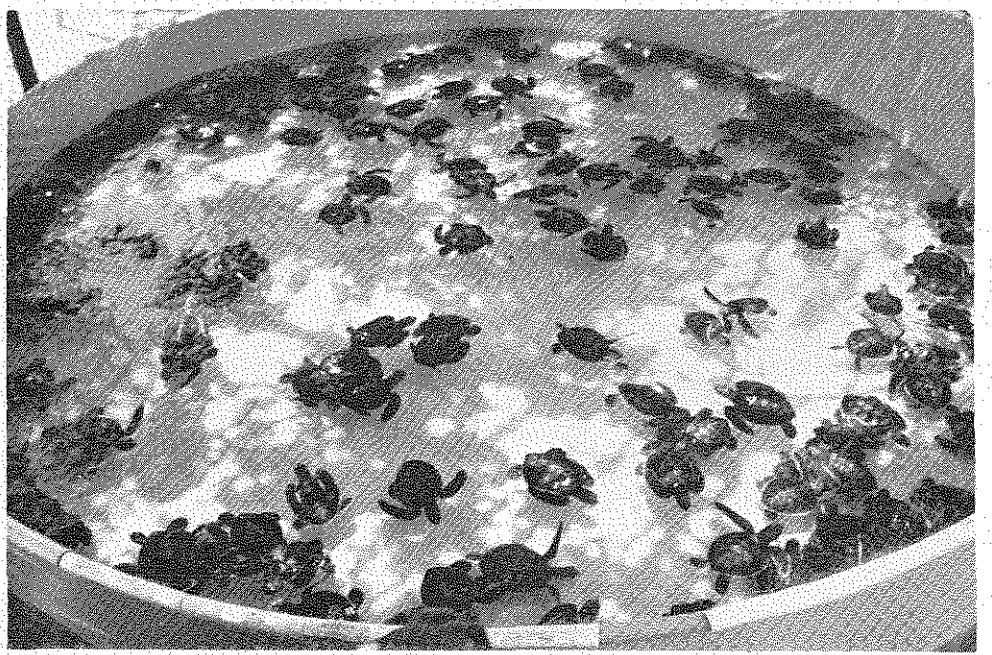


Fig.15. Plastic swimming pool, used as a turtle tank by the Bardi farmers and considered altogether satisfactory by them. The turtles shown are four months old.

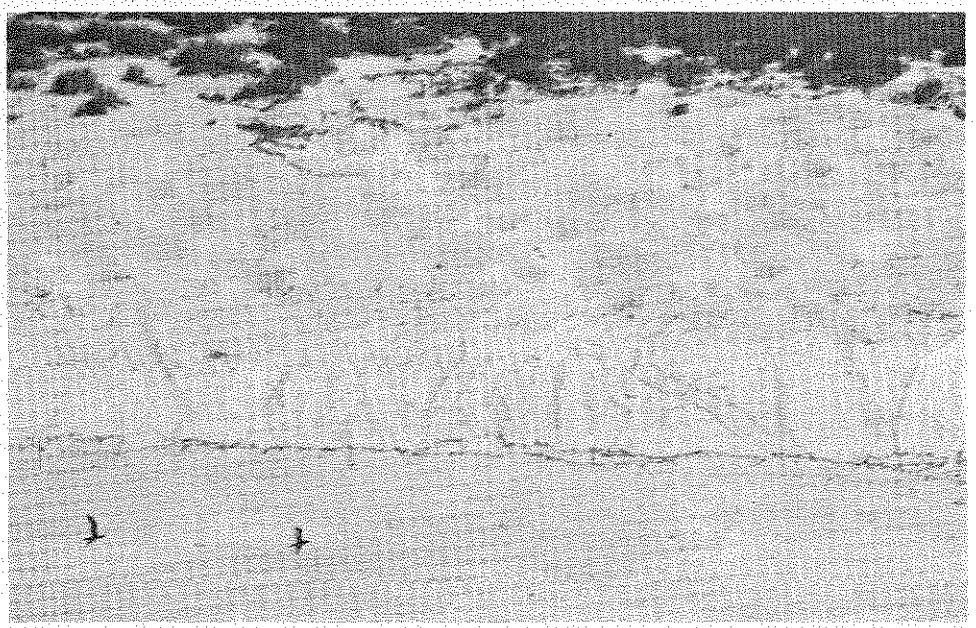
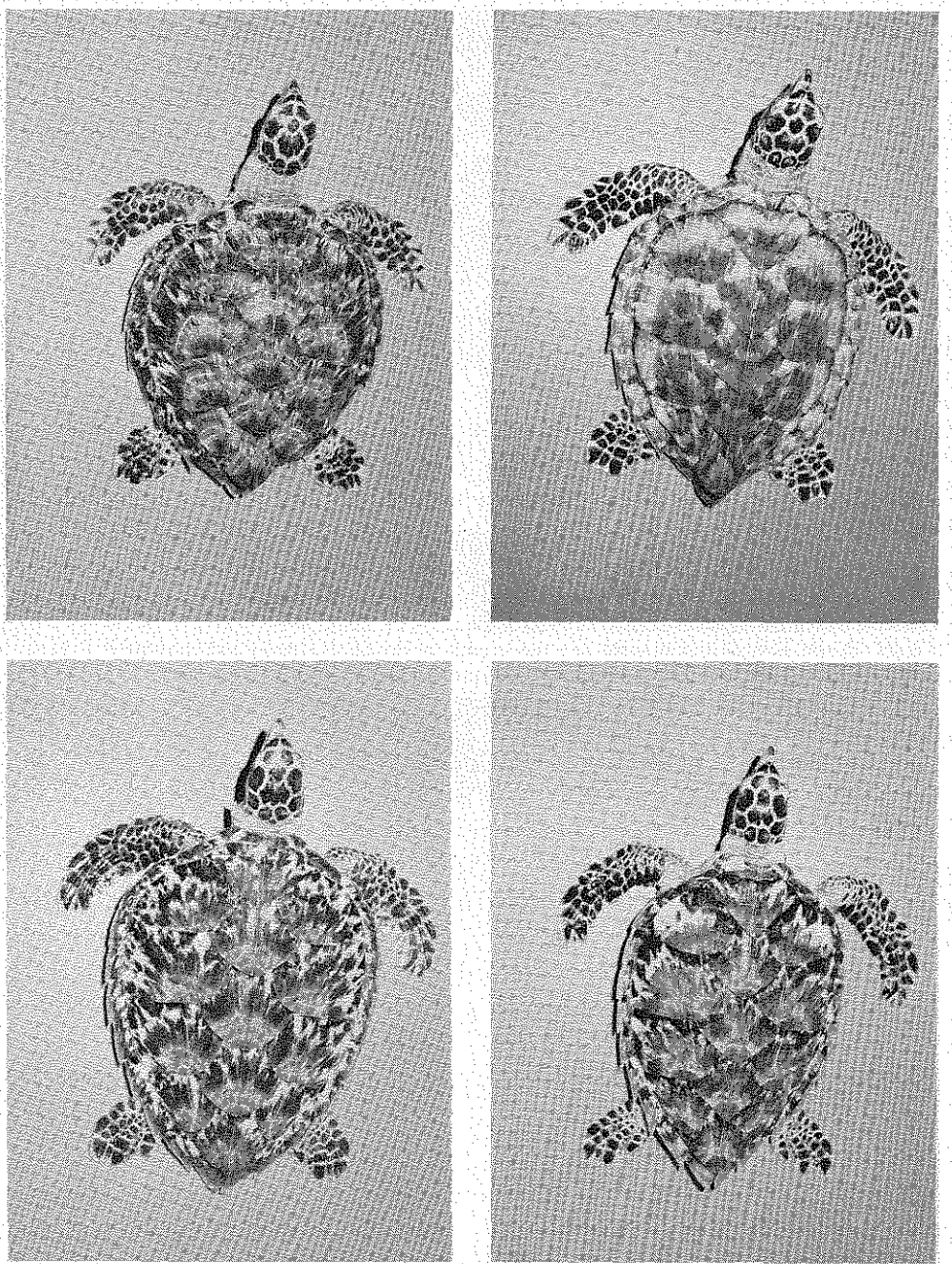


Fig.16. Aerial photograph (from 500 feet) of green turtle nesting ground in Lacepede Islands, from which eggs for Bardi turtle farms are obtained. The upper part of the photograph is land with sparse vegetation; the lower part is water. A thin line of debris on the separating tidal beach marks the current high-water mark. Tracks of turtles that nested the night before cross from the water to the drier upper beach. Craters in the dry sand are body-pits dug by female turtles and in which they rested while nesting.



Figs.17-20 Show four of the mounted hawksbills to be produced by the project for the curio trade. They were selected from a mixed lot to illustrate four of the shell patterns that are subject to segregation on Torres Strait islands. The divergence is far more striking when the consistency of the difference is noted in tanks each holding a number of turtles from a single island.

ADDENDUM TO REPORT ON AN INQUIRY INTO ECOLOGICAL IMPLICATIONS OF A TURTLE FARMING PROJECT

After completion of this report, the taxidermist preparing young turtles to be sold as curios, reported that he had found heavy infestation of worms in the body cavities of some lots of turtles.

Specimens of the worms have been identified by Professor John Sprent of the University of Queensland as the round worm (nematode) anisakis type I and probably either simplex or typica.

Fish are the natural intermediate host of this worm and porpoises and dolphins the definitive host.

The worms are in the turtles as accidential parasites and could not complete the life cycle and reproduce in the tanks.

Continued feeding of infested fish would increase infestation in the turtles, however, and migration from the gut into the tissue might occur.

The Murray Island turtles were the most heavily infested and it is there that sardines are fed most exclusively, especially the spotted herring.

Evidently therefore the frequency of larvae in Torres Strait fishes varies markedly according to species and the Murray Island sardine is probably the source of the trouble at that Island.

Some means of control suggested by Dr. Sprent are:

(i) changing the diet,

(ii) cooking the fish,

(iii) freezing them to –20 degrees and holding them there for 24 hours

and he has indicated that other methods might be explored.

Of the recourses mentioned the second seems impractical because of the tendency of cooked fish to break up into fine waste and create intolerable pollution in the tanks.

It seems possible that mechanical damage done by the worms to the wall of the gut may have caused some of the stunting that we noted in turtles six months old or older.

If so, then control of this parasite must obviously have high priority in the farming project.

22 November 1973

TURTLE FARMING PROJECT IN NORTHERN AUSTRALIA

REPORT ON AN INQUIRY INTO
ORGANISATION, MANAGEMENT AND MARKET PROSPECTS
OF A TURTLE FARMING PROJECT
IN NORTHERN AUSTRALIA

OCTOBER 1973

L.P. SMART, F.C.A.
Marquand & Co.,
51 Queen Street, Melbourne 3000

51 Queen Street
Melbourne 3000

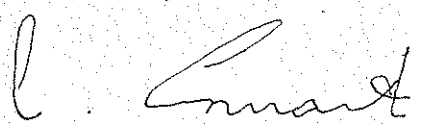
1 November 1973

Dear Senator Willesee,

I enclose herewith my report on an enquiry into Organisation, Management and Market Prospects of a turtle farming project in Northern Australia.

Thank you for the opportunity of working on this unusual but fascinating assignment.

Yours sincerely,



L.P. Smart, F.C.A.

Senator The Hon. Don Willesee,
Special Minister of State,
Parliament House,
Canberra, A.C.T. 2600

Preamble

I am pleased to report on my inquiry into the organisation and management structure of the turtle farming project in Northern Australia and to make recommendations for improvements. I also report on whether the administrative headquarters should be located in Canberra or elsewhere.

Report format in accordance with brief

The terms of reference of the inquiry are detailed in Appendix (1) and my report proceeds in the order set out in the terms of reference.

Approach to inquiry

My approach to this inquiry is summarised in Appendix (2). It should be noted that because the objectives of the turtle project have been stated only in general terms and emphasis has been placed on the conservation aspects I have found it necessary to write the business objectives and strategy to complete the format of this report. These objectives, the strategy, general description and chart of the proposed business and management of turtle farming are set out in Appendix (3).

Material Available

The material available and other source information, data and acknowledgments are detailed in Appendix (4). It is appropriate, however, to express my thanks to Mr P.J. Lawler, O.B.E. and his staff for their attention to my numerous requests. Also Dr A.F. Carr and Professor A.R. Main have given me the benefit of their remarkable knowledge and ability in relating this business study to sound scientific ecological and conservation material. In fact, this report should be read in conjunction with the report dated October 1973 prepared by Dr Carr and Professor Main.

Basis of opinion

This report is based on the data listed in Appendix (4), my observation of the project and my commercial judgment. The financial information used has not been subject to audit. The report is an expression of my opinions of the various matters raised, which opinions are subject to the correctness of the data supplied to me.

To examine the organisation and management structure

'1. TO EXAMINE THE ORGANISATION AND MANAGEMENT STRUCTURE OF THE COMPANIES WHICH HAVE BEEN SET UP IN THE CONTEXT OF THE TURTLE FARMING PROJECT IN NORTHERN AUSTRALIA AND TO CONSIDER WHETHER AND IN WHAT WAYS THEY MIGHT BE IMPROVED. IN PARTICULAR TO CONSIDER WHETHER THE ADMINISTRATIVE HEADQUARTERS SHOULD BE LOCATED IN CANBERRA OR ELSEWHERE'.

Present corporate structure

The present structure comprises three companies:

- Applied Ecology Pty Limited
- Aboriginal and Islander Products Pty Limited
- Aboriginal and Islander Marketing Pty Limited

with common management structure and interlocking directorates.

The organisation and management structures of these companies are no longer suitable for the turtle venture.

The principal reasons are:

Reasons for changing organisation and management structure

(i) Applied Ecology Pty Limited is designed to undertake research and development activity which is an entirely different function from an ongoing production venture. Accordingly Applied Ecology Pty Limited should not control the management of the turtle venture.

(ii) The marketing strategy discussed in section 4 is a co-ordinating function rather than a direct selling function. A co-ordinating marketing function calls for a different modus operandi from that presently proposed and must be kept separate from research and development in ownership, control and direction.

(iii) The business objectives (as distinct from the scientific objectives) as set out in Appendix (3) would be best achieved by a structure which could cater for the turtle venture as an integrated unit but would keep areas of responsibility clearly defined through a corporate or legal status designed to suit the needs of each area of responsibility.

(iv) The business as envisaged is dependent on the 'turtle farmers' and as it is their work, their ability and their business they should have considerable involvement in the management of the turtle venture.

Accordingly I would recommend the following arrangements:

Applied Ecology – Research and Development

(a) *Applied Ecology Pty Limited.* This company should be a scientific applied research company. Its income should be solely from grants for specific research on projects involving Australian flora and fauna for the benefit of Aboriginals and Islanders. The board should include (3) eminent scientists, (1) government representative, e.g. from the Council for Aboriginal Affairs, and (2) distinguished experienced businessmen. The board should be comprised of people who can attract grants for research, set sound parameters for research projects and organise and monitor the projects. The managing director should be a person who has administrative experience and should be based at head office. Applied Ecology Pty Limited should act as the 'technical advisor' to the turtle project but must not manage the project because of the probability that research and development if merged with the commercial turtle activities would result in a confused conglomerate. Such confusion creates breakdown in communications which are difficult under

reasonable conditions and aggravated in this instance by geographical distances involved. Appendix (5) sets out suggested amended objectives and management chart of the operations of Applied Ecology Pty Limited. The administration and management services structure of Applied Ecology Pty Limited would be considerably reduced from the present level.

Cottage industry turtle farm co-operatives or similar corporate structure

(b) *'Cottage industry turtle farm co-operatives'*. In Appendix (3) there is reference to the 'cottage industry turtle farms'. This phrase identifies the business of growing turtles from hatchlings to approximately 15 lb weight in 2 years 8 months. At this stage the 'farmer' would sell his 15 lb turtle to a corporate body which would grow the turtles in sea crawls.

It is essential that the farmer manages this cottage farm part of the business. Dr Carr and Professor Main, in their companion report, highlight the animal husbandry standards of the Torres Strait Islanders, their ingenuity and their obvious ability to handle turtles; these fundamental abilities must be used in the growing of young turtles. Furthermore, it is my opinion that the raising of young turtles would be in harmony with the Islanders' traditional way of life.

The management structure envisaged within this section of the business would operate within the rules of 3 Co-operatives to be formed representing Eastern, Central and Western Island groups. The Co-operatives would each have a Board of Directors of 3 or 4 Island members plus the nominated representative of the Queensland Government Department of Aboriginal and Island Affairs. The co-operatives which could be co-operatives registered under a Companies Act would each employ an inspector and a recorder to facilitate the collection of management data. The co-operatives in consideration of permits, funding, etc. would contract to sell their produce to a company to be formed which would

(i) grow the turtles to slaughter size

(ii) arrange the processing and marketing of the produce.

Appendix (6) sets out suggested objectives and management chart of the operations of these Co-operatives.

Torres Strait Turtles – the operating company

(c) *Torres Strait Turtles Pty Limited* (so named for the purpose of the report) would carry out the erection of sea crawls, the growing of turtles from a minimum 15 lb to slaughter size, the organising of the processing and

selling of the turtle product.

The direction of the company should include Torres Strait Islanders and businessmen. I would recommend a structure of three Islanders (one from each co-operative), two businessmen (one marketing oriented), and two Government observers – one from Queensland Department of Aboriginal Affairs and one from the Australian Government. The objectives and strategy of this company are set out in Appendix (7).

Once again, I am of the opinion that the Islanders should play a prominent role in this company and via the co-operatives own a part of this company. The Australian Government could own fifty-one per cent of the share capital until the project had been fully re-constituted and was self-supporting and then sell part of their equity in equal proportions to the co-operatives.

Location of Administration

The administrative headquarters of Applied Ecology Pty Limited should be in Canberra but as mentioned previously should be considerably smaller than the present administration.

The administrative headquarters of the three co-operatives should be on the Islands.

The headquarters of Torres Strait Turtles Pty Limited should be in Canberra with a branch office established on the island nearest the principal 'turtle sea crawl'. However, the Canberra office would be a statutory office with planning, staffing and direction being handled as much as possible from the operational office. It is important that management is located close to the principal place of business to facilitiate the control of the business.

Audit needs

It would be advisable for the audit of these three groups to be completed either by the Auditor-General's Department or, by an independent professional firm so appointed. In either case the same auditor should be appointed to audit the three groups.

To consider effectiveness of financial management

'2. TO CONSIDER WHETHER FROM A COMMERCIAL VIEWPOINT THE FINANCIAL MANAGEMENT IS EFFECTIVE AND WHETHER THE MANAGEMENT CONTROL REPORTS AND ACCOUNTING PRACTICES THAT HAVE BEEN IMPLEMENTED ARE APPROPRIATE'.

I have not conducted an audit of the internal control procedures adopted by Applied Ecology Pty Limited or of the data presented to me for examination.

However, the information presented to me was not appropriate for an expanded operation. It is important that the financial statements presented to date be subject to audit to establish whether the accounts do show a true and fair view of the state of affairs of the companies.

In respect of the future it is not possible to set out a detailed accounting and reporting procedure as this task is a major exercise and is dependent on the eventual format of the whole organisation. I have scheduled the principal matters which I consider should be the subject of regular management and accounting reporting and this schedule is attached as Appendix (8).

To estimate production costs

'3. TO ESTIMATE PRODUCTION COSTS FOR THE PRODUCTS THE PROJECT WILL INITIALLY PRODUCE (PAYING PARTICULAR ATTENTION TO THE IMPORTANCE OF LABOUR COSTS) AND TO SET OUT THE ASSUMPTIONS ON WHICH THESE ESTIMATES ARE BASED'.

Appendix (9) sets out the detailed workings of the estimated production costs. In summary:

Sea crawl

(i) If a sea crawl can be constructed for $600,000 or less and it has an effective life of at least 20 years, the project is economically feasible.

150 employees

(ii) The project has been constructed on the basis of 100 turtle farms. It is estimated that a total of 150 Islanders would be employed; 120 would be employed in farming and related activity and 30 employed attending the sea crawl and trawler fishing.

Integral part of Islanders life

(iii) The 'farming methods' envisaged can be truly described as cottage industry in respect of growing turtles to 15 lb. Growing turtles in sea crawls is, of course, more intensive farming but the bulk of the work entailed is trawler fishing to provide feed for the turtles. Fishing is an integral part of the Islanders' life.

To assess current demand

'4. TO ASSESS CURRENT DEMAND FOR THESE PRODUCTS AND EXPECTED GROWTH FOR THE NEXT FIVE YEARS'.

I have obtained an overall picture of the marketing and movement of turtle products throughout the world. This data, which is of considerable strategic importance, has been made available to the Department of the Special Minister of State for distribution on a confidential basis. In summary, the sales levels that can be reasonably expected depend entirely on a marketing program designed to fill the objectives of the turtle project.

Sales to be expected

The major producer of turtle meat currently is Mariculture Limited of Grand Cayman Island. Its strategy appears to be similar to that of an intensive poultry breeding industry and they will be marketing their better quality meats through U.S.A. supermarkets, the shell to Japan and elsewhere, and oils and soup meats mainly to Germany and United Kingdom. They have also sold meat to Australia for soup making.

Mariculture Ltd have estimated that within five years their gross sales should be five times present sales and in the region of $17 million per annum. Their market is related primarily to the rapidly growing world market for high protein meat. Turtle steak has a protein content of about 23%, a fat content of about only 0.2% and 102 calories per 100 grams. These factors and the similarity of turtle meat to veal should ensure acceptance of turtle meat in the market place.

Demand for food product

As there is a known world growth market for high protein foods, particularly meat, it is now axiomatic that the demand growth will continue rapidly.

The industry can grow

Accordingly the answer to the question – Can the industry grow? – is simply yes. Provided the industry is based on the production and marketing of food, the demands for the product will grow.

Curios

It will be noted that there has been no reference in this report to the curio trade. I have not taken the curio trade into the economic calculations of the project as a curio trade is 'suicidal' long-term. The sale of turtles as curios is a peculiar marketing situation and one which must be controlled. I recommend that:

(a) If the appropriate laws are relaxed to enable turtles to be sold as curios they be relaxed to permit no more than the manufacture and sale of 10,000 stuffed turtles per annum.

(b) Stuffed turtles should be sold only from Great Barrier Reef souvenir shops as an article depicting the wonders of this area. Australia should not permit marketing of stuffed Australian turtles on overseas markets. It is my opinion that is would not be possible to produce the number of stuffed turtles required to satisfy the demand that would be created world wide.

(c) At the above level of sales the 'Torres Strait Turtles Pty Limited' could augment its income by $20 per turtle or $100,000 – $200,000 per annum.

Tortoise Shell

In respect of tortoise shell from Hawksbill turtles there is a steady demand for shell at substantial prices but it is not possible to determine a growth factor. It is reasonable to assume that the growth of demand in this area is limited.

Assessment of prices

'5. TO MAKE AN ASSESSMENT OF THE GENERAL LEVEL OF PRICES THAT WOULD BE OBTAINED FOR THE PROJECT'S PRODUCTS AND THE SALES LEVELS THAT COULD BE REASONABLY EXPECTED IN THE INITIAL YEARS OF OPERATIONS AND TO IDENTIFY MAJOR FACTORS WHICH COULD INFLUENCE THESE ESTIMATES'.

Appendix 10 (1) sets out the sales levels that could be reasonably expected.

Appendix 10 (2) attached sets out the assessment of the general level of prices that would be obtained for the turtle products and it should be noted in particular that a 100 lb live weight green sea turtle could be reasonably expected to produce sales amounting to $100 F.O.B. Australian main port.

To consider marketing

'6. TO CONSIDER WHAT MARKETING ARRANGEMENTS WILL ENABLE THE PROJECT TO OBTAIN MAXIMUM ADVANTAGE FROM ITS MARKET OPPORTUNITIES BOTH IN AUSTRALIA AND OVERSEAS'.

It should be noted that the projected total sales should be approximately $1 million per annum when the project is in full operation. To establish a traditional network of sales outlets on a turnover of only $1 million is not economically possible because the margins for selling are comparatively small. Accordingly, I am strongly of the opinion that, in respect of turtle product sales (both in Australia and overseas), the operating company should enter into arrangements with existing organisations who have the marketing outlets in Australia and overseas and, therefore, the marketing intelligence to service those markets.

Using marketing agencies

To assess investment level $3.6 million

'7. TO ASSESS THE DESIRABLE LEVEL OF INVESTMENT IN THE PROJECT AND TO ESTIMATE THE RETURN ON FUNDS INVESTED'.

I am of the opinion that the desirable level of investment in the project should be about $3.6 million including research costs to date and the return on these funds invested should be approximately 6.5 per cent per annum (non- compound).

Appendix 11 sets out detail of the calculation and assumptions made in arriving at these figures.

To consider company structure

'8. TO CONSIDER WHETHER THE COMPANY STRUCTURE THAT HAS BEEN ADOPTED IS AN APPROPRIATE MODE OF ORGANISATION FOR THE INDUSTRY WITH PARTICULAR REFERENCE TO THE FOLLOWING QUESTIONS:

A THE EXTENT TO WHICH THE VARIOUS FACETS OF THE PROPOSED TURTLE INDUSTRY SHOULD BE SEPARATED OR INTEGRATED EITHER WITHIN THE SAME ORGANISATION OR IN SEVERAL ORGANISATIONS

B THE MOST APPROPRIATE MODE OF ORGANISATION FOR THE INDUSTRY AS A WHOLE AND ITS VARIOUS FACETS (E.G. CO-OPERATIVES, ONE PROPRIETARY COMPANY. STATUTORY AUTHORITY).

Appendixes 5, 6 and 7 set out the corporate structures which I envisage as being appropriate for the proposed industry. As previously stated I do not consider that the existing company structure is now appropriate.

General recommend-ations

'9. GENERAL RECOMMENDATIONS AND SUMMARY'.

To communicate the feeling and social environment of this project in a traditional feasibility study is difficult and I have therefore made these comments with the purpose of highlighting factors influencing the report.

Need for cash income

Firstly there is a real need for the Island people to earn a cash income. They want an income but there is little scope for industry other than that involving the sea. A modern fishing industry is difficult to envisage in this area because of remoteness and the resulting transport costs which destroy the small margins available in this industry. It would appear that the only workable basis would be a fishing industry on a huge scale which would probably destroy the Islanders' cultural environment.

Provision of employment

Secondly, the young men of the Islands have migrated to the mainland in search of employment. There does appear to be an undercurrent of desire that the men will return to the Island's if there is work. This project will provide work.

Scientific studies

Thirdly, there is a series of scientific studies to be undertaken in this area and the local knowledge of the Islanders is such that they would be excellent field assistants in the collection of the mass of data required for these projects.

Development of project

The project has grown from a research and development situation over a period of approximately 3 years to a stage where it has to either proceed as a research and development study or be converted into a business venture. Because the project is at the crossroads, and because there has been a lack of overall business objectives as distinct from scientific objectives, there is considerable confusion and inconsistency within the management of the turtle project simply because of the lack of understanding of these basic objectives. To move from this hiatus and confusion position into a business venture is not an easy task and much of the report to date states, in effect, what should happen eventually. However, to convert the present into something considerably more ideal several intermediate stages will be involved and so, I have scheduled a course of action (Appendix 12) to set the project in to a correct business environment bearing in mind that the ownership, management and organisation of the industry should be appropriate to the social environment of the people involved. It should be noted the project can have considerable scientific benefits provided that the scientific research undertaken is clearly defined, the objectives known, and the work entailed is in parallel with the business venture. I believe the relevant research and the commerical viability of the project can be co-ordinated.

Recommend-ations

In summary my recommendations are:

(1) The turtle farmers should be consulted for their

comment on the implementation of the report in terms of their requirements.

(2) The business of growing turtles for meat and shell should proceed as a commercial undertaking on the basis detailed in this report, including producers' co-operatives and a processing/marketing company.

(3) The management structure should be re-organised to give the planning, direction and co-ordination that the project needs and deserves.

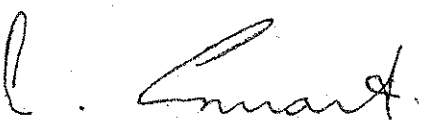
(4) The constraints listed in Appendix 13 should be carefully studied and decisions taken dependent on the outcome of those studies.

(5) The sale of stuffed turtles as curios, if permitted, should be subject to control.

(6) The existing company Applied Ecology Pty Limited should remain as research and development technical advisor.

(7) The companies Aboriginal and Islander Products Pty Limited and Aboriginal and Islander Marketing Pty Limited should be liquidated.

(8) In respect of turtle farming areas other than Torres Strait such as Mornington Island and Cape Leveque these farms can be brought into the business venture (if they so desire) as soon as they are numerically strong enough to own and operate their area co-operative.



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51 Queen Street,
Melbourne, 3000

LIST OF APPENDIXES

APPENDIX 1: TURTLES; Terms of reference of Inquiry into Organisation, Management and Market Prospects

1. To examine the organisation and management structure of the companies which have been set up in the context of the turtle farming project in Northern Australia and to consider whether and in what ways they might be improved. In particular to consider whether the administrative headquarters should be located in Canberra or elsewhere.
2. To consider whether from a commercial viewpoint the financial management is effective and whether the management control reports and accounting practices that have been implemented are appropriate.
3. To estimate production costs for the products the project will initially produce (paying particular attention to the importance of labour costs) and to set out the assumptions on which these estimates are based.
4. To assess current demand for these products and expected growth for the next five years.
5. To make an assessment of the general level of prices that would be obtained for the project's products and the sales levels that could reasonably be expected in the initial years of operations and to identify major factors which could influence these estimates.
6. To consider what marketing arrangements would enable the project to obtain maximum advantage from its market opportunities both in Australia and overseas.
7. To assess the desirable level of investment in the project and to estimate the return on funds invested.
8. To consider whether the company structure that has been adopted is an appropriate mode of organisation for the industry with particular reference to the following questions:
   (a) the extent to which the various facets of the proposed turtle industry should be separated or integrated either within the same organisation or in several organisations
   (b) the most appropriate mode of organisation for the industry as a whole and its various facets (e.g. co-operatives, 1 proprietary company, statutory authority).
9. To report on the matters considered to the Special Minister of State by 1 November including recommendations on the organisation and management of the project and on the directions in which the project should develop its marketing resources and policies.

NOTE: In the course of this assignment the following considerations should be borne in mind:

(a) It is desirable that ownership of the industry should be vested in the communities farming the turtles.

(b) These communities should, to the greatest extent feasible, manage the industry.

(c) The organisation of the industry must be appropriate to its commercial as well as its social environment and facilitate the best use of the resources employed.

APPENDIX 2: OUTLINE OF APPROACH TO THIS INQUIRY

1. Undertake background reading and briefing.
2. Draft an outline report for clarifying key factors and major issues pursuant to the items detailed in the terms of reference.
3. Undertake familiarisation tour of turtle project area in conjunction with Dr Carr and Professor Main with the objects of:
   (a) gaining first hand knowledge of the project
   (b) examining the problems (if any) of communication, lack of consistency and delegation of control
   (c) relating the actual scene to the background data and financial data available from Canberra
   (d) collecting data which may influence the analysis of the project

   and, in particular, equating the problems affecting the ecology and social structure with the organisation management and market prospects.
4. Prepare a questionnaire and data collection list for information required ex Canberra.
5. Visit and study the operations of Applied Ecology Pty Limited.
6. Consider the facts and findings and ensure that terms of reference are maintained.
7. Discuss key factors as determined with Department, Dr Carr and Professor Main.
8. Prepare draft report.
9. Discuss draft report with Department of the Special Minister of State and others as instructed.
10. Present final report.

APPENDIX 3: OBJECTIVES, STRATEGY AND GENERAL DESCRIPTION OF THE PROPOSED DEVELOPMENT OF THE TURTLE PROJECT INTO A REASONABLY VIABLE BUSINESS

Objectives

1. To create meaningful employment for the Islanders in occupations which are in reasonable harmony with their traditional way of life.
2. To develop an infrastructure of meaningful activity for the Islanders which will assist in obtaining economic independence in the Islands.
3. To encourage migration of Islanders back to their homes by creation of employment.
4. To conserve the various species of turtle in Northern Australia.
5. To farm turtles, process, market primarily as a source of food and co-ordinate the business within reasonable economic lines in harmony with the way of life of the Islanders.

Strategy

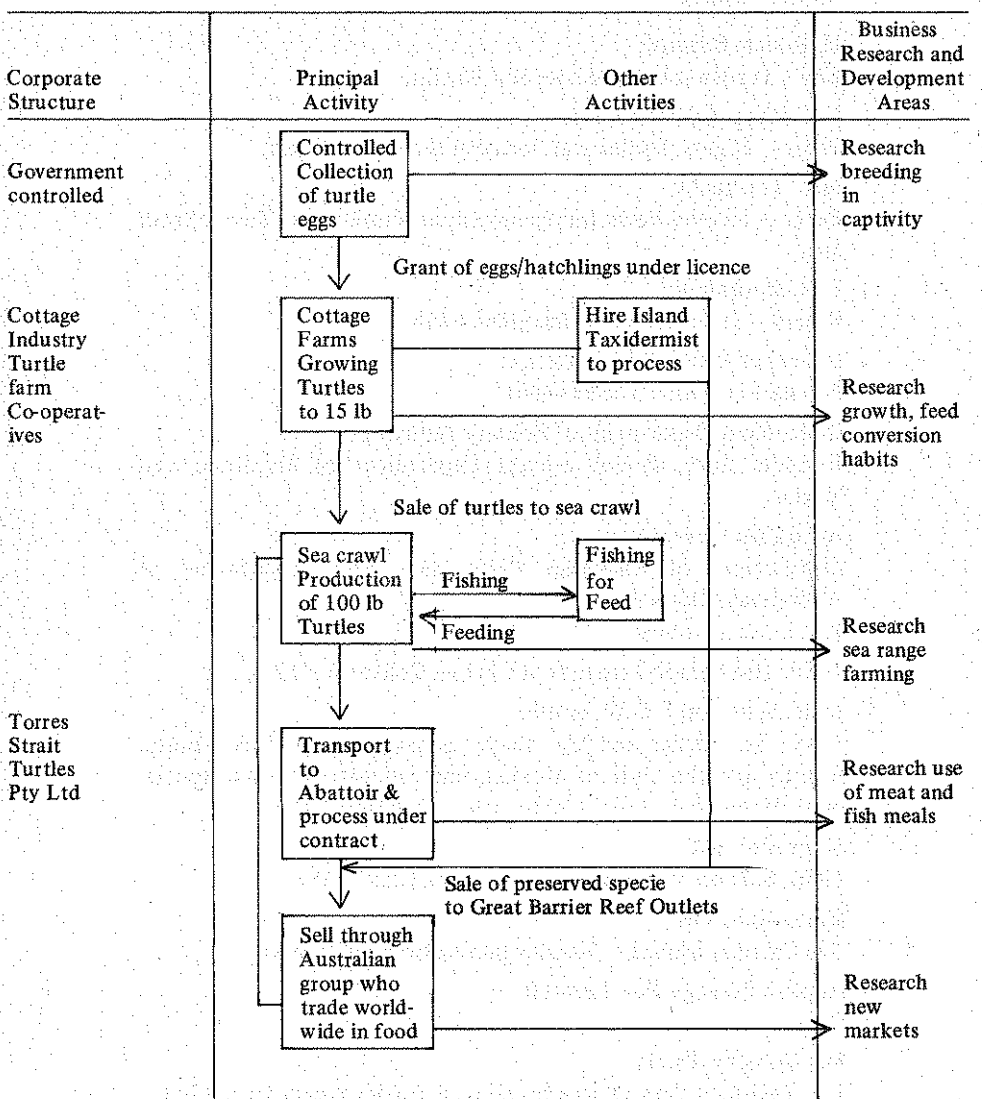
1. Ownership and management of the project as far as possible, should be in the hands of Islanders to ensure that the Islanders' requirements are recognised.
2. Meaningful employment to be created through the cottage industry concept with the 'intensive farming' set aside as a separate commercial venture to enable economical use of capital invested and technical expertise.
3. Research and development into turtles to be in parallel with but segregated from the business ventures.
4. Business strategy to be based on low capital involvement and inexpensive production costs to enable the cottage industry concept to compete on the open world markets with intensive farming high capital cost systems of operation.
5. Minimal overhead structure to assist in competing for sales on the open market.

General Description of the proposed turtle farm.

From a controlled collection of turtle eggs Islanders grow turtles in tanks about 10' x 10' x 1' located on the foreshore of their Islands. The Islanders feed the turtles from fish caught by them on the shallow reefs. It is proposed that the turtle, when it is 15 lb, would be 'sold' to a sea crawl being a paddock in the sea – where they would be cared for by bulk feeding of fish caught from trawlers. When the turtle reached 100 lb weight it would be delivered to an abattoir – say Wyndham – for contract processing and selling. As a side-line a controlled

number of turtles 5,000-10,000 per annum would be stuffed by trained Island taxidermists for sale ONLY to marine gift tourist shops located in the tourist resort areas on the Great Barrier Reef. The economics of this exercise have been calculated excluding any proceeds from a limited sale of stuffed turtles.

Chart of the proposed business of turtle farming



APPENDIX 4: SOURCE OF INFORMATION AND ACKNOWLEDGEMENTS

Queensland Government:
The Land Acts 1962 to 1968 and amendments.

Dr A. Carr:
So excellent a Fishe.

Queensland Department of Aboriginal and Island Affairs:
Annual reports.

H. Robert Bustard:
Kay's Turtles and Australian Sea Turtles.

E.K. Fiske and Maree Tait:
Paper – Rights, Duties and Policy in the Torres Strait.

M.L. Treadgold:
Paper – Income flows and economic structure in the Torres Strait area.

F.W. Moorhouse:
Papers – 1933. Notes on the green turtle.

Bureau of Census and Statistics:
Population census Torres Strait.

Queensland Department of Primary Industries:
Extracts from annual reports Department of Harbours and Marine.

Australian Government:
Department of Overseas Trade data and Department of Aboriginal Affairs data.

Deraniyagala, P.E.P.:
1939. The tetrapod reptiles of Ceylon, Colombo, 412 p.

Ingle, R.M. and F.G.W. Smith:
1949. Sea turtles and the turtle industry of the West Indies, Florida and the Gulf of Mexico, with annotated lists in special publ. Marine Lab. Coral Gables, Univ. of Miami. 107p.

Schroeder, R.E.:
1966. Buffalo of the Sea. Sea Frontiers 12:176:183.

Mariculture Ltd.:
The Cayman Islands – Various publications and reports.

Applied Ecology Pty. Limited:
Data.

Mrs Dorothy Tanus:
For statistical data of weight gains of turtles grown in captivity.

Sir Alexander Gibb & Partners: For learned comment of preliminary costs of construction of causeways for sea crawl.

APPENDIX 5: APPLIED ECOLOGY PTY LIMITED

Objectives (amended)

To initiate and carry out pure and applied scientific researches and investigations.

To undertake pilot studies, schemes, projects and activities to demonstrate the feasibility of research work and investigations.

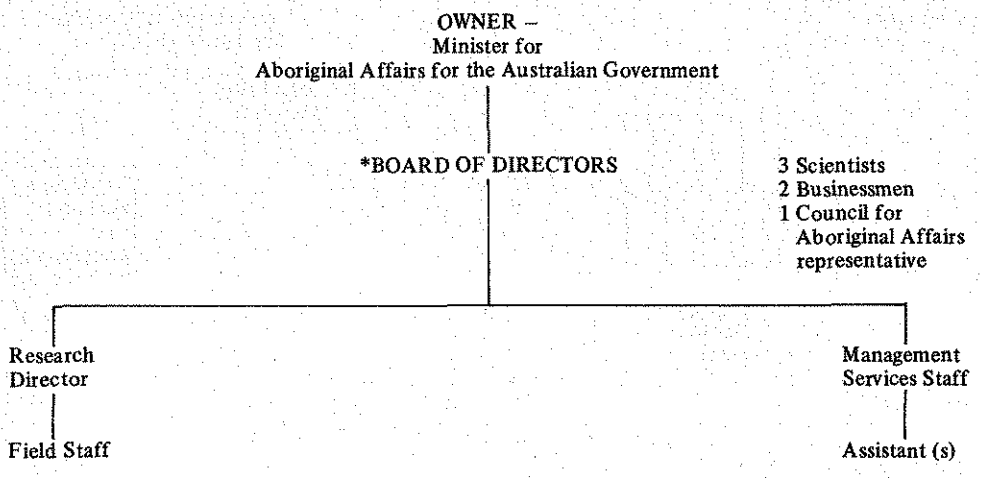
To provide scientific research services, manpower and support to projects which they originally initiated and to others.

To collect and disseminate information.

To achieve a record of performances which will ensure the continuation of grants from the Australian Government and research institutions, and in particular,

To achieve the above objectives in respect of flora and fauna of Australia involving Australian Aborigines and/or Islanders.

Management Chart



* The board of directors is appointed by the Australian Government via the Minister who would seek grants in the proper manner from the Department and also from research institutions.

APPENDIX 6: COTTAGE INDUSTRY TURTLE FARM CO-OPERATIVES; EASTERN, CENTRAL AND WESTERN

Objectives

To grow green sea turtles from hatchlings to a weight of 15 lb each in approximately 2 years 8 months.

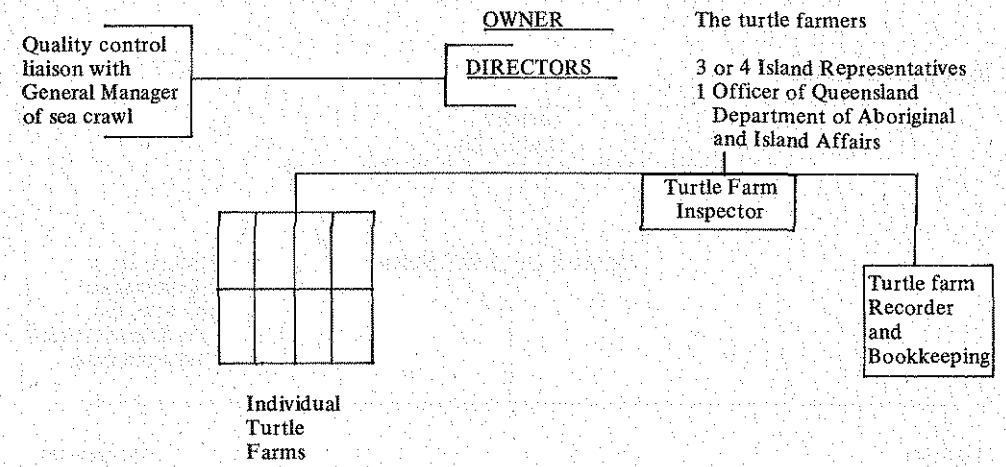
To grow turtles in a cottage farm environment.

To contract all the live turtles to 'Torres Strait Turtles Pty Limited'.

To gain an adequate cash income for the turtle farmers without adversely affecting their way of life.

To operate the quality standard controls on a group or co-operative basis to minimise expense and to ensure consistent standards of product.

Management Chart



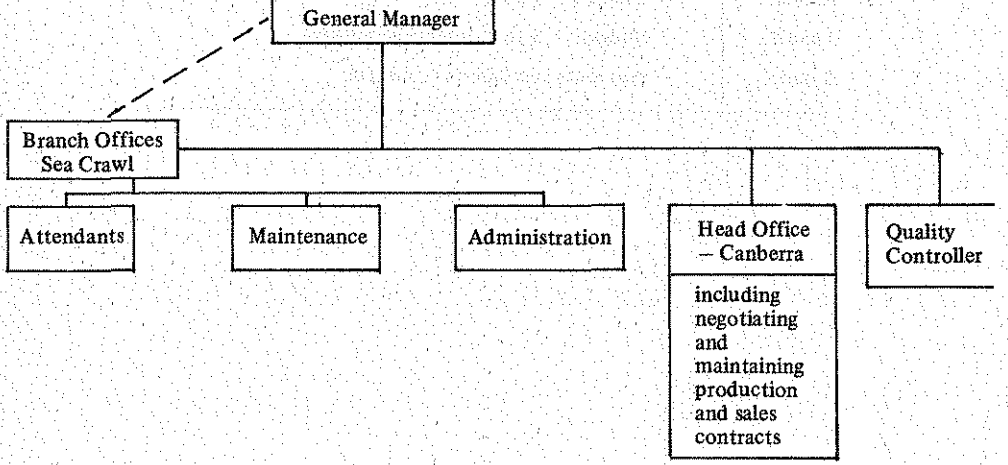
APPENDIX 7: TORRES STRAIT TURTLES PTY LIMITED

Management Chart

OWNER — The 3 Co-operatives and the Australian Governmei

BOARD OF DIRECTORS

3	Islanders (1 from each co-operative)
2	Businessmen
5	Directors
2	Government observers; 1 from Queensland and 1 from the Australian Government
7	



APPENDIX 8: SCHEDULE OF SUGGESTED MANAGEMENT AND ACCOUNTING REPORTING

Period	Report
Monthly	– Turtle stock reports showing Number of turtles Age of turtles Sold since last report Dead and missing since last report Hatchlings since last report.
Monthly	– Schedule of expenditure for the month and period to date compared with budget.
Monthly	– Fish feed weights fed to turtles during the month.
Monthly	– Schedule of growth rates of selected turtles.
Monthly	– Monthly financial statements.
Annual	– Budgets – 1 year
Annual	– Budgets – 5 year (updated annually)
Annual	– Accounts and reports – audited.

APPENDIX 9 (1): PROJECTED ESTIMATES OF PRODUCTION COSTS

TURTLES FROM 15 LB GROWN TO 100 LB GROWN IN SEA CRAWLS

Number of years	Cumulative	1	2	3	4	5	6	7	8	9	10	15
		figures in round '000s										
Cost of turtles from cottage farms	$4,125	–	–	165	330	330	330	330	330	330	330	330
Feeding costs												
Cost of collection of 50 tons of fish per day 4 trawlers at an operating cost of $30,000 each per annum	1,500	–	–	60	120	120	120	120	120	120	120	120
Production costs												
Amortization and maintenance of pens	* 600	–	–	30	30	30	30	30	30	30	30	30
Sea Crawl attendants	325	–	–	25	25	25	25	25	25	25	25	25
Veterinary services	390	–	–	30	30	30	30	30	30	30	30	30
Administration												
Communications	260	–	–	20	20	20	20	20	20	20	20	20
Management Services	650	–	–	50	50	50	50	50	50	50	50	50
Freight and Cartage	920	–	–	–	–	80	80	80	80	80	80	80
	$8,770	–	–	380	605	685	685	685	685	685	685	685

*A preliminary cost of sea crawls and maintenance thereof has been estimated in conjunction with consulting engineers experienced in Island causeway constructing. A causeway 20 feet high and 1 mile long is estimated to cost $600,000 and have a life span of at least 20 years. Although a sea crawl has not been designed based on data from Mariculture Ltd it has been calculated that a 1 mile causeway would enclose an area more than adequate for the number of turtles to be housed.

APPENDIX 9 (2): PROJECTED ESTIMATES OF PRODUCTION COSTS

Number of Years		1	2	3	4	5	6	7	8	9	10	15
One average turtle farm direct costs												
Training allowance	$	1600	1600	1600	–	–	–	–	–	–	–	–
Internal Sales		–	–	1650	3300	3300	3300	3300	3300	3300	3300	3300
Operating Costs – as per Schedule (9(3))		50	50	50	50	50	50	50	50	50	50	50
Annual Total	$	1650	1650	3300	3350	3350	3350	3350	3350	3350	3350	3350
100 Turtle farm group production costs												
Material		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Labour		40160	40160	40160	45160	45160	45160	45160	45160	45160	45160	45160
Expense		12600	12600	12600	12600	12600	12600	12600	12600	12600	12600	12600
Annual Total	$	64760	64760	64760	69760	69760	69760	69760	69760	69760	69760	69760
Proportion of group turtle farm production costs per ONE farm (say)	$	650	650	650	650	650	650	650	650	650	650	650
Summary of estimated total production costs to point of transfer of turtles to sea crawls @ 15 lb – 3 years												
Direct Farm costs		165000	165000	330000	330000	330000	330000	330000	330000	330000	330000	330000
Farm Group Costs		65000	65000	65000	70000	70000	70000	70000	70000	70000	70000	70000
Annual Total		$230000	230000	395000	400000	400000	400000	400000	400000	400000	400000	400000
Cumulative Total		$230000	460000	855000	1255000	1655000	2055000	2455000	2855000	3255000	3655000	5655000
Net Income to farmer before tax and before interest of turtles grown to 15 lb.	$	900	900	2550	2600	2600	2600	2600	2600	2600	2600	2600

NOTE: In all cost and sales calculations no provision has been made for inflation. Because the project is assessed as a basic commodity – foodstuffs – cost increase could tend to be offset by increased sale prices.

APPENDIX 9 (3): PROJECTED ESTIMATES OF OPERATING COSTS FOR ONE 'AVERAGE' TURTLE FARM

Period of Activity	Activity	Estimated Capital Cost	Estimated Annual Operating Cost Excluding Labour	Labour Time
Development time	Construct farm tank	10		5 days
	Construct farm shelter	8		3 days
"	Construct farm drainage	10		
"	Construct work bench	5		
"	Purchase mincer and knives	5		
"	Purchase buckets	5		
"	Purchase fishing gear	12		2 days
"	Purchase spring scales	5		
		$60		10 days
Annual	Amortisation		$ 5	–
Annual	Collect eggs or hatchlings			–
Daily	Water turtles			See below
Daily	Drain water			1 hour
Daily	Clean farm			½ hour
Daily	Water turtles			2½ hours
Daily	Feed turtles			½ hour
Daily	Collect fish			2½ hours
Daily	Maintain equipment		$20	½ hour
Daily	Record fishing time			
Daily	Record weight of feed		$1	½ hour
Daily	Record dead or missing			
Daily	Record weight of turtles			
				8 hours
Monthly	Report monthly			N/A
	Medication		$24	N/A
		$60 per farm	$50 p.a.	8 hours * per day

*With reticulation this time would reduce to 5-6 hours per day. Furthermore, the activity would be more appropriate, then, to the Islanders' traditional way of life.

APPENDIX 9 (4) PROJECTED ESTIMATES OF TURTLE NUMBERS, WEIGHTS AND FEED

Number of years			1	2	3	4	5	6	7	8	9	10	15
One Average Turtle Farm													
Number	Age	– 1 yr	150	150	150	150	150	150	150	150	150	150	150
		– 2 yr	–	122	122	122	122	122	122	122	122	122	122
		– 3 yr	–	–	110	110	110	110	110	110	110	110	110
			150	272	382	382	382	382	382	382	382	382	382
Weights	1 lb @	– 1 yr	150	150	150	150	150	150	150	150	150	150	150
	6 lb @	– 2 yr	–	732	732	732	732	732	732	732	732	732	732
	20 lb @	– 3 yr	–	–	2200	2200	2200	2200	2200	2200	2200	2200	2200
			150	882	3082	3082	3082	3082	3082	3082	3082	3082	3082
Feed per Day	4 oz	– 1 yr	38	38	38	38	38	38	38	38	38	38	38
	1 lb	– 2 yr	–	122	122	122	122	122	122	122	122	122	122
	2 lb	– 3 yr	–	–	220	220	220	220	220	220	220	220	220
			38	160	380	380	380	380	380	380	380	380	380
Above product from One 'Average' Turtle Farm transferred to a sea crawl													
Number	Age	– 4 yr	–	–	–	99	99	99	99	99	99	99	99
		– 5 yr	–	–	–	–	90	90	90	90	90	90	90
		– 6 yr	–	–	–	–	–	80	80	80	80	80	80
			–	–	–	99	189	269	269	269	269	269	269
Weights	45 lb	– 4 yr	–	–	–	4 455	4455	4455	4455	4455	4455	4455	4455
	100 lb	– 5 yr	–	–	–	–	9000	9000	9000	9000	9000	9000	9000
	120 lb	– 6 yr	–	–	–	–	–	9600	9600	9600	9600	9600	9600
				–	–	4455	13455	23055	23055	23055	23055	23055	23055
Feed per pay	3 lb	– 4 yr	–	–	–	297	297	297	297	297	297	297	297
	4 lb	– 5 yr	–	–	–	–	360	360	360	360	360	360	360
	5 lb	– 6 yr	–	–	–	–	–	400	400	400	400	400	400
			–	–	–	297	657	1057	1057	1057	1057	1057	1057

APPENDIX 9 (5): PROJECTED ESTIMATES OF TURTLES, NUMBERS, WEIGHTS AND FEED AGGREGATE OF 100 FARMS

Number of years		1	2	3	4	5	6	7	8	9	10	15
NUMBER	Age – 1 yr	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
	– 2 yr	–	12200	12200	12200	12200	12200	12200	12200	12200	12200	12200
	– 3 yr	–	–	11100	11100	11100	11100	11100	11100	11100	11100	11100
	– 4 yr	–	–	–	9900	9900	9900	9900	9900	9900	9900	9900
	– 5 yr	–	–	–	–	9000	9000	9000	9000	9000	9000	9000
	– 6 yr	–	–	–	–	–	8000	8000	8000	8000	8000	8000
		15000	88200	38300	48200	57200	65200	65200	65200	65200	65200	65200
WEIGHTS	1 lb @ – 1 yr	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
	6 lb @ – 2 yr	–	73200	73200	73200	73200	73200	73200	73200	73200	73200	73200
	20 lb @ – 3 yr	–	–	220000	220000	220000	220000	220000	220000	220000	220000	220000
	45 lb @ – 4 yr	–	–	–	445500	445500	445500	445500	445500	445500	445500	445500
	100 lb @ – 5 yr	–	–	–	–	900000	900000	900000	900000	900000	900000	900000
	120 lb @ – 6 yr	–	–	–	–	–	960000	960000	960000	960000	960000	960000
		15000	88200	308500	753700	1653700	2613700	2613700	2613700	2613700	2613700	2613700
FEED PER DAY	4 oz – 1 yr	3800	3800	3800	3800	3800	3800	3800	3800	3800	3800	3800
	1 lb – 2 yr	–	12200	12200	12200	12200	12200	12200	12200	12200	12200	12200
	2 lb – 3 yr	–	–	22000	22000	22000	22000	22000	22000	22000	22000	22000
	3 lb – 4 yr	–	–	–	29700	29700	29700	29700	29700	29700	29700	29700
	4 lb – 5 yr	–	–	–	–	36000	36000	36000	36000	36000	36000	36000
	5 lb – 6 yr	–	–	–	–	–	40000	40000	40000	40000	40000	40000
		3800	16000	38000	67700	103700	143700	143700	143700	143700	143700	143700

APPENDIX 10 (1): PROJECTED ESTIMATES OF INCOME FROM SALE OF TURTLES AGGREGATE OF 100 FARMS

Number of Years	1	2	3	4	5	6	7	8	9	10	15
External Sale											
Gross Sales excluding curios	$ –	–	–	–	900000	900000	900000	900000	900000	900000	900000
Cumulative	$ –	–	–	–	900000	1.80 m	2.70 m	3.60 m	4.50 m	5.40 m	9.90 m
Projected estimates of 'farmer' subsidy and 'internal' sale of 15 lb weight turtles											
Annual payments to 100 farmers	$160000	160000	325000	330000	330000	330000	330000	330000	330000	330000	330000
Cumulative	$160000	320000	645000	975000	1305000	1635000	1965000	2295000	2625000	2955000	4605000
Projected estimates of gross values of turtles											
$1.00 per inch of carapace $ 6 ea. – 1 yr	$ 90000	90000	90000	90000	90000	90000	90000	90000	90000	90000	90000
$2.00 per lb $ 12 ea. – 2 yr	–	146400	146400	146400	146400	146400	146400	146400	146400	146400	146400
$2.00 per lb $ 40 ea. – 3 yr	–	–	444000	444000	444000	444000	444000	444000	444000	444000	444000
$1.60 per lb $ 72 ea. – 4 yr	–	–	–	712800	712800	712800	712800	712800	712800	712800	712800
$1.20 per lb $120 ea. – 5 yr	–	–	–	–	900000	900000	900000	900000	900000	900000	900000
$1.33 per lb $160 ea. – 6 yr	–	–	–	–	–	–	–	–	–	–	–
	$ 90000	236400	680400	1393200	2293200	2293200	2293200	2293200	2293200	2293200	2293200

APPENDIX 10 (2): CALCULATIONS OF SELLING PRICES OF TURTLES

Green turtles – based on prices received from World markets

Weight 100 lb	Approx. weight* lb	F.O.B. Price per lb $	Price F.O.B. $
Steak meat	12	1.20 per lb	14.40
Industrial red meat	24	50 per lb	12.00
Breast plates and back plates	20	50 per lb	10.00
Gellatinous meat	6	1.05 per lb	6.30
Flippers	12	40 per lb	4.80
Liver, heart and kidney	4	25 per lb	1.00
Skins	5	2.00 per lb	10.00
Refined Oil	4	8.20 per lb	32.80
Shell as artifacts	5	5.10 per lb	25.50
Non-edible material	8	6 per lb	.48
	100 lb.		$117.28

Live turtles – based on United States import statistics.

1971	$2.10 Aust.	per lb of live turtle
1972	$2.60	per lb of live turtle

Based on the above quoted U.S. prices a 120 lb live turtle C.I.F. U.S.A. is valued at

1971	$252	per 120 lb turtle
1972	$312	per 120 lb turtle.

Hawksbill turtles

The price of Hawksbill turtle shell is variable due to shell patterns, thickness and outlets. In Japan, for example, a large shell can sell at $51 Australian per lb giving a value of $250-$350 per turtle. However, a value of in excess of $100 is considered realistic.

Assumption

From examination of the marketing data available and selling turtle products on a consistent annual basis a value of $100 Aust. F.O.B. is, in my opinion, a realistic price for a 100 lb turtle.

* The weight calculations have been calculated from data received from numerous sources. It would appear that additional quality meats can be extracted from the industrial red meat but for the purpose of the exercise I have erred towards conservatism.

APPENDIX 10 (3): NOTES ON MAJOR FACTORS AFFECTING SALES VALUES

1. Consistency of supply and quality should assist in the establishment of a stable market and price.
2. The major World supplier – Mariculture Limited – is likely to expand its operations. Accordingly, there could be temporary price declines, from time to time, as additional product is absorbed into the market.
3. As the demand for high protein meat is growing rapidly the farming activities should be concentrated on green sea turtles rather than hawksbill. The hawksbill shell markets, although apparently lucrative, do not have the apparent growth in demand as does the meat and oil market.

APPENDIX 11: ESTIMATE OF LEVEL OF INVESTMENT IN THE PROJECT

Schedule of Capital Works

Water reticulation on farms				
$2,000 per farm x 100 farms			$	200,000
Sea crawl – causeway				600,000
Cold storage units				150,000
Housing				100,000
Other out buildings				50,000
Trawlers				200,000
				1,300,000
Establishment costs – to date	Say	*		500,000
Additional 4 months @ $55,000		*		220,000
				2,020,000
Pre income operating costs				
Farmer allowances				
and costs	Year 1	see above	*	
	Year 2	see above	*	
	Year 3			350,000
	Year 4			575,000
	Year 5			655,000
				$3,600,000

Return on total funds invested including training allowances and research and development.

Year	Capital	Cumulative Profits before tax and before interest
1	$ 500000	
2	2020000	**Calculation**
3	2370000	Sales $ 9.900000
4	2945000	Stocks 2.293200
5	3600000	12.193200
6	3600000	
7	3600000	Total
8	3600000	Expenses 8.770000
9	3600000	$ 3.423200
10	3600000	
To		Non-compound
15	$3600000	$3423200 average annual return = 6.5% (approx.)

APPENDIX 12: SCHEDULE OF ACTION

To proceed with the recommendations detailed herein and, after discussion with the Islanders, a General Manager (elect) should be appointed. His duties would be:

1. To arrange for an examination of the constraints.
2. To arrange for the continuing administration of the turtle project and the formation of the various Co-operatives.
3. To form Torres Strait Turtles Pty Ltd and to develop the project into the business as outlined in the report.

At the same time, the proposed Board of Directors should be formed into a committee to advise and assist the General Manager elect until the Torres Strait Turtles Pty Ltd company is incorporated. At that time they would be appointed as directors. Once the company has been structured the Directors and General Manager would continue to be responsible for the implementation of the project.

As a separate exercise, action should be taken to liquidate the two companies referred to in the report.

In respect of Applied Ecology Pty Limited, direction as suggested in the report can be implemented simply by advising the Board of Directors of the company the requirements of the shareholder (The Australian Government).

APPENDIX 13: CONSTRAINTS

The following items are key factors which have to be examined in relation to the turtle project.

1. Export of turtle products.
   The laws applicable to endangered species should be considered and where appropriate provision made to permit farming of turtles and the export of turtle product.
2. Control of sale of turtles as curios.
   A procedure to ensure adequate control of sale of turtles as curios has to be adopted and it would appear that the procedure involves both the Queensland State Government and the Australian Government.
3. Sea crawls.
   The proposed sea crawl has to be designed and firm costs estimated. The preliminary estimates to date are based on assumptions concerning location, estimated tidal movements and other matters which have yet to be determined. The preliminary cost estimates are subject to the results of a detailed study.
4. Anthropological.
   The final location of the proposed sea crawl has to be agreed by the Islanders as there are anthropological reasons to be considered.

ADDENDUM TO REPORT ON AN INQUIRY INTO ORGANISATION, MANAGEMENT AND MARKET PROSPECTS OF A TURTLE FARMING PROJECT IN NORTHERN AUSTRALIA

The worm infestation which has been reported is the sort of detailed management matter which should be resolved in the preliminary stages of the proposed project. However, to clarify the issue I would be pleased if you would append to my report the following paragraph in appendix 13 (Constraints) as point number 5.

'5. Animal Husbandry
The diseases (if any) afflicting turtles should be studied to ensure that they cannot be transmitted to humans. Historically it would appear that there has been no serious problem, however problems similar to those encountered in raising livestock on farms could appear in turtles. Products from turtles afflicted in any way could be condemned unsuitable for human consumption as is done in the meat industry'.