The status of the dugong in the northern Great Barrier Reef Marine Park

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EXECUTIVE SUMMARY

1. Australia has international responsibilities for the management of dugongs in the Great Barrier Reef Region. One of the World Heritage values of the Region is that it "provides major feeding grounds for large populations of the endangered species *Dugong dugon*". In addition, the dugong has high biodiversity value as the only species in the Family Dugongidiae and one of only four species in the Order Sirenia, all four species of which are listed as vulnerable to extinction by the World Conservation Union.

2. Aerial surveys for dugongs were conducted over an area of some 25,800 km^2 in the inshore waters of the Great Barrier Reef Marine Park (GBRMP) between 15th November and 4th December 1995. Survey specific correction factors were used to correct for perception bias (the proportion of animals visible in the transect which are missed by observers) and to standardise for availability bias (the proportion of animals that are invisible due to water turbidity).

3. These surveys indicate that the number of dugongs in the region has not changed significantly since the mid 1980s. However, it is important to appreciate that this is regional-scale assessment which is not capable of detecting local-scale declines unless they are very large.

4. Threats to dugongs in this region include incidental mortality in mesh nets, traditional hunting and habitat loss. Areas where the magnitude of these threats may be locally unsustainable include: southern Princess Charlotte and Bathurst Bays where incidental drowning in mesh nets is the major impact and the hunting grounds of the Lockhart River and Hopevale Aboriginal communities.

5. Dugongs are seriously threatened on the coast of the GBR region south of Cooktown and in Hervey Bay. In these regions, dugong numbers have declined precipitously since the mid 1980s. Accordingly, it is essential that dugong numbers are maintained at their current level in the Northern Great Barrier Reef and that the likelihood of local depletions is minimised.

RECOMMENDATIONS

Overall approach

1. That the management of dugongs in the northern Great Barrier Reef be directed at reducing all threatening processes so that their mortality does not exceed sustainable levels. Threatening processes include incidental mortality from mesh netting, traditional hunting, and habitat loss. This approach corresponds with that advocated by the "Turtle and dugong conservation strategy for the Great Barrier Reef Marine Park" (Ellis 1994) and the draft of "A Management Program for the Conservation and Management of the Dugong (*Dugong dugon*) in Queensland" (Queensland Department of Environment and Heritage 1994) being produced under the *Nature Conservation Act 1992* (Queensland).

Indigenous management

2. That the Great Barrier Reef Marine Park Authority offer to assist the Cape York Land Council to develop a culturally appropriate program to enable the peoples of Cape York Peninsula to take responsibility for managing their dugong harvest sustainably through co-management with the Great Barrier Reef Marine Park Authority and the Queensland Department of Environment. The co-management regimes developed to regulate the Indigenous use of marine mammals in Alaska should be investigated as possible models.

3. That the Great Barrier Reef Marine Park Authority continue to urge the appropriate Commonwealth and State Ministers to develop a long-term strategy for the training, career structure and resourcing of Indigenous community rangers so that they may participate effectively in dugong management and research programs.

4. That the Great Barrier Reef Marine Park Authority facilitate processes to ensure that the results of this research are relayed back to Indigenous communities in an effective manner. e.g. community visits, videos, brochures. (Peter Corkeron has already visited Lockhart River in July 1996 under the aegis of the GBRMPA to discuss the survey results).

5. That the Great Barrier Reef Marine Park Authority write to the Queensland Department of Health and ask them to consider the conservation status of dugongs and green turtles in their literature urging Indigenous peoples to eat bush foods.

Fishery interactions

6. That the Great Barrier Reef Marine Park Authority formally request the Queensland Fisheries Management Authority to:

   - Ask the Tropical Finfish Management Advisory Committee to consider measures to protect dugongs in developing the management plan for mesh netting such as:

     * reducing latent effort through a buy-back scheme or restricting netting endorsements to fishers "who could demonstrate a significant commercial level of involvement over a three year period" (The Recreational Fishing Consultative Committee 1993, p. 18).
     * introducing area restrictions on individual netting endorsements,
     * reducing the use of illegal nets by tagging commercial nets with individual identifiers,
     * introducing an amnesty period for the surrender of illegal nets,
     * closing areas where dugongs occur and where the QFMA logbook data indicate that netting has not occurred in the last three years.

   - Change the Fisheries Regulation 1995 Qld to require fishers to report incidental capture of dugongs in their logbooks and make the failure to do so a serious fisheries offence (if this is possible under the Fisheries Act 1994 Qld; if not, consideration should be given to amending the Act).

7. That the Great Barrier Reef Marine Park Authority and the Queensland Fisheries Management Authority develop a policy concerning compensation for fishers whose livelihoods have been affected by effort reduction due to spatial closures established to reduce the ecosystem effects of fishing.

8. That the Great Barrier Reef Marine Park Authority ask the Queensland Commercial Fishermen's Organisation to make special efforts to ensure that fishers working in remote areas such as Cape York are included in the proposed endangered species workshops to be conducted by QCFO in association with the CRC Reef Research.

Habitat Loss

9. That the Great Barrier Reef Marine Park Authority request the Queensland Department of Natural Resources to develop an Integrated Catchment Management Program for the rivers draining into the Great Barrier Reef along the coast of Cape York in view of the plan to increase cattle numbers in the region as foreshadowed in the Draft Stage 2 Report of the Cape York Land Use Study.

Marine Park Management and Zoning

10. That discussions be held with all stakeholders especially traditional owners and fishers about extending the network of Dugong Protected Areas along the eastern coast of Cape York, recognising the principle endorsed by the Great Barrier Reef Ministerial Council (1996) of having Dugong Protected Areas at approximately 200km intervals. In particular, consideration should be given to:

    * establishing a Dugong Protected Area along the southern coast of Princess Charlotte Bay between Port Stewart and Cape Melville (Bathurst Bay being particularly important)
    * zoning Queensland Marine Parks adjacent to the National Park B, Scientific Research and Preservation Zones in the GBRMP in a complementary manner;
    * banning mesh netting in the creeks and rivers that open into these protected areas;
    * banning mesh netting in areas used for traditional hunting.

11. That a significant proportion (e.g. 20%) of deepwater seagrass meadows be closed to trawling in accordance with the Precautionary Principle;

Research

12. That the Great Barrier Reef Marine Park Authority develop a plan for dugong research and monitoring in the World Heritage Area using an established prioritisation process.

13. That the following projects be considered in developing the plan:
    * a program to document the spatio-temporal patterns of dugong hunting and other subsistence activities and the socio-economic factors affecting these patterns in remote communities;
    * a review of existing information on Indigenous knowledge of dugong ecology;
    * satellite tracking to establish information on dugong movements and habitat use in the northern Great Barrier Reef region;
    * seagrass mapping and monitoring;
    * experiments to test the effects of trawling on deepwater seagrasses;
    * the development of cost-effective methods for monitoring the distribution and abundance of seagrasses at various spatial scales;
    * the timing and nature of future aerial surveys to monitor dugong numbers.

Distribution of this report

That copies of this report be made available to interested parties including (but not limited to):

the Cape York Land Council
the Queensland Fisheries Management Authority,
the Chair of the Tropical Finfish Management Advisory Committee,
the Queensland Department of Primary Industries,
the Queensland Department of Environment,
the Queensland Department of Family Services,
the Queensland Commercial Fishermen's Association,
the Australian Nature Conservation Agency, and
the Co-operative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef.
the Indigenous Tropical Health Centre at the University of Queensland
Tropical Public Health Unit of the Queensland Department of Health

INTRODUCTION

Australia has international responsibilities for the management of dugongs in the Great Barrier Reef Region. One of the World Heritage values of the Region is that it "provides major feeding grounds for large populations of the endangered species *Dugong dugon*" (Great Barrier Reef Marine Park Authority (GBRMPA) 1981, p. 7). In addition, the dugong has high biodiversity value as the only species in the Family Dugongidiae and one of only four species in the Order Sirenia. All four extant species of Sirenian are listed as vulnerable to extinction by the IUCN (IUCN 1990).

In 1984, 1985 and 1990, dugongs were counted during an aerial survey over an area of some 31288 km^2 in the inshore waters of the Great Barrier Reef Marine Park between Cape Bedford and Hunter Point (Marsh and Saalfeld 1989 a, Marsh *et al.* 1993). Survey specific correction factors were used to correct for perception bias (the proportion of animals visible in the transect which are missed by observers) and to standardise for availability bias (the proportion of animals that are invisible due to water turbidity (Marsh and Sinclair 1989).

In 1990, the survey resulted in a minimum population estimate of 10,471 $\pm$ s.e. 1578 dugongs at an overall density of 0.33 $\pm$ s.e. 0.05 dugongs km^{-2}, confirming that this region is the most important dugong habitat within the Great Barrier Reef Marine Park and one of the most important in Australia. The result compared with 8,110 $\pm$ s.e. 1037 dugongs at an overall density of 0.26 $\pm$ s.e. 0.03 dugongs km^{-2} in 1985. There was no significant difference between dugong densities in 1985 and 1990, suggesting that dugong numbers were being maintained in the northern Great Barrier Reef region.

Marsh and Saalfeld (1989 a) recommended that the aerial surveys of the region be repeated at five year intervals to monitor the status of the dugong stock. We report here on the third survey in the monitoring series conducted in November-December 1995. The survey indicated that although dugong numbers do not appear to be declining at a regional scale, there are some early indications of a local decline in the hunting grounds of the Lockhart River community.

METHODS

The inshore waters between Cape Bedford (15° 15'S) and Hunter Point (11° 30'S) were surveyed between 15th November and 4th December 1995. In order to increase repeatability, the survey was conducted only when the weather conditions were good (usually Beaufort Sea State < 4; Table 1 and Appendix Table 1). Whenever possible, daily schedules were arranged to: (1) avoid severe glare associated with a low or midday sun, and (2) ensure that very shallow areas were surveyed at high tide. Figure 1 shows the transect design flown in 1995, with the transect design for 1990 displayed for comparison.

Survey methodology

Aerial survey methodology has been detailed by Marsh and Sinclair (1989 a and b) and Marsh and Saalfeld (1989 a). The transect width (200 m on either side of the aircraft at survey altitude) was demarcated with fibre glass rods attached to artificial wing struts

on either side of the aircraft. Each sighting was recorded as being made in the upper, middle or lower third of the transect to facilitate deciding whether simultaneous sightings by tandem observers were of the same group of animals.

Transects were flown in an east-west direction and usually extended from the coast to the outer barrier reef. Transects were spaced 5' latitude apart, except where sampling intensity was increased due to the presence of large seagrass beds. The weather early in the survey was poor, and it would have been impossible to conduct the entire survey in the time available. As a result, the following minor changes were made to the survey design (Figure 1):

1. All transects north of Transect 443, approximately Campbell Point (Figure 1) were truncated immediately to the east of the mid-shelf reefs. No dugongs were observed in this region on the previous surveys (Marsh et al. 1993).
2. The northernmost six transects and one transect just north of Lockhart River were not surveyed.
3. The transects flown in Block 1 matched those flown in the 1985 survey rather than the 1990 survey (resulting in increased coverage of this Block compared with the 1990 survey). In 1990, Block 1 was surveyed at an intensity of 9%, in 1995, it was sampled at 17%.

A total of 25,800 km^2 was surveyed compared with 31,288 km^2 in 1990. A global positioning system mounted in the aircraft facilitated precise and accurate navigation. The aircraft was fitted with a radar altimeter for accurate height control.

Correction factors

As in the previous surveys, population estimates were corrected for perception bias (the groups of animals visible on the transect line that were missed by observers) and availability bias (the groups of animals unavailable to the observers due to water turbidity). The corrections for perception bias were calculated using the Peterson Mark Recapture Model on the basis of the proportion of the relevant sightings seen by one (specified) or both members of each tandem team (Marsh and Sinclair 1989 a). Availability bias corrections for dugongs were calculated by standardising the proportion of dugongs sighted during the survey to the number seen on the surface in clear water where all dugongs were potentially available (Marsh and Sinclair, 1989 a). The corrections for availability bias for dugongs make the untested assumption that a constant proportion of the target species is at the surface and are likely to be conservative.

Analysis

As the transects were variable in area, the Ratio Method (Jolly, 1969; Caughley and Grigg, 1981) was used to estimate the density, population size and associated standard errors for each taxon for each block. Any statistical bias resulting from this method is considered inconsequential due to the relatively high sampling intensity (Table 2, see also Caughley and Grigg, 1981). Input data were the estimated number of dugongs (in groups of fewer than 10 animals) for each tandem team per transect calculated with the corrections for perception and availability biases. The resultant standard errors of the

population estimates were adjusted to incorporate the errors associated with the various correction factors as outlined in Marsh and Sinclair (1989 a). The numbers of dugongs in groups of more than 10 were added to the estimates of the population size and density of the appropriate block at the end of the analysis, as outlined in Norton-Griffiths (1978).

Differences between this survey and the previous surveys in the numbers of dugongs were tested using analysis of variance. Input data were the ln (x+1) corrected counts of dugongs per transect. Adjustments were made for the alterations in survey design. Fixed factors in the model were time and block. Transect was treated as a random factor nested within block. All significance tests were two tailed.

Density diagrams, adjusted for sampling intensity, were produced using the Arc/Info GIS package. A coverage of 5 x 5 nm square grids overlaying the survey area was used to calculate the densities of dugongs.

Density in each cell was calculated as:

$$\text{Density km}^{-2} = \text{Corrected number of dugongs sighted in each cell / Area surveyed in each cell}$$

where, Area surveyed in cell = Transect length in km * Transect width (i.e. 0.4 km).

RESULTS

Group size and composition

A total of 295 groups comprising 491 dugongs was sighted in the northern Great Barrier Reef during the 1995 aerial survey. Figure 2 shows the density diagram derived from dugong sightings. The size and composition of groups are summarised in Figure 3a. A total of 59 (20% of groups) groups were female calf pairs. The proportion of calves in the population (12%) was not significantly different from that observed in 1990 (χ^2_1=0.178, p>0.05). The largest group observed was a herd estimated at 27 animals, seen just south of the Starcke River mouth (Block 2). Another herd estimated at 24 animals was observed between Princess Charlotte Bay and Campbell Point (Block 5).

Population and density estimates

The mean group sizes and correction factors used to calculate the population and density estimates in 1995 are given in Table 3. Appendix Table 2 lists the raw data. The estimates of numbers of dugongs in the various blocks in the survey area for this survey and those in 1984, 1985 and 1990 are given in Table 4. Appendix Figures 1 through 6 are maps of the dugong sightings in the northern Great Barrier Reef in 1995.

In 1995, the highest numbers of dugongs were in Bathurst Bay and Princess Charlotte Bay (Block 5). This region accounted for almost half the dugongs in the survey area and hence is the most important dugong habitat in the Great Barrier Reef region on the coastal waters of Cape York (Table 4). The highest densities of dugongs were

observed in the area off the Starcke River mouth; the inshore area in the vicinity of Campbell Point and Cape Sidmouth; and in Shelburne Bay (Blocks 2, 6 and 11 respectively, Table 4; Figure 2).

A minimum population estimate of 8190 ± s.e. 1172 dugongs at an overall density of 0.32± s.e. 0.045 dugongs km^{-2} was calculated for the region on the basis of the 1995 survey (Table 4). Population estimates for 1985, 1990 and 1995 do not differ significantly (Table 5). Nor was there any significant interaction between time and block suggesting that the regional-scale distribution of dugongs had remained relatively constant.

DISCUSSION

Status of the population

The surveys suggest that dugong numbers are being maintained in the region. However, the survey technique is designed to detect only regional-scale trends and cannot accurately detect changes on a local scale. It would be inappropriate, for example, to use these surveys to evaluate the sustainability of dugong hunting by members of Cape York communities as these activities occur at a local rather than a regional scale.

Given Australia's World Heritage responsibilities to protect dugongs and the difficulty in detecting trends in dugongs populations at spatial and temporal scales useful to management (Marsh 1995a), it important to minimise impacts. Accordingly, we present recent information on impacts on dugongs in this region. All of these impacts must be considered in the context of the dugong's life history. Population simulations (Marsh 1995b) indicate that dugong numbers are unlikely to increase at more than about 5% per year, even if all the females in a population are breeding maximally. The maximum rate of increase must be lower in areas where there is mortality due to incidental drowning in mesh nets and Indigenous hunting.

Using the PBR concept to estimate a sustainable catch

The Potential Biological Removal, or PBR (Barlow et al. 1995; Wade in press) is defined as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The PBR is a product of the following factors:

- the minimum population estimate of the stock N_{min} (defined as the 20th percentile of a log-normal distribution based on an absolute estimate of the number of animals in that stock that is not more than four years old;

- the maximum rate of increase r_m; the default value for Florida manatees (which breed earlier and more often than dugongs) is 0.04;

- a recovery factor (RF) of between 0.1 and 1. The use of a RF less than one allocates a proportion of the expected net production towards population growth and compensates for uncertainties that might prevent population recovery such as biases in the estimation of N_{min} and r_m or errors in the determination of stock structure. Population simulations suggest that the default value for endangered species should be 0.1 and that the default for depleted or threatened stocks or stocks of unknown status should be 0.5. Stocks taken primarily by Indigenous subsistence hunters that are not known to be decreasing could have higher values for RF up to and including 1.

If r_m is assumed to be 0.04 (4%, the default value for manatees) and the RF 0.05 (the default value for stocks of unknown status), the maximum sustainable loss from all anthropogenic impacts is 0.02 (2%) per year.

It is important to recognise that focusing on the processes which threaten dugongs without regard to other species may lead to an increase in the impacts on populations of other threatened species, particularly green turtles. We suggest that efforts to reduce these processes should address their impact on green turtles as well as dugongs.

Incidental catch by fishing operations

The incidental catches of dugongs in mesh nets in the southern GBR has received widespread publicity with 15 of 30 dugong carcasses reported between January and September 1996 being probable net kills (A.R. Preen personal communication). Dugongs are also caught in mesh nets set by commercial fishers in the northern GBR (CYRAG 1996) and presumably as a result of illegal netting in the area. Aboriginal communities in the region have been complaining about this problem for many years (e.g. CYRAG 1996). In October 1996, one of us (Marsh) received an unsolicited telephone call from a commercial fisher who works in this area confirming the problem and identifying Bathurst Bay (where many dugongs were seen during the 1995 survey, Figure 2 and Appendix Figure 3) as a region of particular concern.

A comparative analysis of the spatial distribution of dugong density, mesh netting effort and enforcement capability (Marsh *et al.* 1996) also identified the sector between Port Stewart and Cape Melville as a particularly high risk area for dugongs drowning in mesh nets. It is the only area on the GBR coast with the combination of high dugong density, high fishing effort and low enforcement capability. The regional scale stability of the dugong population suggested by the aerial surveys does not confirm that the bycatch of dugongs in mesh nets is sustainable in this sector. As explained above, the survey technique is appropriate for detecting only regional-scale trends. On the basis of these data and accepting that it is unlikely that the enforcement capability will be increased in this remote area, we suggest that discussions be carried out with the fishers operating in this sector with a view to developing strategies for reducing the dugong bycatch as a matter of urgency.

The QFMA logbook data indicate that the commercial mesh netting effort is very low throughout the remainder of the region covered by the aerial surveys:

Sector	*Commercial netting effort in 1994 (km net days)*
Hunter Point-Cape Grenville	0
Cape Grenville-Cape Direction	13.5
Cape Direction-Port Stewart	12.3
Port Stewart-Cape Melville	240.9
Cape Melville-Cape Flattery	23

However, the capacity for this effort to increase is high. There are 1029 fishers with net endorsements which allow them to work the entire east coast of Queensland (QFMA 1996); 272 fishers with endorsements for barramundi netting. Some (if not most) of the barramundi fishers are a subset of the net fishers (L. Gwynne, pers. comm. 1995). The fishery involves a large number of small vessels. Most mesh net fishers are also involved in other forms of fishing such as crabbing. Many fishers with net fishing endorsements use them relatively rarely or not at all (M. Doohan QFMA pers. comm. 1996).

The netting closures in the Dugong Protection Areas in the southern GBR from 1998 may lead to some increase in effort in the high density dugong areas in the northern GBR under the present management arrangements. The major disincentive for this to happen is the remoteness of the northern region. Nonetheless, it would be prudent to negotiate closures and other measures to prevent an increase in effort with the fishing industry as part of the fisheries management planning process. In particular, it is inappropriate to allow fishing in the rivers and creeks adjacent to those parts of the region which already have high protection from through GBRMP zoning. Any closures must acknowledge the wish of Indigenous peoples to increase their involvement in commercial fisheries on Cape York (CYRAG 1996).

It has been suggested by the Queensland Commercial Fishermen's Organisation (QCFO) that arrangements be put in place for net fishers to donate the carcasses of dugongs killed in nets to Indigenous peoples. Any such arrangements would need to be designed to minimise the chance of their leading to an increase in the number of dugongs killed in commercial mesh nets.

Indigenous hunting

The social reasons for traditional hunting are complex. In the Cape York communities, hunting often occurs to provide meat for the families or households of the hunter (Roberts *et al.* 1996). Although meat is available in community stores, it is expensive and often of medium quality. Anecdotal evidence suggests that fresh fish and meat are preferred sources of protein (Roberts *et al.* 1996). However, the importance of bush protein such as dugong meat to the diet of the Indigenous inhabitants of Cape York Peninsula has not been formally documented as it has in Arnhem land (Altman 1984) and Torres Strait (Harris *et al.* 1994, Dews and Harris 1995). Indigenous communities are being encouraged to increase their consumption of bush protein as parts of programs to improve their health (CYRAG 1996). Such programs do not acknowledge the legitimacy of conservation concerns about some of the food species promoted.

There are few quantitative data on the number of dugongs hunted in this region and most statistics are out of date (see Marsh and Corkeron 1996 for details of dugong harvest). Anecdotal evidence suggests that the take of some communities may be unsustainable. For example, over one weekend in November 1995, at least eight and possibly 12 dugongs were taken from the area between Lockhart River and Night Island, by people from Peninsula communities, including residents of communities to the north of Lockhart River. The adjacent area (Blocks 8, 9 and 14) has an estimated minimum population of 645 ± s.e. 254 dugongs. The estimated sustainable take from a population of 600 animals would be approximately twelve animals of both sexes per year (see above). The sustainable take from the Lockhart River region would be higher than this as the population estimates are conservative by an unknown amount. In Blocks 8 and 9, dugong population estimates varied from 745 ± s.e. 218 in 1985 to 1016 ± s.e. 328 in 1990 and 645 ± s.e. 254 in 1995. These data demonstrate the difficulties of using the aerial survey technique for determining the status of dugongs in localised areas.

It is not possible to be certain of the sustainablity of the present dugong catch without the following additional information:

(1) absolute estimates of the dugong population size (rather than the minimum estimates presented here,
(2) estimates of the dugong catch,
(3) current estimates of life history parameters.

Theoretically, hunting is unlikely to drive a species to extinction because hunting pressure declines with the density of the prey species since it takes longer to find and animals when density is low. However, this inbuilt safeguard does not necessarily apply when:
(1) the technology available to the hunters improves with consequential deceases in the search time, and/or
(2) hunting is targeted towards more than one species (Bomford and Caughley 1996).

In addition, the ethos of taking only enough for one's family may not ensure sustainablity if settlements grow rapidly and taboos formerly regulating wildlife use are weakened (Collins *et al.* 1996). All these conditions are relevant to the Indigenous hunting of dugongs off the coast of Cape York as exemplified by improvements in technology, the change in the size of settlements and the weakening of taboos. In addition, dugongs and turtles are hunted together. Thus dugong hunting will cease only when the combined density of dugongs and green turtles is so low that hunting is not worthwhile. As our aerial surveys indicate that turtles are much more abundant than dugongs in this region (Marsh and Saalfeld 1988 and unpublished data), we consider that there is a very real danger of their being seriously impacted by hunting unless it is regulated in some way,

Communities like Lockhart River complain that people from the west coast of Cape York Peninsula and Bamaga cull animals from what they see as their traditional fisheries. Roberts *et al.* (1996) document sea voyages by hunters from Injinoo and New Mapoon to Shelburne Bay on hunting trips. People also travel by road from Weipa to Lockhart River to hunt dugongs (see Deirings 1993). At present, such forays

are limited by the small size of boats used, the cost of fuel and road access. Extensive travel to many hunting grounds in the region is currently constrained by weather, especially during periods of rough seas (sea travel) and during the wet season (land travel). This can change rapidly. For example, construction of a road between Cape Flattery and Lookout Point in 1991 enabled men from Hopevale to hunt in the Starcke River area during the winter (R. Williams pers. comm.), the season when access by sea is limited by the south-east trade winds.

The establishment of outstations which is being encouraged (CYRAG 1996) is probably also changing the spatial pattern of hunting. Although this is likely to diminish the refugial value of areas where hunting does not currently occur, there may be benefits such as additional local control of hunting and a reduction of in the number of dugongs hunted near established communities.

Indigenous peoples living on reserves were exempt from the restrictions on dugong hunting under the *Fisheries Act 1976* Qld. The *Fisheries Act 1994* Qld is silent on this issue but the *Nature Conservation Act 1992* Qld provides for the traditional use of natural resources by Aborigines and Torres Strait Islanders provided that such use is accordance with the provisions in conservation plans. This section of the *Nature Conservation Act 1992* Qld has not been proclaimed as yet. Hunting is, however, allowed under permit in the Great Barrier Reef Marine Park (GBRMP) in all zones except Preservation Zones under the *Great Barrier Reef Marine Park Act 1975* Cth and in Queensland Marine Parks under *the Marine Parks Act 1982* Qld. This Queensland legislation is of limited relevance to Cape York communities as the Cape York Marine Park has not yet been established. The legal entitlement to traditional hunting by Indigenous peoples in Cape York is in marked contrast to the situation in nearby Torres Strait where the traditional way of life of the Indigenous inhabitants is specifically protected under the Torres Strait Treaty Article 10. *The Native Title Act 1993* Cth recognises the right of Native Title holders to hunt without permits, however, as no determination has yet been made in favour of Native Title claimants, this law has achieved little.

Thus the present legal status of Indigenous hunting by Cape York communities does not satisfy the findings of the Law Reform Commission (1986), because it does not 'bring legislation into line with current practice'. Administrative policy has been tested on this issue and has proved ineffectual as demonstrated by a series of cases in which attempts have been made to prosecute Indigenous peoples for taking wildlife (see Roberts *et al.* 1996). All cases have received wide media publicity and have resulted in charges being dropped on no penalties enforced.

A large inshore Preservation Zone was established in the GBRMP primarily to protect dugongs in the region south of Cape Melville. Some modifications of the boundaries of this Zone are likely as a result of the rezoning of this Section but hunting will still be banned in coastal waters over at least one third of the coast between Murdoch Island and Cape Melville under co-operative arrangements with local Indigenous peoples.

Rapid effective implementation of a comprehensive and workable co-operative management regime (perhaps along lines parallel to the Cape York Land Use Strategy (CYPLUS)) is the only viable option to manage dugong hunting by Cape York

communities. As the then Executive Director of the Cape York Land Council (Pearson 1995) has written:

> *In talking about conservation regimes, Peninsula Aboriginal people will be most resistant to outsiders, particularly governments, unilaterally telling them how they should manage their land,* and
>
> *The development of land management capacity at the community level will take time.*

It is reasonable to assume that "land" could be replaced with "wildlife" when issues of dugong conservation are considered, a view reinforced by the wishes expressed in documents such as *Caring for Country, our Coast and Sea, the Lockhart River Sea Plan* (Wynter and Hill 1995) and the Draft Cape York Land Use Strategy (CYRAG 1996).

Mechanisms need to be developed as a matter of urgency to: (1) ensure that special significance of the dugong to Aboriginal and Torres Strait Islander peoples is formally recognised, and (2) mechanisms are put in place to empower these peoples to take a significant strategic and operational role in the development of all dugong management and research initiatives including the development of legislation and threat abatement plans. The Council of Elders model developed in the more urban areas of the GBR region (Cook 1994) may be a useful prototype. Other models that should be investigated include those developed to regulate Indigenous marine mammal fisheries in Alaska (Freeman 1989, Richard and Pike 1993, Marine Mammal Commission 1995). Effective co-operative management will require the development of a long-term strategy for the training, career structure and resourcing of Indigenous community rangers so that they may participate effectively in dugong management and research programs as well as playing an increasingly important role in managing their lands (CYRAG 1996).

Habitat protection

In the northern GBR, dugongs depend on the extensive meadows of shallow coastal and deepwater seagrasses. Almost all the shallow coastal habitat is currently in areas zoned as free from trawling activity under GBRMP regulations. This protection is assisted by the QFMA policy of coastal strip closures to protect juvenile prawns (Lee Long and Coles 1996). However, the more recently discovered deepwater seagrasses (Coles *et al.* 1995, Lee Long *et al.* 1989, 1996) are not afforded this protection. Dense meadows are usually avoided by trawlers but the low density seagrass meadows which are so important to dugongs may be vulnerable to the effects of trawling. This has not been evaluated (Lee Long and Coles 1996).

Natural events such as floods and cyclones can cause widespread loss of seagrasses in both shallow and deep water (Poiner and Peterken 1995, Preen *et al.* 1995, Preen and Marsh 1995). The seagrasses may take a decade to recover (Poiner and Peterken 1995), the dugongs will take much longer (Marsh and Corkeron 1996). Current land use practices may exacerbate the effects of these natural events but serious damage can also occur in areas in which adjacent land use is low such as the Gulf of Carpentaria

and Torres Strait (Poiner and Peterken 1995). Although integrated catchment management programs are seen as an important part of good management for the seagrasses in the GBR (Lee Long and Coles 1996), these programs have not been established in catchments on Cape York as yet (Robson 1996).

Seagrasses off the coast of Cape York do not yet face the immediate threats from urban and agricultural runoff, and coastal development that impact on the GBR coast further south (Lee Long and Coles 1996). Good land use planning is required to minimise the chance of such impacts. The draft Cape York Land Use Strategy emphasises the need for sustainable land use but has as its objective a more than threefold increase in cattle numbers. The Draft Strategy considers that a more comprehensive water management strategy for the region is not warranted at present (CYRAG 1996).

At present, we do not have cost effective protocols for monitoring temporal changes in seagrasses at a regional scales. This is a serious issue for the conservation of seagrasses in the remote northern regions of the GBR and needs to be addressed as a matter of urgency.

A chain of dugong sanctuaries

It will be vital to the future of dugongs south of Cooktown to maintain the genetic links between the large populations of dugongs in Torres Strait and the Northern Great Barrier Reef and the smaller more isolated populations to the south. D. Tikel (unpublished data 1996) has used molecular techniques to determine the stock structure of dugongs. Dugongs from South-East Asia (Thailand, Philippines and Indonesia) are distinct from those in Australian waters. Within Australia, two genetic groups (haplotype clusters) occur: (1) North and West Australian and (2) East Australian. These two groups overlap in the Great Barrier Reef Region. These data are consistent with an isolation by distance model. That is, only geographically proximal populations (neighbours) are interbreeding. Dugongs from south east Queensland have less genetic variation in the control region of the mitochondrial DNA (the target DNA region for inter-population comparisons) than those from Torres Strait. This result is consistent with the much larger number of dugongs in Torres Strait than at the southern extremity of their range and the more limited opportunities for the peripheral population to interbreed with dugongs from other areas.

An appropriate strategy to maintain these genetic links along the east coast of Queensland will be a series of strategically located areas closed to mesh netting. The Great Barrier Reef Ministerial Council (1997) has established a series of Dugong Protection Areas in the Great Barrier Reef Region from Hinchinbrook Island south. Some areas where dugongs are protected already exist off the coast of Cape York. These include areas from which dugong hunting and mesh netting are not permitted under the present zoning regime and areas where hunters do not go at present and where mesh netting activity is low. We understand that several Indigenous groups are supportive of the concept of a chain of dugongs sanctuaries in the inshore waters of the northern Great Barrier Reef (Ross Williams pers. comm. 1996). We suggest that a series of Dugong Protection Areas off the coast of Cape York should be negotiated

formally with local Indigenous groups and commercial fishers as part of the planning processes for:
(1) the Far Northern Section of the Great Barrier Reef Marine Park,
(2) the Cape York Marine Park, and
(3) the tropical inshore fin fishery.

In establishing these sanctuaries, it will be important to recognise that satellite tracking has demonstrated that dugongs use creeks in the Region (Marsh and Rathbun 1990).

CONCLUSIONS

The number of dugongs in the northern Great Barrier Reef region is internationally significant. The draft Action Plan for Australian Dugongs (Marsh *et al.* in press) lists the status of the dugong in this region as Lower Risk (conservation dependent) because they believe that the status of the population could deteriorate if management is not pro-active in minimising the threatening processes outlined above. It is important that management initiatives are introduced in the region to pre-empt a decline in dugong numbers similar to that recorded already in the southern Great Barrier Reef Region (Marsh and Corkeron 1996).

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Table 1:

Weather conditions encountered during the 1985, 1990 and 1995 surveys. Values for Beaufort sea state and glare are the mean of the modes for each transect with range in parentheses. Glare is measured as 0 - none; 1 - <25% of the field of view affected; 2 - 25 - 50%; 3 > 50%.

Variable	*1985*	*1990*	*1995*
Wind speed (km/hr)	<28	<15	<15
Cloud cover (oktas)	0-5	0-7	2-7
Minimum cloud height (m)	305-1525	1500-35000	305-1220
Beaufort sea state	1.5(0-4)	1.5(0-2.5)	3.0(1-4)
Glare*	1(0-2.5)	2.2(1-3)	1.5(0-3)
Visibility (km)	8->50	N/A	10-30

*taken from the worst side of the aircraft for each transect

Table 2:

Areas of survey blocks and sampling intensisties for the 1995 survey.

Block	*Area (km^2)*	*Sampling Intensity (%)*
1	1022.87	17.3
2	644.65	18.2
3	1051.42	16.8
4	5604.52	8.2
5	7984.77	8.5
6	464.59	8.5
7	984.27	8.6
8	967.53	12.4
9	3071.54	8.2
10	271.99	15.9
11	409.99	23.5
12	101.98	8.5
13	2998.66	7.7
14	222.09	22.7
overall	25800.87	9.8

Table 3:

Estimates of the arithmetric mean of dugong group sizes, and correction factors generated as detailed above, and used in the population estimates for dugongs for the 1995 survey of the northern Great Barrier Reef. (cv) refers to coefficient of variation for the relevant estimate.

Group size (cv)	*Perception correction factor estimate (cv)*		*Availability correction factor estimate (cv)*
	Port	Starboard	
1.5017 (0.0407)	1.1478(0.0269)	1.0945(0.0174)	1.8816 (0.1241)

Table 4:

Estimates of dugong numbers for each block in the 1985, 1990 and 1995 surveys. The values given are population estimates ± one standard error incorporating the errors resulting from sampling.

Block	*1985*	*1990*	*1995*
1	0±0	36±35	55±25
2	1644±570	1564±488	910±157
3	272±110	903±650	832±213
4	626±256	768±202	235±101
5	3630±714	3782±767	4396±1052
6	792±423	1673±1037	676±312
7	0±0	182±97	0±0
8	611±192	829±305	305±181
9	134±104	187±97	272±177
10	24±23	35±34	20±80
11	222±81	268±66	309±109
12	27±26	37±32	-
13	128±83	207±99	82±69
14	-	-	98±26
Total	8110±1073	10471±1578	8190±1172*

*1995 total data include two herds (see Results section), totalling 51 animals.

No estimate is given for block #12 in 1995, as one transect only was flown in that block.

Block 14 (Temple Bay) is part of Block 8 (*sensu* Marsh and Saalfeld 1989). Additional transects were flown in this area in 1990 due to the relevance of the area to the siting of the proposed Cape York Space Port. These additional transects were not used in population comparisons between 1990 and 1985 and values for the Block are not presented in the report on the 1990 survey (see Marsh *et al.* 1993, Tables 2 and 7). Therefore, they are not included here.

Table 5:

Summary of analysis of variance comparing estimates of the dugong population of the northern GBR for 1985, 1990 and 1995. Data were transformed by ln (x+1).

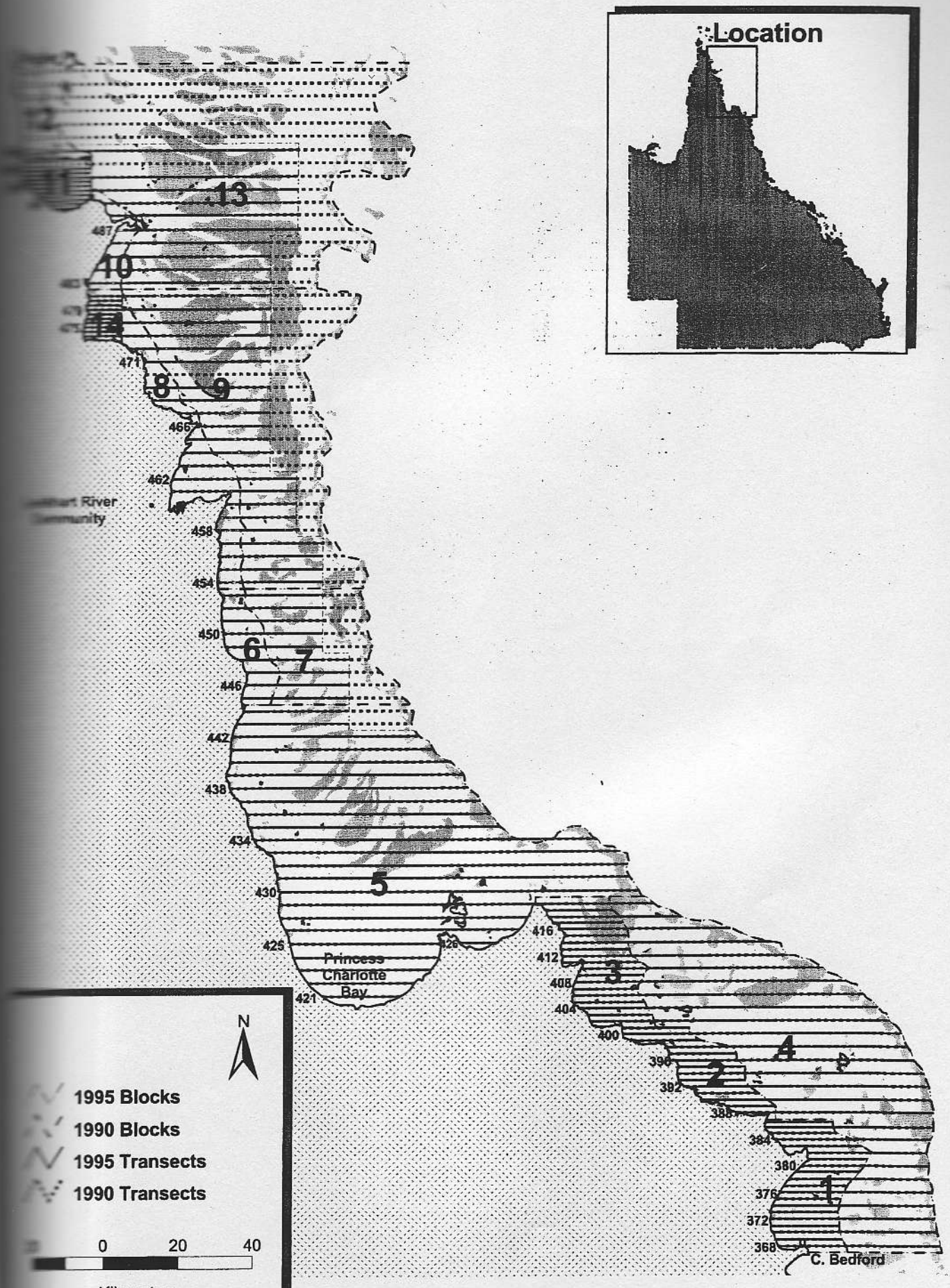
Source of Variation	*SS*	*DF*	*MS*	*F*	*Significance of F*
RESIDUAL	193.02	322	.60		
BLOCK**	30.90	11	2.81	4.69	.000
YEAR*	2.60	2	1.30	2.17	.116
TRANSECT WITHIN BLOCK*	228.10	161	1.42	2.36	.000
BLOCK BY YEAR*	14.98	22	.68	1.14	.307
(Model)*	569.94	196	2.91	4.85	.000
(Total)	762.96	518	1.47		

R-Squared = .747
Adjusted R-Squared = .593

*Tested against Residual
**Tested against Transect nested in Block

Figure 1:

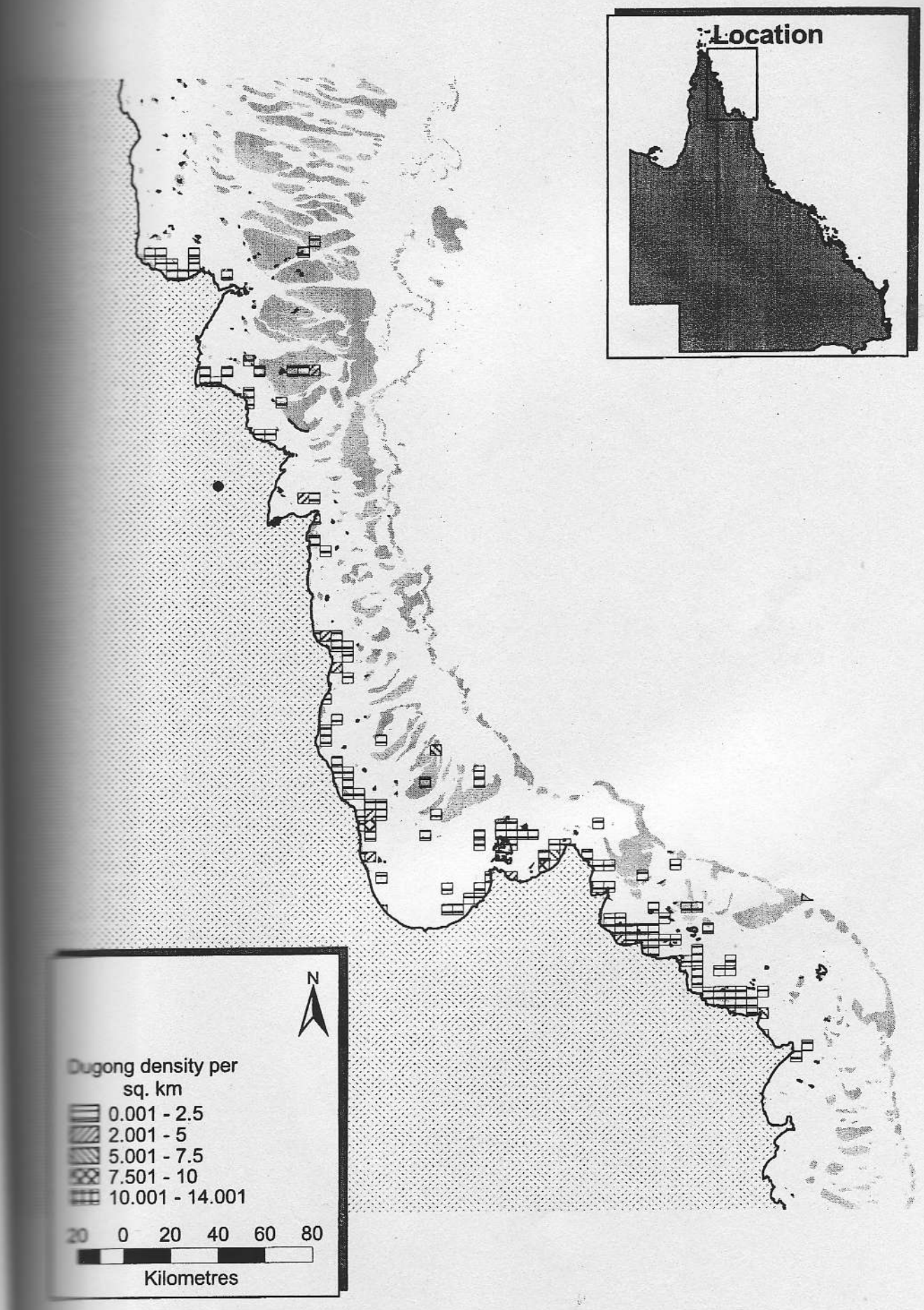
The transect lines and blocks of the 1995 survey of the northern Great Barrier Reef Marine Park, with transects flown in 1990 shown for comparison.


Location
13
12
11
10
9
8
7
6
5
4
3
2
1
487
471
466
462
458
454
450
446
442
438
434
430
425
421
416
412
408
404
400
396
392
388
384
380
376
372
368
Princess Charlotte Bay
C. Bedford
N
1995 Blocks
1990 Blocks
1995 Transects
1990 Transects
0
20
40
Kilometres

Barrier

Figure 2:

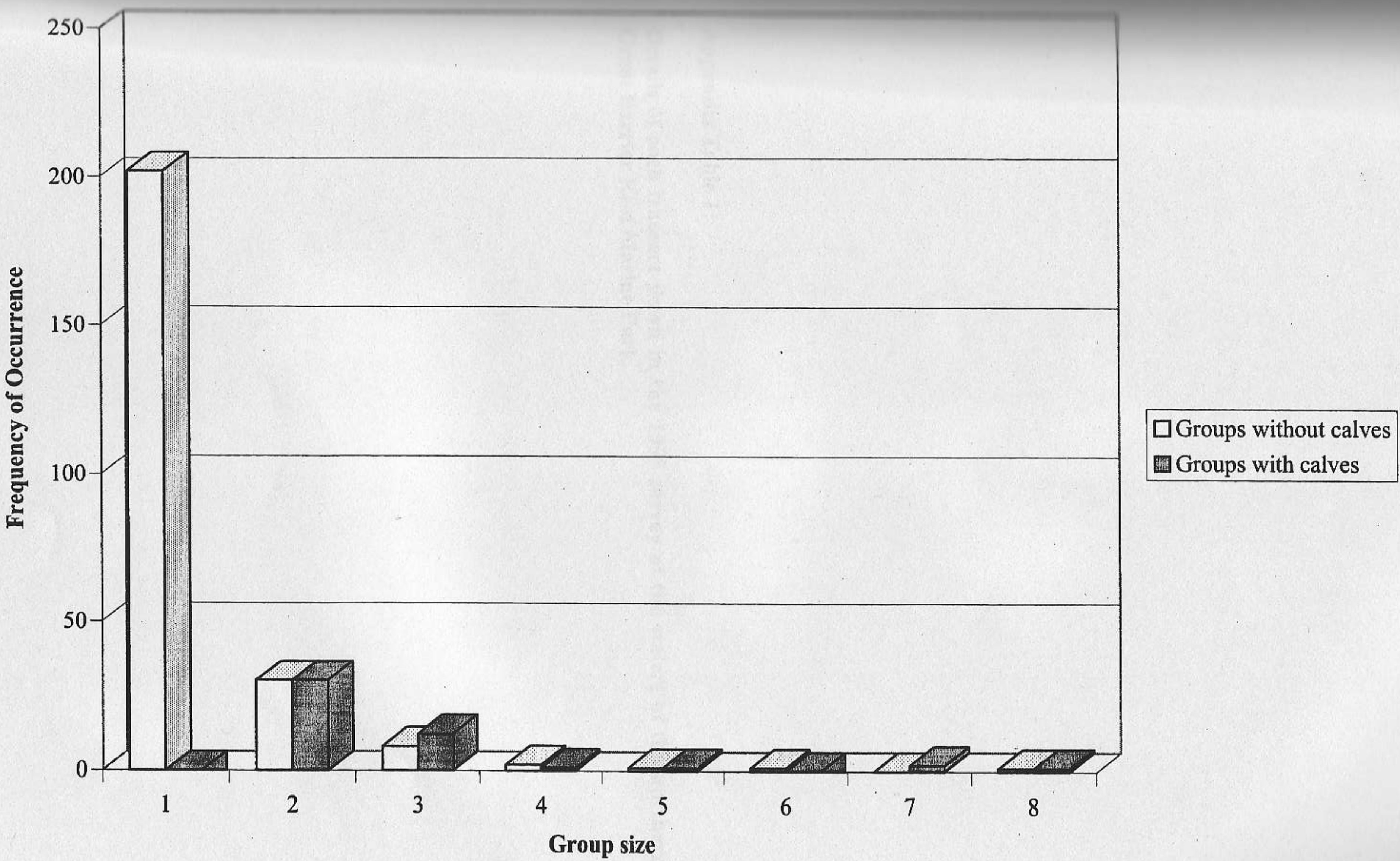
Dugong density in the waters of the northern Great Barrier Reef Marine Park in November - December 1995, calculated on a 5 x5 nm square grid and adjusted for sampling intensity.



ne Park in
l adjusted

Figure 3:

The numbers of groups of dugongs of various sizes in the waters of the northern Great Barrier Reef Marine Park, with calves (dark stippling) and without calves (light stippling).


Frequency of Occurrence
250
200
150
100
50
0
1
2
3
4
5
6
7
8
Group size
Groups without calves
Groups with calves

Appendix Table 1:

Details of each transect flown in the 1995 survey of the waters of the northern Great Barrier Reef Marine Park.

Transect number	Block	median Beaufort sea state	Transect distance (km)	Transect area (sq km)	Raw count of dugongs - stbd	Raw count of dugongs - port	Adjusted count of dugongs - stbd	Adjusted count of dugongs - port	Adjusted count of dugongs - total
368	4	4	30.76	12.304	0	0	0	0	0
368	1	4	22.553	9.021	0	0	0	0	0
369	1	3	21.94	8.776	0	0	0	0	0
370	4	4	31.7	12.68	0	0	0	0	0
370	1	4	22.532	9.013	0	0	0	0	0
371	1	4	22.798	9.119	0	0	0	0	0
372	4	4	31.14	12.456	0	0	0	0	0
372	1	4	22.963	9.185	0	0	0	0	0
373	1	4	22.834	9.134	0	0	0	0	0
374	4	4	30.78	12.312	0	0	0	0	0
374	1	4	22.248	8.899	0	0	0	0	0
375	1	4	21.526	8.61	0	0	0	0	0
376	4	4	28.77	11.508	0	0	0	0	0
376	1	4	21.218	8.487	0	0	0	0	0
377	1	4	21.137	8.455	0	0	0	0	0
378	4	4	24.65	9.86	0	0	0	0	0
378	1	4	21.471	8.588	0	0	0	0	0
379	1	4	21.205	8.482	0	1	0	3.243	3.243
380	4	4	21.1	8.44	0	0	0	0	0
380	1	4	20.751	8.3	0	0	0	0	0
381	1	4	19.598	7.839	0	0	0	0	0
382	4	4	18.11	7.244	0	0	0	0	0
382	1	4	20.961	8.384	0	0	0	0	0
383	1	4	26.556	10.622	1	0	3.093	0	3.093
384	4	4	25.65	10.26	0	0	0	0	0
384	1	4	25.555	10.222	0	0	0	0	0
385	1	4	22.319	8.928	1	0	3.093	0	3.093
386	4	4	34.5	13.8	0	0	0	0	0
386	1	4	20.734	8.294	0	0	0	0	0
387	1	4	22.41	8.964	0	0	0	0	0
388	4	3	51.77	20.708	0	0	0	0	0
388	2	3	12.98	5.192	3	2	9.278	6.486	15.764
389	2	1	16.228	6.491	2	0	6.185	0	6.185
390	4	3	53.44	21.376	0	0	0	0	0
390	2	3	22.09	8.836	2	1	6.185	3.243	9.428

Transect number	Block	median Beaufort sea state	Transect distance (km)	Transect area (sq km)	Raw count of dugongs - stbd	Raw count of dugongs - port	Adjusted count of dugongs - stbd	Adjusted count of dugongs - port	Adjusted count of dugongs - total
391	2	1	20.956	8.382	5	2	15.463	6.486	21.95
392	4	3	58.87	23.548	0	1	0	3.243	3.243
392	2	3	21.009	8.404	2	2	6.185	6.486	12.672
393	2	1	22.042	8.817	1	3	3.093	9.73	12.822
394	4	3	58.89	23.556	0	0	0	0	0
394	2	3	22.096	8.838	0	1	0	3.243	3.243
395	2	3	22.154	8.862	1	0	3.093	0	3.093
396	4	4	55.27	22.108	0	0	0	0	0
396	2	4	23.22	9.288	2	1	6.185	3.243	9.428
397	2	3	22.104	8.842	1	1	3.093	3.243	6.336
398	4	4	57.25	22.9	0	0	0	0	0
398	2	4	22.178	8.871	2	1	6.185	3.243	9.428
399	2	3	22.077	8.831	3	4	9.278	12.973	22.251
400	4	3	69.61	27.844	0	0	0	0	0
400	2	3	22.198	8.879	7	1	21.648	3.243	24.892
401	2	3	22.168	8.867	0	1	0	3.243	3.243
402	4	3	76.53	30.612	0	0	0	0	0
402	3	3	22.674	9.07	6	6	18.556	19.459	38.015
403	3	3	21.819	8.728	4	2	12.37	6.486	18.857
404	4	3	72.95	29.18	1	1	3.093	3.243	6.336
404	3	3	25.86	10.344	1	3	3.093	9.73	12.822
405	3	3	23.955	9.582	4	2	12.37	6.486	18.857
406	4	3	73.88	29.552	0	0	0	0	0
406	3	2	22.423	8.969	1	1	3.093	3.243	6.336
407	3	1	21.85	8.74	0	1	0	3.243	3.243
408	4	3	67.86	27.144	2	0	6.185	0	6.185
408	3	3	22.144	8.858	1	0	3.093	0	3.093
409	3	2	22.488	8.995	0	0	0	0	0
411	3	2	26.693	10.677	1	1	3.093	3.243	6.336
412	4	2	51.57	20.628	0	0	0	0	0
412	3	3	23.449	9.38	0	1	0	3.243	3.243
413	3	1	23.183	9.273	1	1	3.093	3.243	6.336
414	4	3	48.05	19.22	0	0	0	0	0
414	3	3	22.184	8.874	1	0	3.093	0	3.093
415	3	1	21.462	8.585	0	1	0	3.243	3.243

Transect number	Block	median Beaufort sea state	Transect distance (km)	Transect area (sq km)	Raw count of dugongs - stbd	Raw count of dugongs - port	Adjusted count of dugongs - stbd	Adjusted count of dugongs - port	Adjusted count of dugongs - total
416	4	3	34.14	13.656	0	1	0	3.243	3.243
416	3	3	23.062	9.225	1	0	3.093	0	3.093
417	3	2	23.816	9.526	0	1	0	3.243	3.243
418	4	2	20.42	8.168	0	0	0	0	0
418	3	1	24.096	9.638	0	1	0	3.243	3.243
419	3	2	22.833	9.133	0	1	0	3.243	3.243
420	4	2	14.77	5.908	0	0	0	0	0
420	3	2	25.059	10.024	0	0	0	0	0
421	5	2	25.512	10.205	0	0	0	0	0
422	5	1	35.264	14.106	4	0	12.37	0	12.37
423	5	2	43.565	17.426	2	1	6.185	3.243	9.428
424	5	3	48.129	19.252	1	1	3.093	3.243	6.336
425	5	2	49.631	19.852	0	2	0	6.486	6.486
426	5	3	12.615	5.046	1	1	3.093	3.243	6.336
427	5	2	78.282	31.313	9	17	27.834	55.135	82.968
428	5	2	82.919	33.168	7	12	21.648	38.919	60.567
429	5	3	85.834	34.334	3	3	9.278	9.73	19.008
430	5	3	120.688	48.275	4	3	12.37	9.73	22.1
431	5	3	118.496	47.398	4	8	12.37	25.946	38.316
432	5	3	118.811	47.524	4	3	12.37	9.73	22.1
433	5	3	119.054	47.622	0	3	0	9.73	9.73
434	5	3	115.148	46.059	2	1	6.185	3.243	9.428
435	5	4	83.918	33.567	2	3	6.185	9.73	15.915
436	5	4	81.497	32.599	1	3	3.093	9.73	12.822
437	5	4	80.752	32.301	1	1	3.093	3.243	6.336
438	5	4	79.997	31.999	2	2	6.185	6.486	12.672
439	5	3	79.285	31.714	0	2	0	6.486	6.486
440	5	4	73.828	29.531	1	0	3.093	0	3.093
441	5	4	67.573	27.029	0	1	0	3.243	3.243
442	5	3	62.738	25.095	0	0	0	0	0
443	5	2	0	0	1	1	3.093	3.243	6.336
444	5	3	35.654	14.262	0	0	0	0	0
445	7	3	26.03	10.412	0	0	0	0	0
445	6	2	10.302	4.121	0	1	0	3.243	3.243
446	7	3	24.27	9.708	0	0	0	0	0

Transect number	Block	median Beaufort sea state	Transect distance (km)	Transect area (sq km)	Raw count of dugongs - stbd	Raw count of dugongs - port	Adjusted count of dugongs - stbd	Adjusted count of dugongs - port	Adjusted count of dugongs - total
446	6	3	10.767	4.307	1	2	3.093	6.486	9.579
447	7	3	23.42	9.368	0	0	0	0	0
447	6	2	11.247	4.499	1	0	3.093	0	3.093
448	7	3	26.7	10.68	0	0	0	0	0
448	6	2	9.763	3.905	0	3	0	9.73	9.73
449	7	3	19.31	7.724	0	0	0	0	0
449	6	3	13.562	5.425	3	7	9.278	22.703	31.98
450	7	3	19.9	7.96	0	0	0	0	0
450	6	3	13.713	5.485	0	0	0	0	0
451	7	3	21.27	8.508	0	0	0	0	0
451	6	3	12.899	5.16	0	0	0	0	0
452	7	3	25.63	10.252	0	0	0	0	0
452	6	3	8.459	3.384	0	0	0	0	0
453	7	3	26.09	10.436	0	0	0	0	0
453	6	3	8.288	3.315	0	0	0	0	0
454	9	3	27.19	10.876	0	0	0	0	0
454	8	3	8.533	3.413	0	0	0	0	0
455	9	3	27.8	11.12	0	0	0	0	0
455	8	3	7.618	3.047	0	0	0	0	0
456	9	3	26.96	10.784	0	0	0	0	0
456	8	3	8.39	3.356	0	0	0	0	0
457	9	3	27.99	11.196	0	0	0	0	0
457	8	3	6.958	2.783	0	1	0	3.243	3.243
458	9	2	17.36	6.944	0	0	0	0	0
458	8	3	9.726	3.89	1	0	3.093	0	3.093
459	9	3	18.99	7.596	0	0	0	0	0
459	8	3	7.088	2.835	0	0	0	0	0
460	9	3	19.18	7.672	0	0	0	0	0
460	8	3	4.581	1.832	0	1	0	3.243	3.243
461	9	3	18.97	7.588	0	0	0	0	0
461	8	3	23.388	9.355	0	0	0	0	0
462	9	4	19.95	7.98	0	0	0	0	0
462	8	4	22.114	8.846	1	1	3.093	3.243	6.336
463	9	3	13.32	5.328	0	0	0	0	0
463	8	3	17.525	7.01	0	0	0	0	0

Transect number	Block	median Beaufort sea state	Transect distance (km)	Transect area (sq km)	Raw count of dugongs - stbd	Raw count of dugongs - port	Adjusted count of dugongs - stbd	Adjusted count of dugongs - port	Adjusted count of dugongs - total
464	9	3	19.58	7.832	0	0	0	0	0
464	8	3	9.769	3.908	0	0	0	0	0
465	9	3	21.67	8.668	0	0	0	0	0
465	8	3	7.123	2.849	0	0	0	0	0
466	9	3	23.33	9.332	0	0	0	0	0
466	8	3	1.738	0.695	0	0	0	0	0
467	9	3	24.89	9.956	0	0	0	0	0
467	8	3	6.329	2.532	0	0	0	0	0
468	9	3	30.57	12.228	0	0	0	0	0
468	8	4	9.462	3.785	4	0	12.37	0	12.37
469	9	3	31.33	12.532	0	0	0	0	0
469	8	3	11.612	4.645	0	0	0	0	0
471	8	3	5.312	2.125	0	1	0	3.243	3.243
471	9	3	37.54	15.016	1	0	3.093	0	3.093
472	9	2	38.62	15.448	0	0	0	0	0
472	8	2	9.829	3.932	1	1	3.093	3.243	6.336
473	9	4	41.14	16.456	0	0	0	0	0
473	8	4	36.172	14.469	0	0	0	0	0
473	14	4	13.386	5.354	1	1	3.093	3.243	6.336
474	14	4	13.496	5.398	1	1	3.093	3.243	6.336
475	14	4	13.248	5.299	0	1	0	3.243	3.243
476	9	4	43.02	17.208	1	4	3.093	12.973	16.066
476	8	4	34.636	13.854	0	0	0	0	0
476	14	4	14.128	5.651	0	1	0	3.243	3.243
477	14	4	12.427	4.971	1	0	3.093	0	3.093
478	14	4	11.886	4.754	0	0	0	0	0
479	9	4	47.64	19.056	1	0	3.093	0	3.093
479	8	4	27.838	11.135	0	0	0	0	0
479	14	4	12.509	5.004	0	0	0	0	0
480	14	3	12.104	4.842	0	0	0	0	0
481	14	4	11.391	4.556	0	0	0	0	0
482	9	4	49.93	19.972	0	0	0	0	0
482	8	4	24.1	9.64	0	0	0	0	0
482	14	4	11.73	4.692	0	0	0	0	0
483	13	2	51.06	20.424	0	0	0	0	0

Transect number	Block	median Beaufort sea state	Transect distance (km)	Transect area (sq km)	Raw count of dugongs - stbd	Raw count of dugongs - port	Adjusted count of dugongs - stbd	Adjusted count of dugongs - port	Adjusted count of dugongs - total
483	10	2	12.738	5.095	0	0	0	0	0
484	13	2	47.7	19.08	0	0	0	0	0
484	10	2	12.557	5.023	0	0	0	0	0
485	13	2	49.38	19.752	0	0	0	0	0
485	10	2	8.144	3.258	0	0	0	0	0
486	13	3	47.44	18.976	0	0	0	0	0
486	10	3	7.191	2.876	0	0	0	0	0
487	13	2	53.88	21.552	0	0	0	0	0
487	10	2	7.772	3.109	0	0	0	0	0
488	13	2	55.58	22.232	0	0	0	0	0
488	10	2	8.462	3.385	0	0	0	0	0
489	13	2	61.1	24.44	0	0	0	0	0
489	10	2	5.418	2.167	0	1	0	3.243	3.243
490	11	2	9.03	3.612	0	0	0	0	0
491	11	2	13.08	5.232	0	0	0	0	0
492	11	2	16.946	6.778	5	5	15.463	16.216	31.679
493	11	2	20.964	8.386	3	1	9.278	3.243	12.521
494	13	2	68.34	27.336	0	0	0	0	0
494	10	3	45.534	18.214	0	0	0	0	0
494	11	3	21.652	8.661	2	2	6.185	6.486	12.672
495	11	2	24.887	9.955	0	0	0	0	0
496	11	2	26.378	10.551	1	1	3.093	3.243	6.336
497	13	2	70.52	28.208	1	1	3.093	3.243	6.336
497	11	2	26.957	10.783	2	0	6.185	0	6.185
498	11	1	26.891	10.756	0	0	0	0	0
499	11	2	27.208	10.883	0	0	0	0	0
501	11	2	26.604	10.642	0	1	0	3.243	3.243
502	13	1	74.77	29.908	0	0	0	0	0
502	12	2	21.761	8.704	0	0	0	0	0
410	3	3	22.012	8.805	0	1	0	3.243	3.243

Appendix Table 2:

Raw data used to calculate correction factors for dugongs for the survey.

Corrections for perception bias

NUMBER OF GROUPS OF DUGONGS

Port			**Starboard**		
Mid	*Rear*	*Both*	*Mid*	*Rear*	*Both*
48	21	62	34	20	62

Appendix Table 3:

Data used in the Analysis of Variance comparing the results of the 1985, 1990 and 1995 surveys of the waters of the northern Great Barrier Reef Marine Park.

Block	Transect	1995 transect	1985	1990	1995
1	1	368	0	0	0.0
1	2	370	0	0	0.0
1	3	372	0	0	0.0
1	4	374	0	0	0.0
1	5	376	0	0	0.0
1	6	378	0	0	0.0
1	7	380	0	0	0.0
1	8	382	0	0	0.0
1	9	384	0	3.1	0.0
1	10	386	0	0	0.0
2	1	388	34.2	3.1	15.8
2	2	389	117	3.1	6.2
2	3	390	12.7	31.2	9.4
2	4	391	29.9	3.1	26.0
2	5	392	8.8	3.1	12.7
2	6	393	0	12.4	12.8
2	7	394	8.8	68.6	3.2
2	8	395	4.4	9.3	3.1
2	9	396	4.2	3.1	9.4
2	10	397	0	0	6.3
2	11	398	17.1	15.6	9.4
2	12	399	4.4	84.2	22.3
2	13	400	26.2	28.1	24.9
3	1	402	4.2	59.2	38.0
3	2	404	4.4	9.3	12.8
3	3	406	8.5	3.1	6.3
3	4	408	0	0	3.1
3	5	410	0	3.1	3.2
3	*6*	*412*	*0*	*0*	*3.2*
3	7	414	0	0	3.1
3	8	416	4.2	0	3.1
3	9	418	0	0	3.2
3	10	420	0	0	0.0
4	1	368	0	0	0.0
4	2	370	0	0	0.0
4	3	372	0	0	0.0
4	4	374	0	3.1	0.0
4	5	376	0	0	0.0
4	6	378	0	0	0.0
4	7	380	0	0	0.0
4	8	382	0	0	0.0
4	9	384	0	0	0.0
4	10	386	0	0	0.0
4	11	388	0	0	0.0
4	12	390	0	6.2	0.0
4	13	392	4.2	15.5	3.2
4	14	394	16.9	3.1	0.0
4	15	396	4.4	0	0.0
4	16	398	0	0	0.0
4	17	400	0	6.2	0.0
4	18	402	4.2	0	0.0
4	19	404	0	6.2	6.3
4	20	406	8.6	3.1	0.0
4	21	408	0	6.2	6.2
4	22	410	17.5	9.4	0.0
4	23	412	0	6.2	0.0
4	24	414	0	0	0.0

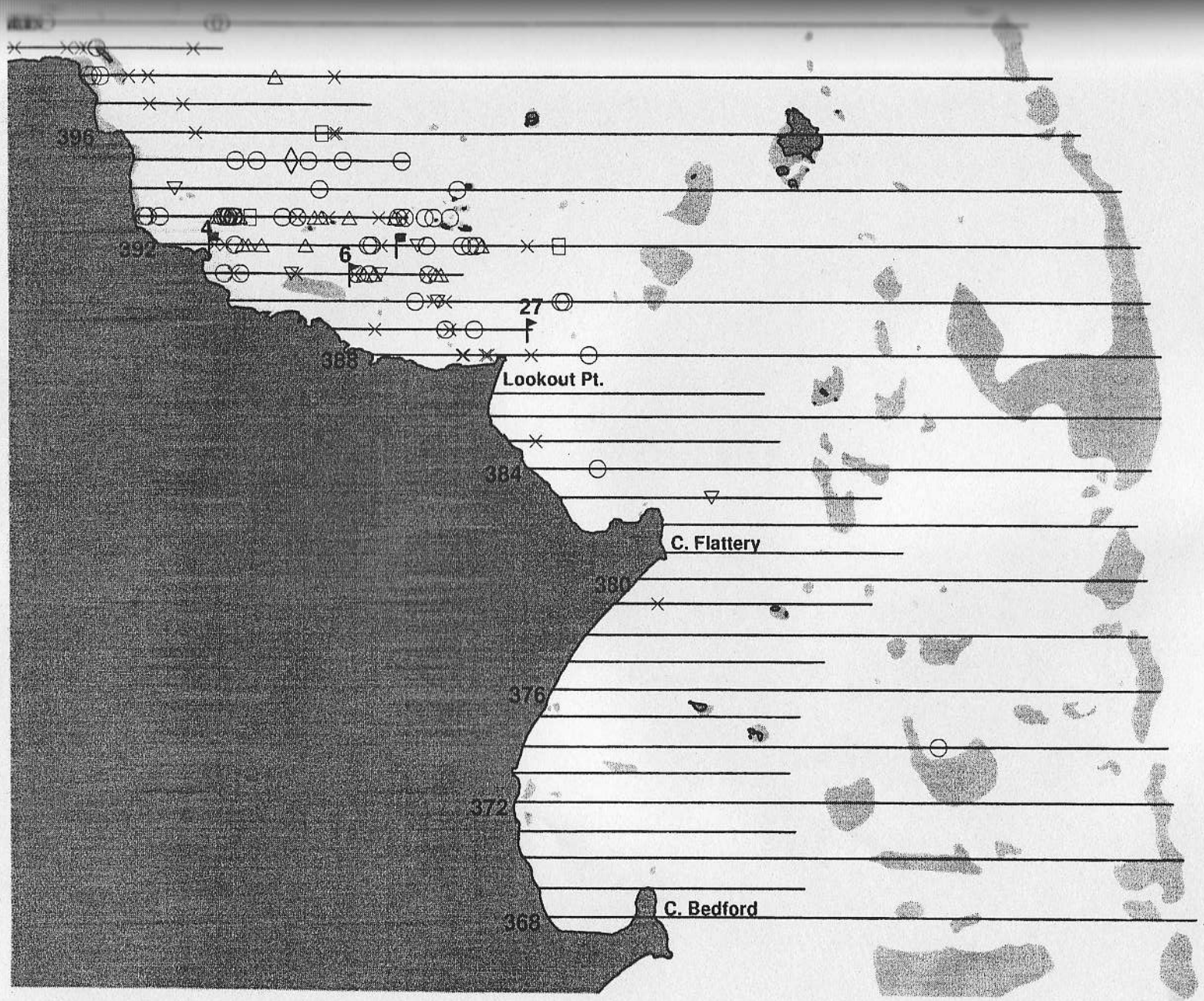
Block	Transect	1995 transect	1985	1990	1995
4	25	416	0	3.1	3.2
4	26	418	0	3.1	0.0
4	27	420	0	0	0.0
5	1	421	10.1	0	0.0
5	2	422	18.6	3.1	12.4
5	3	423	0	15.6	9.4
5	4	424	18.6	0	6.3
5	5	425426	24.5	37.4	12.8
5	6	427	34.6	21.8	83.0
5	7	428	37.2	28.1	60.6
5	8	429	8.5	3.1	19.0
5	9	430	4.2	6.2	22.1
5	10	431	4.4	37.4	38.3
5	11	432	21.5	15.5	22.1
5	12	433	25.7	31.1	9.7
5	13	434	30.4	25	9.4
5	14	435	21.8	31.2	15.9
5	15	436	17.1	25	12.8
5	16	437	4.4	3.1	6.3
5	17	438	4.2	9.4	12.7
5	18	439	17.3	0	6.5
5	19	440	4.4	0	3.1
5	20	441	4.4	7.4	3.2
5	21	442	4.4	3.1	0.0
5	22	443	4.4	3.1	6.3
5	23	444	0	3.1	0.0
6	1	445	17.1	6.2	3.2
6	2	446	0	24.9	9.6
6	3	447	0	3.1	3.1
6	4	448	4.2	3.1	9.7
6	5	449	38.8	99.7	32.0
6	6	450	0	9.3	0.0
6	7	451	0	0	0.0
6	8	452	0	0	0.0
6	9	453	4.2	0	0.0
7	1	445	0	0	0.0
7	2	446	0	6.2	0.0
7	3	447	0	3.1	0.0
7	4	448	0	3.1	0.0
7	5	449	0	0	0.0
7	6	450	0	3.1	0.0
7	7	451	0	0	0.0
7	8	452	0	0	0.0
7	9	453	0	0	0.0
8	1	454	2.4	9.4	0.0
8	2	455	0	0	0.0
8	3	456	0	0	0.0
8	4	457	0	0	3.2
8	5	458	4.5	0	3.1
8	6	459	2.2	0	0.0
8	7	460	0	5.1	3.2
8	8	461	2.3	6.2	0.0
8	9	462	4.7	24.9	6.3
8	10	463	2.2	9.4	0.0
8	11	464	4.5	0	0.0
8	12	465	0	0	0.0
8	13	466	0	0	0.0

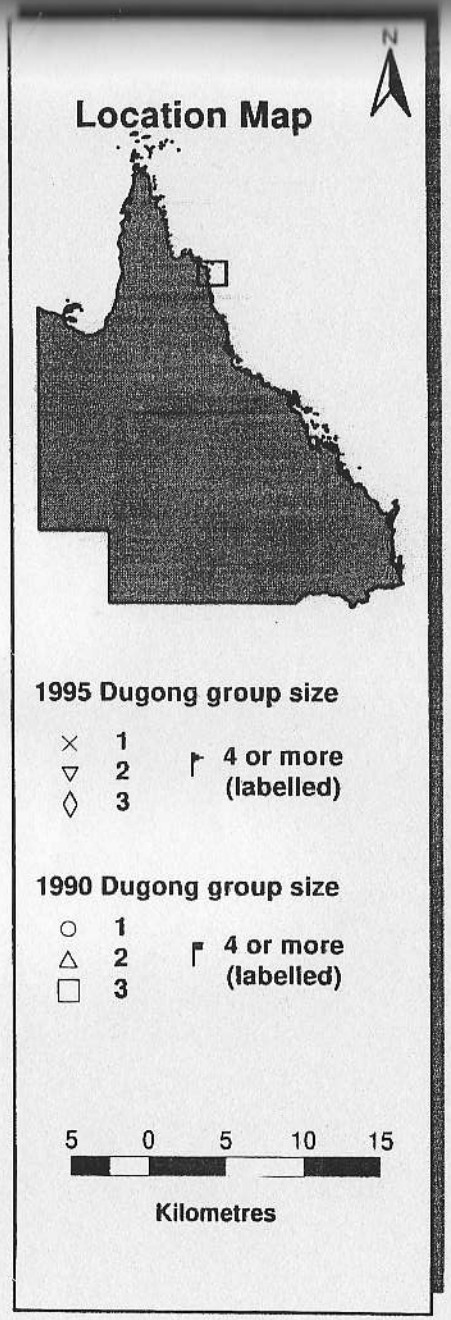
Block	Transect	1995 transect	1985	1990	1995
8	14	467	0	0	0.0
8	15	468	2.2	0	12.4
8	16	469	0	0	0.0
8	17	471	2.3	4.7	3.2
8	18	472	0	10.2	6.3
8	19	473	4.7	0	0.0
8	20	476	11.6	0	0.0
8	21	479	0	0	0.0
8	22	482	0	0	0.0
9	1	454	0	0	0.0
9	2	455	4.9	0	0.0
9	3	456	0	0	0.0
9	4	457	2.3	5.1	0.0
9	5	458	0	0	0.0
9	6	459	0	0	0.0
9	7	460	0	0	0.0
9	8	461	0	0	0.0
9	9	462	0	0	0.0
9	10	463	0	0	0.0
9	11	464	0	0	0.0
9	12	465	0	0	0.0
9	13	466	0	0	0.0
9	14	467	0	0	0.0
9	15	468	0	0	0.0
9	16	469	0	0	0.0
9	17	471	0	0	3.1
9	18	472	0	4.7	0.0
9	19	473	0	0	0.0
9	20	476	0	0	16.1
9	21	479	0	6.2	3.1
9	22	482	0	0	0.0
10	1	483	0	0	0.0
10	2	484	0	0	0.0
10	3	485	0	0	0.0
10	4	486	0	0	0.0
10	5	487	2.2	3.4	0.0
10	6	488	0	0	3.2
10	7	489	0	0	0.0
11	1	490	0	7	0.0
11	2	491	9.2	3.6	0.0
11	3	492	2.2	7	31.7
11	4	493	4.5	0	12.5
11	5	494	2.2	0	12.7
11	6	495	0	3.7	0.0
11	7	496	20.9	10.7	6.3
11	8	497	13.9	14.4	6.2
11	9	498	0	10.7	0.0
11	10	499	0	6.8	0.0
11	11	501	5.3	7.1	3.2
13	1	483	0	0	0.0
13	2	484	0	0	0.0
13	3	485	0	0	0.0
13	4	486	2.3	0	0.0
13	5	487	0	0	0.0
13	6	488	0	0	0.0
13	7	489	2.3	7	0.0

Block	Transect	1995 transect	1985	1990	1995
13	8	494	0	0	0.0
13	9	497	0	0	6.3
13	10	502	0	0	0.0

Appendix Figure 1:

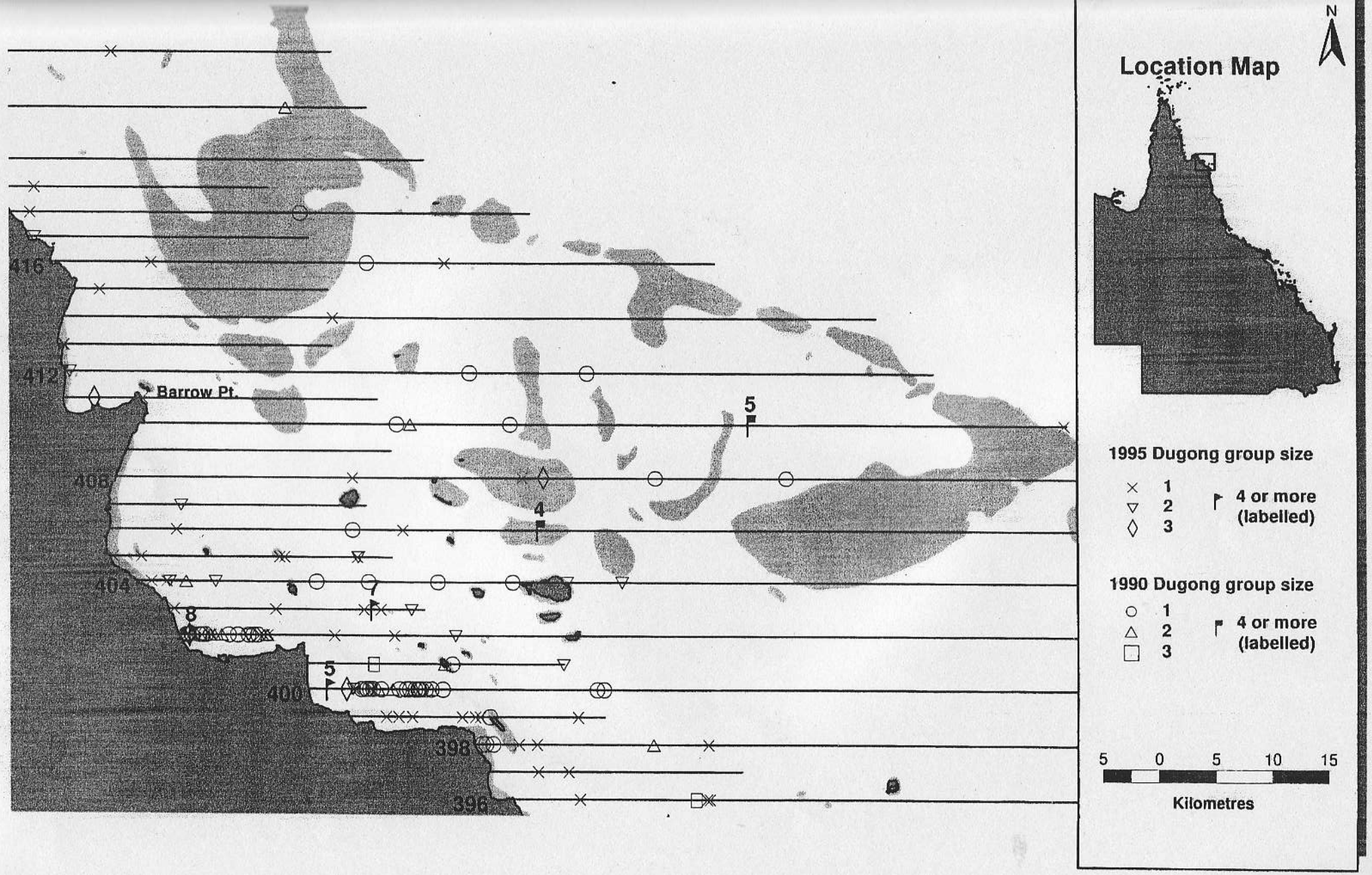
Survey area between Cape Bedford and Murdoch Point (approximately) showing positions of dugong sightings in November - December 1995, with 1990 data provided for comparison. The numbers associated with the sightings do not necessarily reflect the sizes of actual groupings observed. Transect numbers for 1995 are shown.


396
392
6
27
388
Lookout Pt.
384
C. Flattery
380
376
372
C. Bedford
368


N
Location Map
1995 Dugong group size
1
2
3
4 or more (labelled)
1990 Dugong group size
1
2
3
4 or more (labelled)
5 0 5 10 15
Kilometres

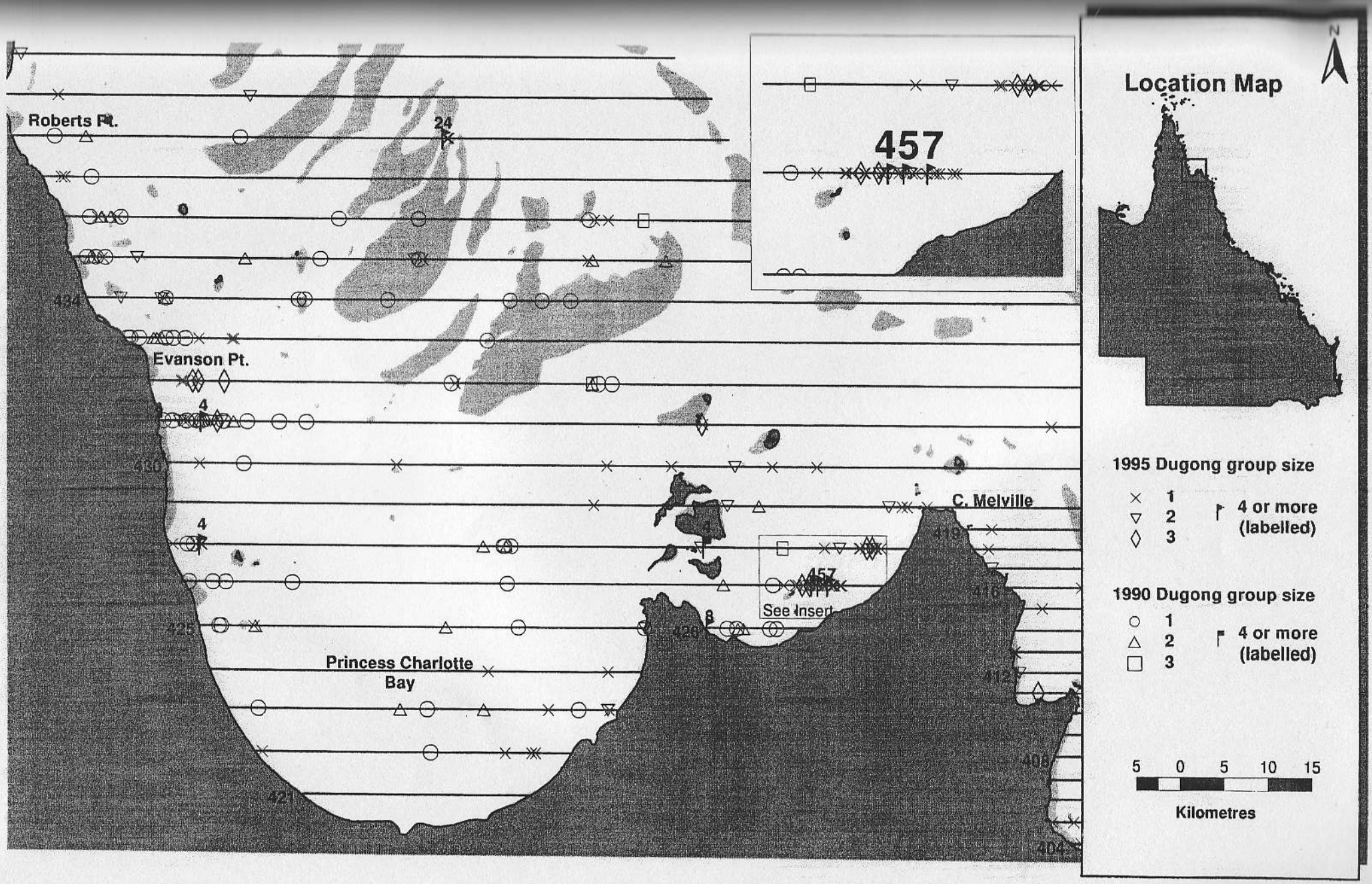
Appendix Figure 2:

Survey area between Murdoch Point and Cape Melville (approximately) showing positions of dugong sightings in November - December 1995, with 1990 data provided for comparison. The numbers associated with the sightings do not necessarily reflect the sizes of actual groupings observed. Transect numbers for 1995 are shown.


Location Map
N
1995 Dugong group size
1
2
3
4 or more (labelled)
1990 Dugong group size
1
2
3
4 or more (labelled)
5 0 5 10 15
Kilometres
Barrow Pt.
416
412
408
404
400
398
396
5
4
8
7
5

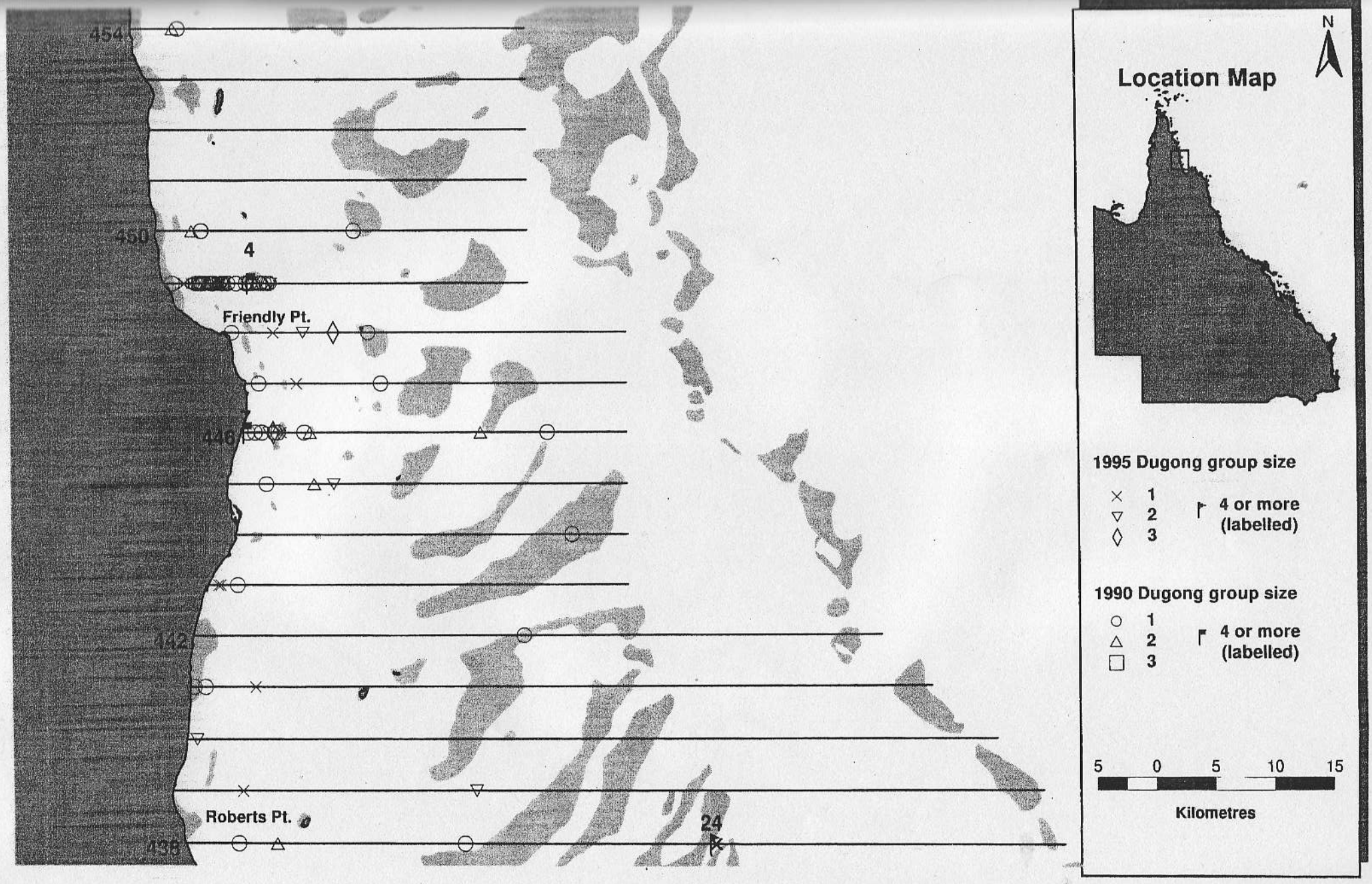
Appendix Figure 3:

Survey area between Cape Melville and Roberts Point (approximately) showing positions of dugong sightings in November - December 1995, with 1990 data provided for comparison. The numbers associated with the sightings do not necessarily reflect the sizes of actual groupings observed. Transect numbers for 1995 are shown.


Roberts Pt.
24
434
Evanson Pt.
4
430
4
425
Princess Charlotte
Bay
421
457
See Insert
8
C. Melville
418
416
412
408
404
Location Map
N
1995 Dugong group size
1
2
3
4 or more
(labelled)
1990 Dugong group size
1
2
3
4 or more
(labelled)
5 0 5 10 15
Kilometres

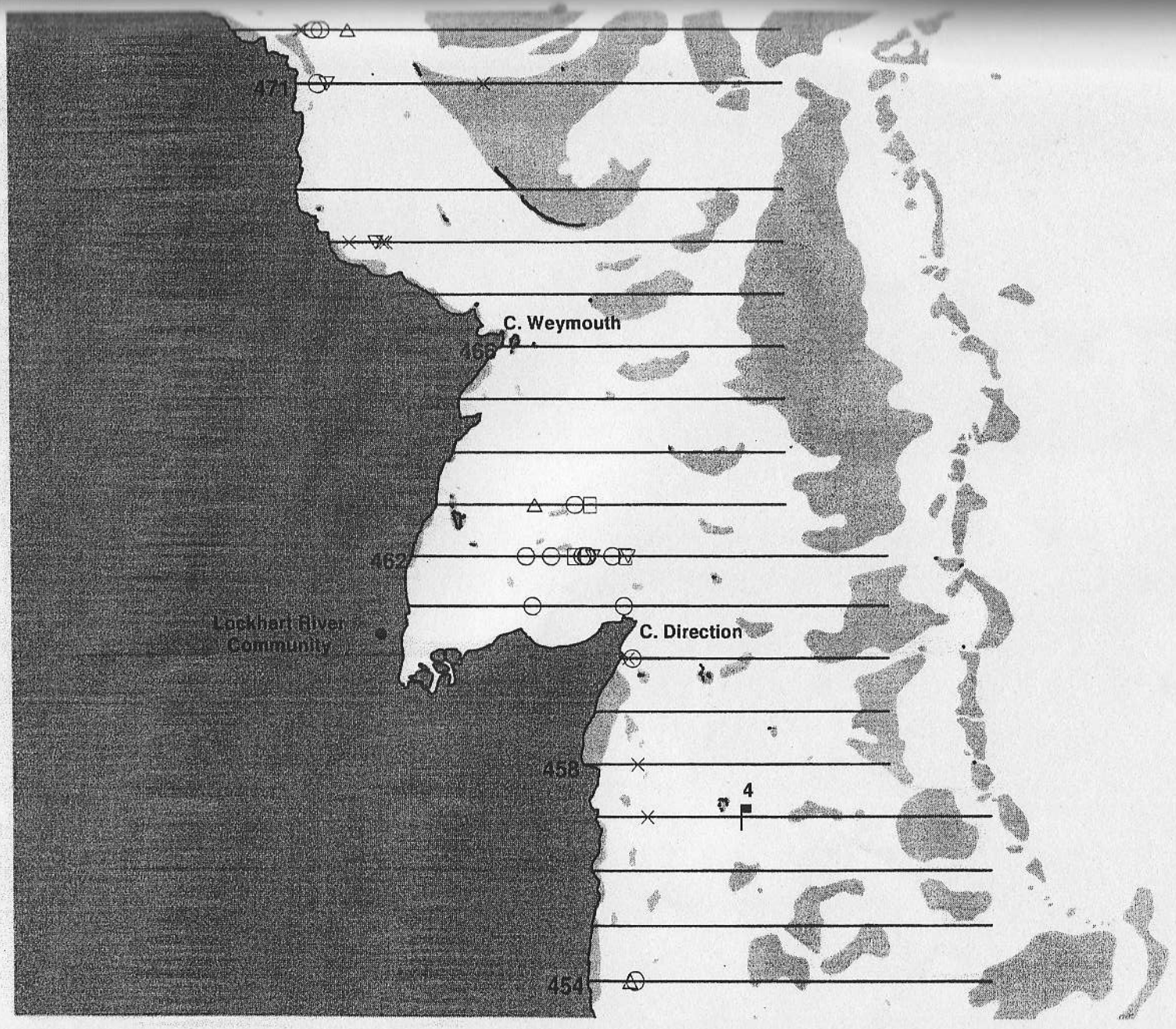
Appendix Figure 4:

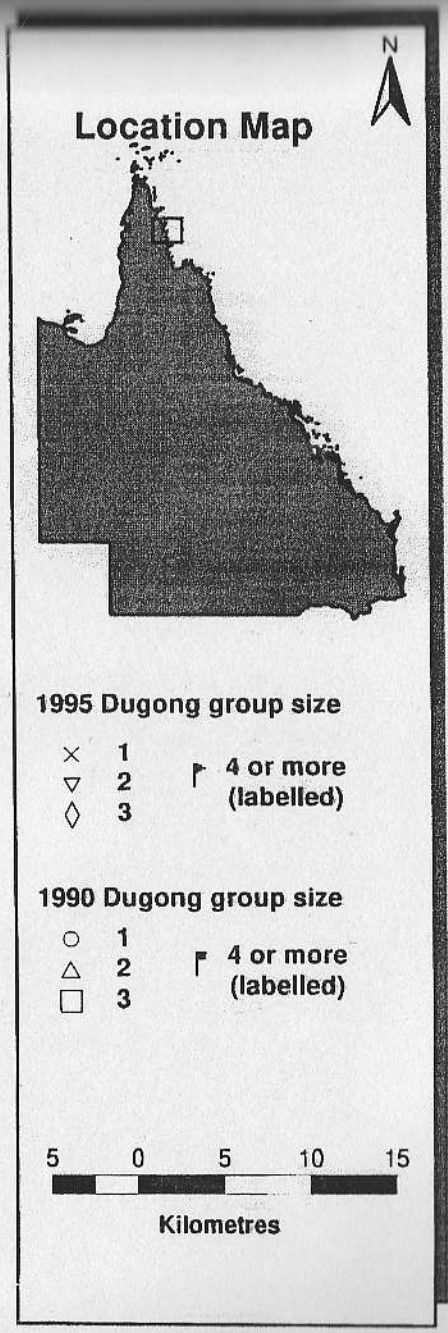
Survey area between Roberts Point and Night Island (approximately) showing positions of dugong sightings in November - December 1995, with 1990 data provided for comparison. The numbers associated with the sightings do not necessarily reflect the sizes of actual groupings observed. Transect numbers for 1995 are shown.


454
450
4
Friendly Pt.
446
442
Roberts Pt.
436
24
N
Location Map
1995 Dugong group size
1
2
3
4 or more (labelled)
1990 Dugong group size
1
2
3
4 or more (labelled)
5 0 5 10 15
Kilometres

Appendix Figure 5:

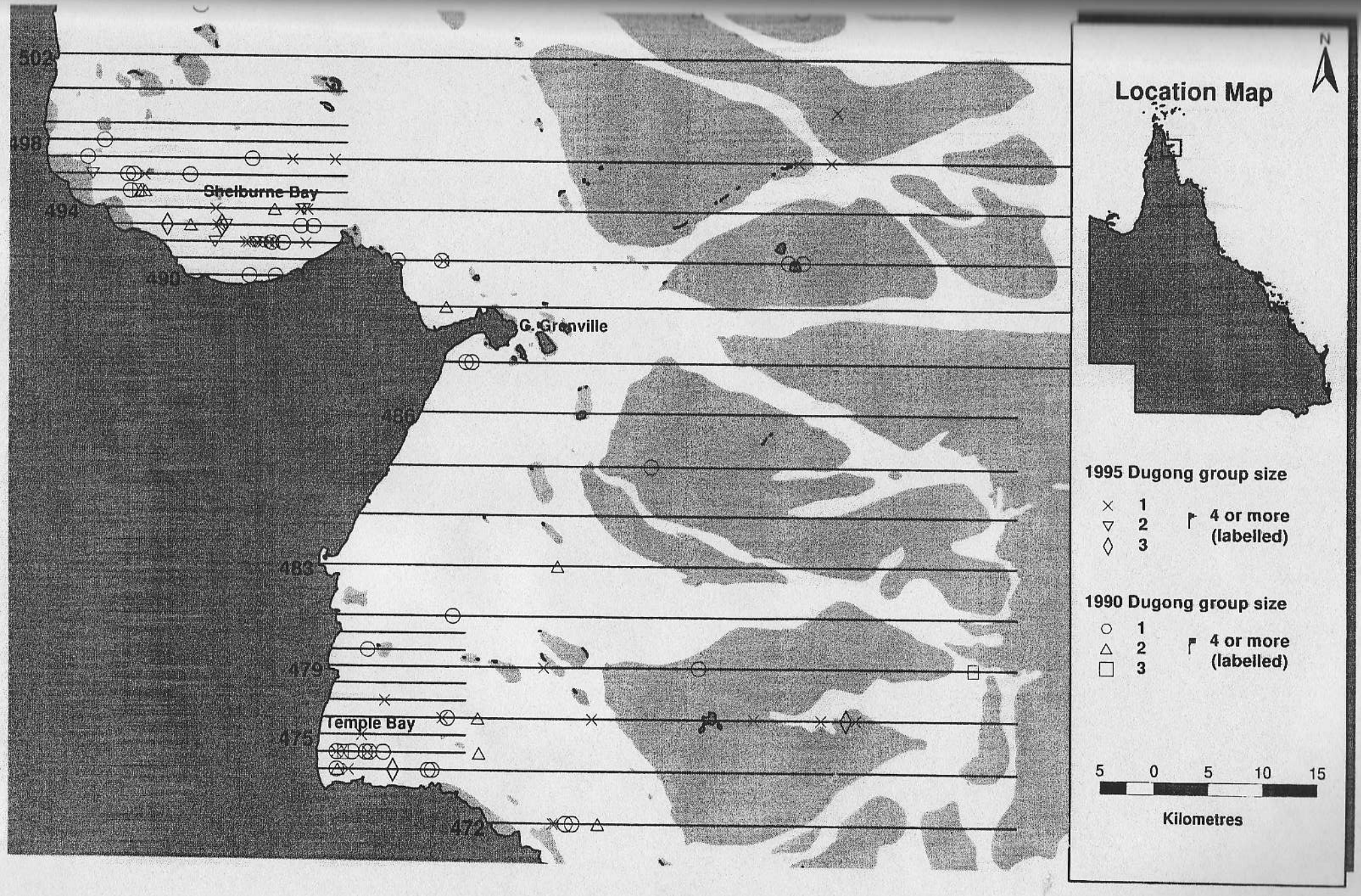
Survey area between Night Island and Temple Bay (approximately) showing positions of dugong sightings in November - December 1995, with 1990 data provided for comparison. The numbers associated with the sightings do not necessarily reflect the sizes of actual groupings observed. Transect numbers for 1995 are shown.


471
C. Weymouth
468
462
Lockhart River
Community
C. Direction
458
4
454


N
Location Map
1995 Dugong group size
1
2
3
4 or more
(labelled)
1990 Dugong group size
1
2
3
4 or more
(labelled)
5 0 5 10 15
Kilometres

Appendix Figure 6:

Survey area between Cape Weymouth and Shelburne Bay (approximately) showing positions of dugong sightings in November - December 1995, with 1990 data provided for comparison. The numbers associated with the sightings do not necessarily reflect the sizes of actual groupings observed. Transect numbers for 1995 are shown.


502
498
494
490
Shelburne Bay
G. Grenville
486
483
479
475
Temple Bay
472
Location Map
N
1995 Dugong group size
1
2
3
4 or more (labelled)
1990 Dugong group size
1
2
3
4 or more (labelled)
5 0 5 10 15
Kilometres