"STOCK ASSESSMENT IN THE NORTH-EAST AUSTRALIAN PRAWN TRAWL FISHERY"

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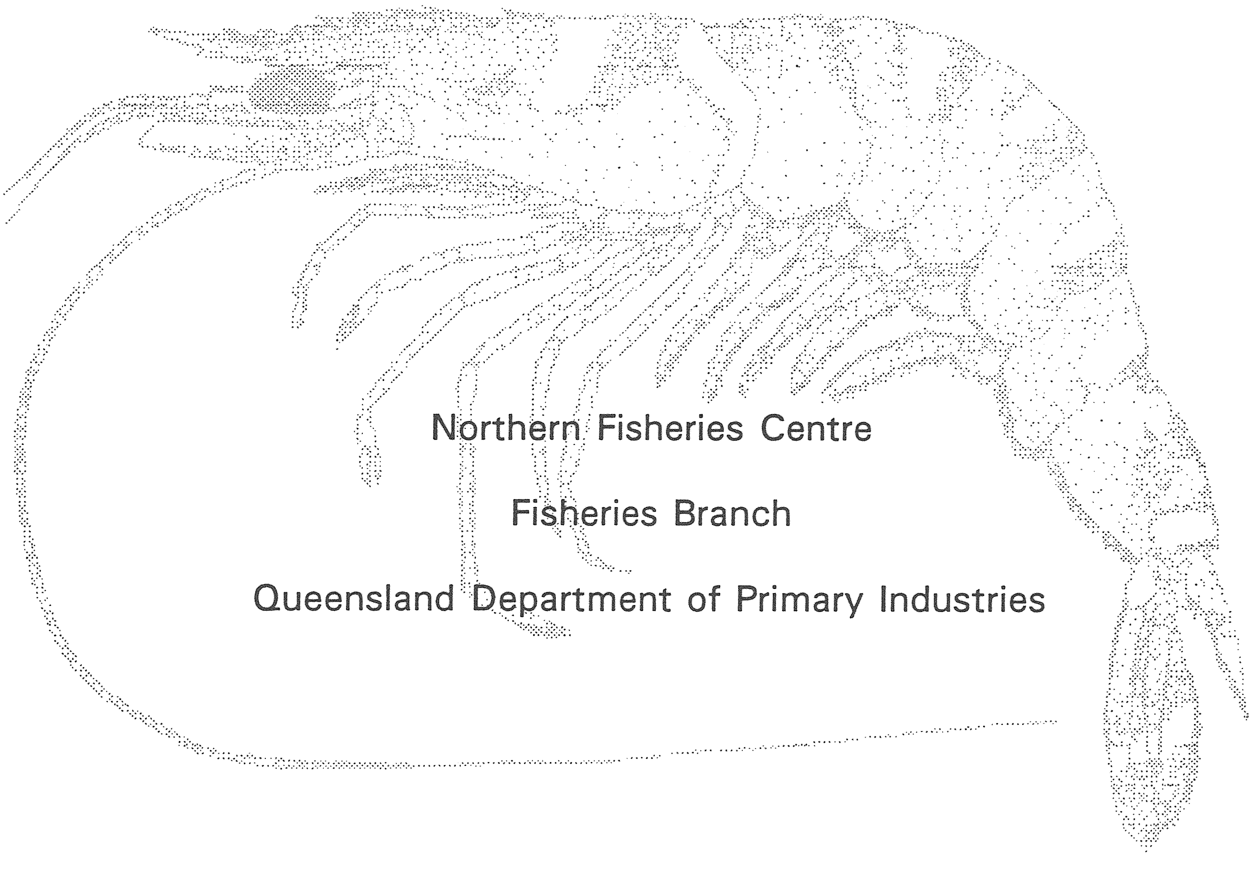

Northern Fisheries Centre

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1 SUMMARY

Seasonal closures are one of several management measures applied to the highly valuable north-east Australian prawn trawl fishery. The timing of these closures, which are intended to prevent growth overfishing and to maximise harvests, is based on anecdotal information and on inadequate biological data.

To redress this paucity of quantitative data, we gathered detailed information on the commercial prawn species from Princess Charlotte Bay, the largest prawn trawl ground in north Queensland, and from the fishery near Cairns. Specifically, we examined catch and effort trends from logbook records, sampled adult prawns in the fishery and juvenile prawns in nursery areas, conducted tagging experiments, and then used the information from these investigations in a computer simulation model, with which we evaluated the seasonal closure regime.

Analysis of logbook data revealed that annual catch and effort in Princess Charlotte Bay was greater in 1991 than in 1990, but that catch per unit effort (CPUE) remained constant between years. Monthly effort and CPUE in Princess Charlotte Bay declined rapidly following peaks early in the fishing season. Fishing effort near Cairns peaked later (May - July) than in Princess Charlotte Bay. "Tiger" prawns represented the largest proportion of the commercial catch in Princess Charlotte Bay and near Cairns. The proportion of tiger prawns in the catch in Princess Charlotte Bay increased between years.

Adult prawns were sampled monthly by trawl in Princess Charlotte Bay during 1990 and 1991, and near Cairns in 1990. The same eight species of commercial prawns were found in both areas, but the proportion of each species differed between areas. Blue endeavour, brown tiger, and grooved tiger prawns represented 80% by number of our survey catch in Princess Charlotte Bay. Red endeavour, grooved tiger and blue endeavour prawns made up 85% of our survey catch near Cairns. There were differences in spatial distribution between species within Princess Charlotte Bay, but most prawns were caught in waters between 10 m and 30 m deep. A decrease in the catch rates of most species in 1991 in Princess Charlotte Bay may have been related to increased rainfall and decreased water temperature.

Juvenile prawns were sampled by beam trawl in Princess Charlotte Bay between October 1990 and June 1991, and in Cairns harbour between July 1989 and November 1990. We found juveniles of eight commercial prawn species (the same species we found as adults in the fishery) on a range of nursery habitats in Princess Charlotte Bay, and we found six of these species in Cairns harbour. Juvenile blue endeavour and brown tiger prawns were the most abundant species and occupied the broadest range of sites in Princess Charlotte Bay, while blue endeavour, grooved tiger and brown tiger prawns represented 97% of the catch in Cairns harbour. The spatial distribution of juvenile blue endeavour prawns in Princess Charlotte Bay correlated significantly with percentage cover of seagrass. Juvenile red spot king prawn abundance in Princess Charlotte Bay was equally influenced negatively by muddy sediments, and positively by coarse sand sediments.

While life-history patterns were evident, life-history timing varied between species, locations, and years, and the relative strength and timing of each life-history stage did not necessarily correspond. Brown tiger prawns spawned continuously in Princess Charlotte Bay, but settlement of juveniles in nursery areas peaked in October/November, and recruitment into the fishery was greatest in February/March. Grooved tiger prawn spawning was extended, but recruitment was greatest in March/April, both in Princess Charlotte Bay and near Cairns. Settlement of grooved tiger prawns was greatest from November to February in Princess Charlotte Bay. Spawning and recruitment of blue endeavour prawns in Princess Charlotte Bay were continuous, but settlement was greatest from March to June. The April/May settlement of blue endeavour prawns near Cairns followed an April spawning peak. Recruitment of red endeavour prawns near Cairns was continuous. Most settlement in Cairns harbour corresponded with early (March/April) spawning peaks, but survival from later spawning peaks appeared low.

More than 16 000 tagged brown tiger prawns were released in Princess Charlotte Bay during the seasonal closures in 1990 and 1991 to provide estimates of parameters for use in modelling procedures. The overall return rate was 9%. Most prawns were recaptured within Princess Charlotte Bay, but there was some southerly movement in 1990, which did not occur in 1991. Fishing effort may have influenced perceived migration patterns. Estimated growth parameters were similar to those found for brown tiger prawns in other parts of northern Australia. There were differences between release months in the growth coefficient (***K***) for males. Females grew larger than males. The overall instantaneous rate of natural mortality was 8.4% week^{-1} in 1990 and 7.2% week^{-1} in 1991. Variation in natural mortality between years and sexes may have been caused by variable predation rates.

Length-weight relationships, which were used in modelling procedures, were established for the eight commercial prawn species found in Princess Charlotte Bay and near Cairns.

Seasonal closure options for Princess Charlotte Bay in 1990 and 1991, and for Cairns in 1990, were evaluated by computer simulation. Appropriate model parameters were gathered from our sampling programs, logbook data, and the literature. A range of values for natural and fishing mortality were used to incorporate uncertainty associated with these parameters. Species which comprised 95% of the commercial catch in Princess Charlotte Bay, and which comprised more than 90% of the commercial catch near Cairns, were modelled. Simulations of a range of seasonal closures in Princess Charlotte Bay predicted maximum gains in value ($) of between 5% and 9%. Simulations of the closure regimes implemented in Princess Charlotte Bay predicted similar gains (4% to 8%). Near Cairns, where a seasonal closure was not implemented, simulations predicted maximum gains of less than 1%.

We consider that the seasonal closures implemented in Princess Charlotte Bay in 1990 and 1991 were appropriate, and that it was also appropriate that no closure was implemented near Cairns. We conclude, then, that the current seasonal closure regime is an appropriate management measure for the north-east Australian prawn trawl fishery.

Industry would benefit from future research in several areas. Our ability to evaluate management options would improve with a better appreciation of:

1. the response of fishers to management measures,

2. long-term inter-annual variation in recruitment patterns, and

3. the relative importance of different nursery areas (e.g. deep-water versus reef-top seagrass).

2 INTRODUCTION

The north-east prawn trawl fishery is a highly valuable component of Australia's east coast prawn trawl fishery. Approximately 7800 t of prawns were caught in the fishery from Cairns to Cape York between 1988 and 1990 (CFISH logbook data). Almost 1000 trawlers operated in the Queensland east coast trawl fishery in 1991, and Cairns was the home port of 221 of these vessels in 1990 (QFMA 1991). Approximately one-third of eligible vessels operate in Princess Charlotte Bay (Trainor *et al.* 1992).

Various management measures are currently applied to the north-east prawn trawl fishery. Concerns about excessive fishing capacity led to the introduction of limited entry in 1979. A trawler length limit of 20 m and a combined net headrope-footrope limit of 88 m were introduced to prevent large trawlers endorsed to fish in the Gulf of Carpentaria from operating in Queensland east coast state waters. Area (strip) closures are applied in many localities, and a regime of seasonal closures was introduced in 1985 in waters north of Mackay. Seasonal closures were intended to prevent growth overfishing (i.e. the capture of prawns smaller than an optimal, or export, size), and managers aimed to achieve a maximum harvest by closing the fishery when juvenile prawns migrated from (usually) inshore nursery areas to offshore (adult) areas. Closure timing was based on information from fishers, along with social considerations (festive seasons, etc.) and somewhat limited biological criteria.

During our study, the fishery from Cape Tribulation north to Torres Strait (Figure 2.1) was closed between January 1, 1990 and April 14, 1990. The same area was closed between February 15 and April 7 the following year, while the Princess Charlotte Bay region (Figure 2.1) was closed from January 1, 1991 to April 7, 1991.

Studies of commercial prawn species and size composition in the north-east Australian prawn trawl fishery were conducted between 1985 and 1989 (Coles *et al.* 1985a, Coles *et al.* 1987a, Lee Long *et al.* 1991). While these studies provided a basis for understanding the processes involved, it was clear that biological data needed to optimise the timing of closures and maximise returns from the fishery was incomplete. Further research was needed to provide:

- information on the variability in life-cycle timing and species composition between the different east coast fishing grounds;
- quantitative data on more than just the dominant species for determining closure timing in a multi-species fishery;
- information on prawn growth, movement, and natural mortality for the fishery; and
- information to establish annual changes in life-cycle timing and population parameters, and the effect this would have on the appropriateness of closure dates.

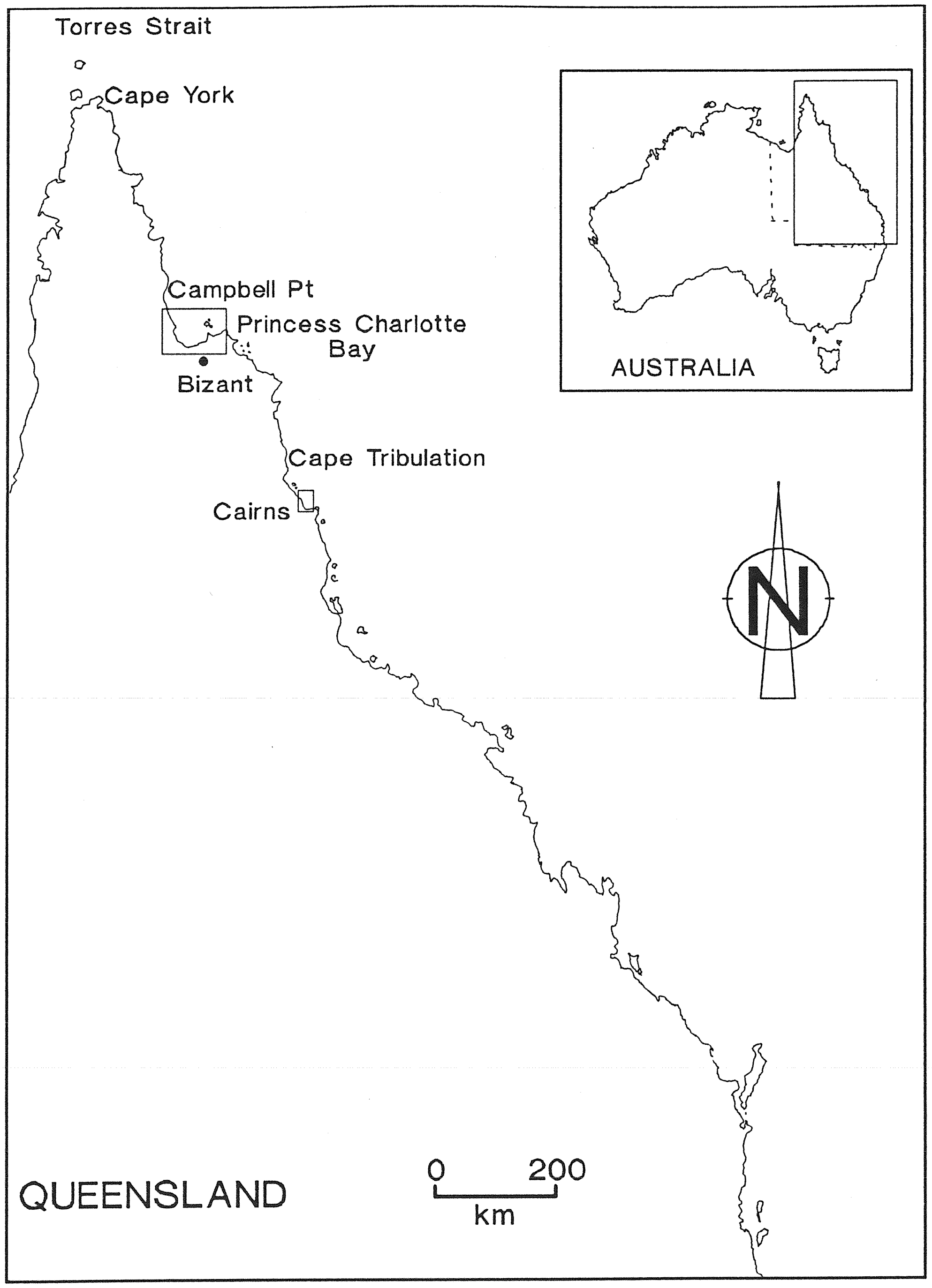

Figure 2.1 Study area.

We gathered detailed information for management on the commercial prawn species (Table 2.1) in Princess Charlotte Bay, the largest prawn trawl ground in north Queensland. Trainor *et al.* (1992) estimated a gross production value of up to $10m per annum for Princess Charlotte Bay. Princess Charlotte Bay is located at latitude 14.25°S and longitude 144°E on the eastern coast of Queensland (Figure 2.1). Four rivers flow into this large, shallow, muddy, mangrove-fringed bay (Frankel 1974), which contains several extensive, mid-shelf platform reefs elongated normal to shore (Sahl and Marsden 1987). The area has two distinct climatic periods: (i) the "dry season", characterised by south-east trade winds, and (ii) the "wet season", characterised by north-west winds which bring equatorial air masses and heavy rains (Sahl and Marsden 1987).

Table 2.1 Common and corresponding scientific names of commercial prawns found in Princess Charlotte Bay and near Cairns.

Common name	Scientific name
Brown tiger prawn	*Penaeus esculentus* Haswell, 1879
Grooved tiger prawn	*P. semisulcatus* de Haan, 1850
Western king prawn	*P. latisulcatus* Kishinouye, 1896
Red spot king prawn	*P. longistylus* Kubo, 1943
White banana prawn	*P. merguiensis* de Man, 1888
Leader prawn	*P. monodon* Fabricius, 1798
Blue endeavour prawn	*Metapenaeus endeavouri* (Schmitt, 1926)
Red endeavour prawn	*M. ensis* (de Haan, 1850)

We gathered similar biological information from the fishery near Cairns (Figure 2.1) so that variations in species composition and recruitment timing between sites could be quantified. Cairns has a similar climate to Princess Charlotte Bay, and is also adjacent to both reef and river environments. The catch from the fishery near Cairns is smaller than the catch from Princess Charlotte Bay (Section 3). Seasonal closures were not implemented near Cairns during our study.

Specifically, our objectives were to:

(a) identify nursery grounds for prawns recruiting to the major fishing grounds of Princess Charlotte Bay and near Cairns, and to follow the movement and timing of juveniles onto the fishing grounds and adult prawns on these grounds, and

(b) develop a quantitative model of recruitment, growth and yield for the commercially important prawns in the fishery, and to evaluate the closure management scheme presently applied to the fishery.

The first set of objectives was addressed in three phases of research:

1. Adult prawns (Section 4) were sampled in the fishery in Princess Charlotte Bay during 1990 and 1991, and near Cairns in 1990. This provided essential information on the size, species composition and recruitment patterns of commercial prawns.

2. Juvenile prawns (Section 5) were sampled in nursery areas in Princess Charlotte Bay between October 1990 and June 1991, and near Cairns between July 1989 and November 1990. This enabled us to identify nursery areas and to investigate factors which influence the distribution of juvenile prawns in these areas, and to determine the timing of juvenile settlement and emigration.

3. Tagging experiments (Section 6) were conducted in Princess Charlotte Bay during the 1990 and 1991 seasonal closures. These

experiments provided us with information on movements of adult prawns, and with estimates of growth and natural mortality rates.

In addition, information on fishing effort and catch (Section 3) was obtained from CFISH logbook data. Morphometric relationships are presented in Section 7. The information contained in Sections 3 - 7 was applied in a computer simulation model, which we used to evaluate the seasonal closure regime (Section 8).

3 FISHING EFFORT AND CATCH

3.1 Abstract

Logbook data from January 1990 to December 1991, and between Campbell Point and Cairns, was obtained. Catch and effort trends were examined for use in analyses and interpretation of results from adult prawn sampling, tagging experiments and closure modelling. Fishing effort was centred in Princess Charlotte Bay, at Cape Flattery/Cape Bedford, and (in 1991 only) near Cairns. Annual effort and catch increased between years in Princess Charlotte Bay, but annual catch per unit effort (CPUE) remained relatively constant. Effort was evenly distributed throughout Princess Charlotte Bay in 1990, but more effort occurred in the western part of Princess Charlotte Bay in 1991. Monthly effort and CPUE in Princess Charlotte Bay declined rapidly following peaks early in the fishing season. Effort peaked in July 1990 and May/June 1991 near Cairns, and may have been influenced by seasonal closures in other fisheries. Tiger prawns represented the largest proportion of the catch in Princess Charlotte Bay and near Cairns. The proportion of tiger prawns in the catch increased between years in Princess Charlotte Bay, while the proportion of both endeavour and king prawns decreased.

3.2 Introduction

Catch and effort data from exploited stocks are necessary for appropriate management of commercial fisheries (Demory and Golden 1983). Fishing effort data are used in stock assessment, as a measure of fishing mortality, and as a measure of fishing costs, while catch per unit effort (CPUE) data are used to estimate changes in stock abundance (Gulland 1983).

There is little long-term catch and effort data available for the Queensland east coast prawn fishery (QFMA 1991). Beurteaux and Coles (1988) used berthage and aerial surveillance data to provide a history of fishing effort for the region between Townsville and Cape York. A compulsory logbook program for Queensland east coast trawl fisheries was not initiated until January 1988. Trainor *et al.* (1992) found that both effort and catch declined in Princess Charlotte Bay, while CPUE remained constant, between 1988 and 1990. During the same period, catches consisted mainly of "tiger" (60%) and "endeavour" (35%) prawns (Trainor *et al.* 1992). Fishers do not generally distinguish commercial prawns to species level in their logbook entries. Tiger prawns are comprised of brown and grooved tiger prawns, endeavour prawns are comprised of blue and red endeavour prawns, "king" prawns are comprised of western and red spot king prawns, and "banana" prawns are comprised of white banana prawns (Section 4).

In this section, catch and effort trends for the area and period in which we sampled are outlined. This information was used in analyses and interpretation of results from adult prawn sampling (Section 4), tagging experiments (Section 6) and closure modelling (Section 8).

3.3 Methods and materials

CFISH log book data (30' grids) was obtained from the Queensland Department of Primary Industries, Fisheries Branch. Data from January 1990 to December 1991, and between Campbell Point and Cairns (Figure 2.1) were included. For Cairns, only catch data from 1990 were included. This effectively encompassed the area and period of our study (Section 2).

Approximately 3% of logbook entries had catch data without corresponding effort (hours trawled) information. We decided to use boat days to represent annual and monthly effort, as the missing information on hours trawled was unevenly distributed through space and time. CPUE, however, was calculated using hours trawled, but all catches without corresponding hourly effort data were omitted from this analysis.

3.4 Results and discussion

3.4.1 Effort

Fishing effort fluctuated along the coast in both 1990 and 1991. Centres of effort were Princess Charlotte Bay (grids D11 and E11), Cape Flattery/Cape Bedford (grids G12 and G13) and, in 1991 only, near Cairns (grid H16) (Figure 3.1). Effort levels were also high north of Princess Charlotte Bay (grid D10) and near Cape Tribulation (grid H15) (Figure 3.1). Relatively little effort occurred in the regions between Princess Charlotte Bay and Cape Flattery, and between Cape Bedford and Cape Tribulation (Figure 3.1). Vessels had more opportunity to fish south of Cape Tribulation, as this area was not encompassed by the seasonal closure.

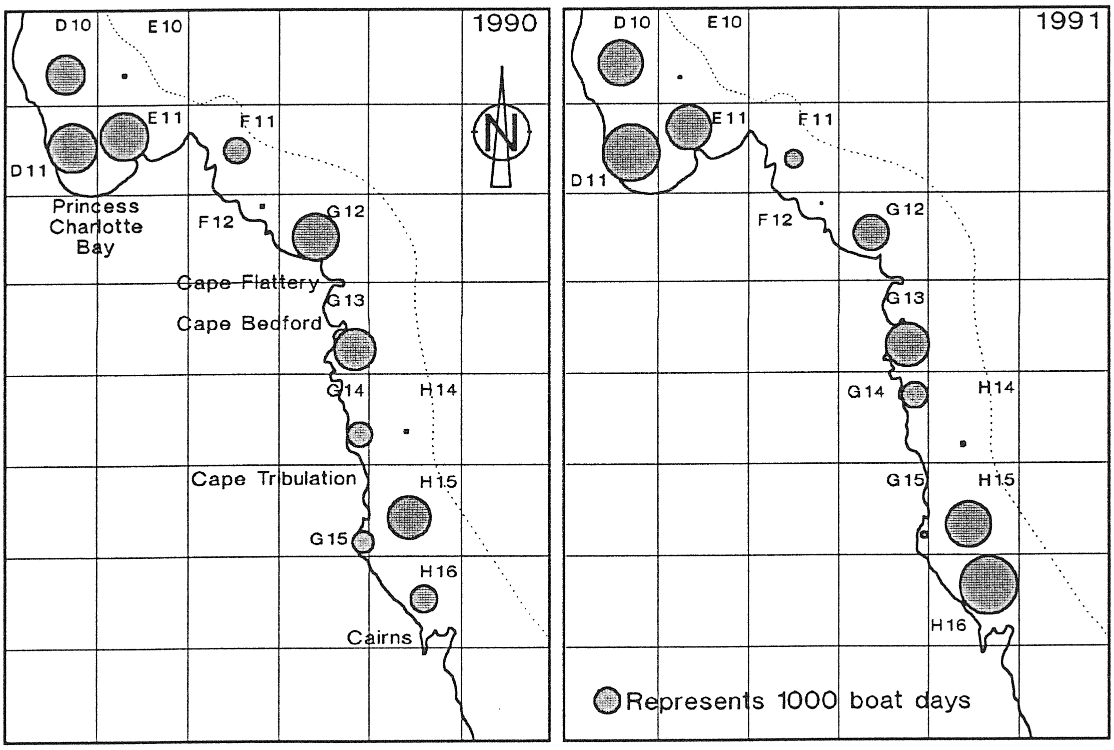

Figure 3.1 Annual fishing effort in 30' grids.

Total effort in Princess Charlotte Bay was 20% greater in 1991 than in 1990 (Figure 3.1). Effort declined markedly (by more than 50%) in Princess Charlotte Bay between 1988 and 1990 (Trainor *et al.* 1992). It remains to be seen whether effort levels in Princess Charlotte Bay have stabilised or will fluctuate markedly in the future. Effort was almost evenly distributed between the western (grid D11) and eastern (grid E11) parts of Princess Charlotte Bay in 1990, but was 40% greater in the western area than in the eastern area in 1991 (Figure 3.1). Annual effort in the Cape Flattery/Cape Bedford region was similar in 1990 and 1991 (Figure 3.1). Annual effort near Cairns increased by 115% between years (Figure 3.1). It is unclear why this large increase occurred.

Effort in Princess Charlotte Bay was concentrated near the start of the fishing season, particularly in 1991 (Figure 3.2). Monthly effort in Princess Charlotte Bay peaked in May of 1990, and in April the following year (Figure 3.2). Vessels had one week longer to fish in April 1991 than in April 1990 due to different opening dates (Section 2), but this does not entirely account for the greater effort at the start of the 1991 season (i.e more boats fished in Princess Charlotte Bay at the start of the 1991 fishing season). Effort declined rapidly following the early peaks, although minor, mid-season peaks occurred in September 1990 and July 1991 (Figure 3.2).

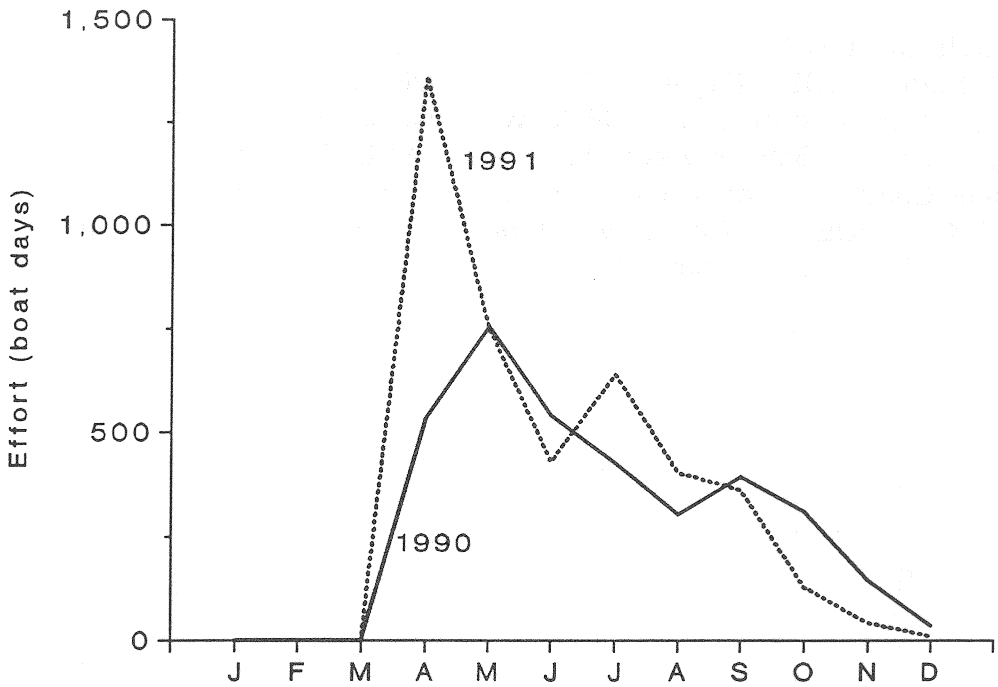

Figure 3.2 Monthly fishing effort in Princess Charlotte Bay.

Effort near Cairns peaked in July of 1990, and May/June 1991 (Figure 3.3). In general, fishers did not opt to trawl near Cairns when the fishery north of Cape Tribulation was closed, as effort near Cairns was very low during the early part of the year, especially in 1990 (Figure 3.3). It is possible that effort patterns near Cairns were influenced by seasonal closures in other fisheries, and that fishers who may otherwise have operated near Cairns used this period to refit and to take part in festive/social activities. Alternatively, fishers may have trawled in more southerly waters during the early part of the year.

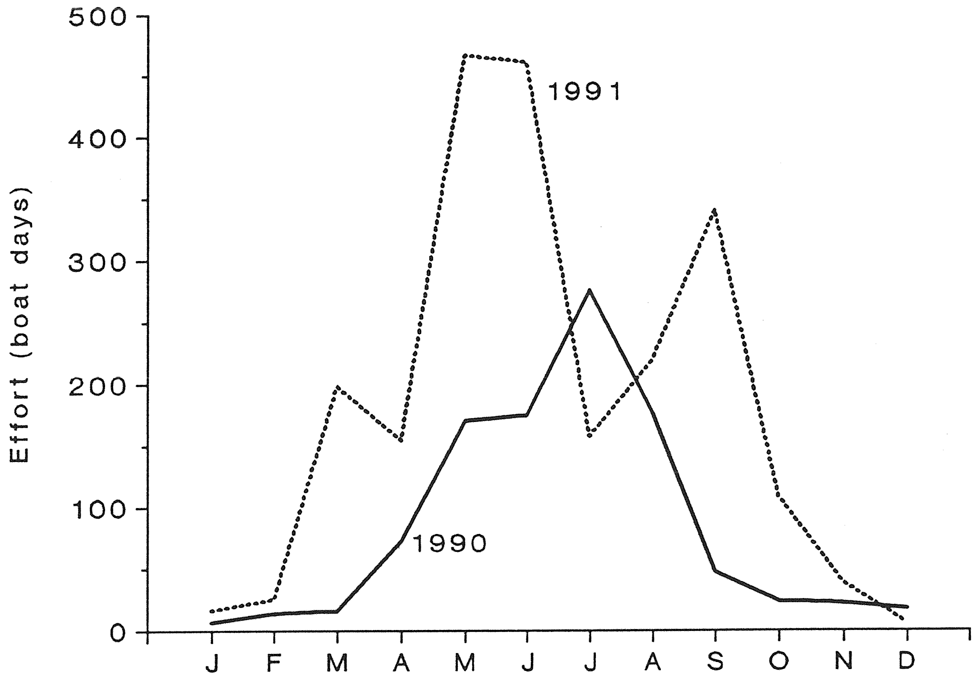

Figure 3.3 Monthly fishing effort near Cairns.

3.4.2 Catch

Total catch and CPUE. Total catch in Princess Charlotte Bay was 43% greater in 1991 than in 1990 (Figure 3.4), but CPUE remained relatively constant at about 10 kg h^{-1} (Figure 3.5). CPUE was also constant at about 10 kg h^{-1} in Princess Charlotte Bay between 1988 and 1990 (Trainor *et al.* 1992). Total catch near Cairns was only about one-quarter of that in Princess Charlotte Bay (Figure 3.4). CPUE near Cairns was about 20% lower than in Princess Charlotte Bay (Figure 3.5). Note that CPUE effort calculations omit catches for which effort was not recorded.

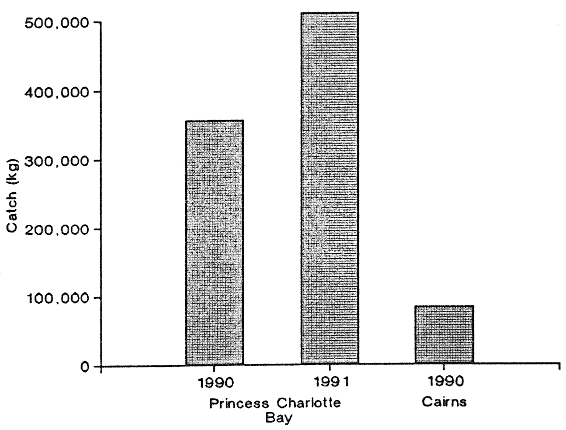

Figure 3.4 Annual commercial catch.

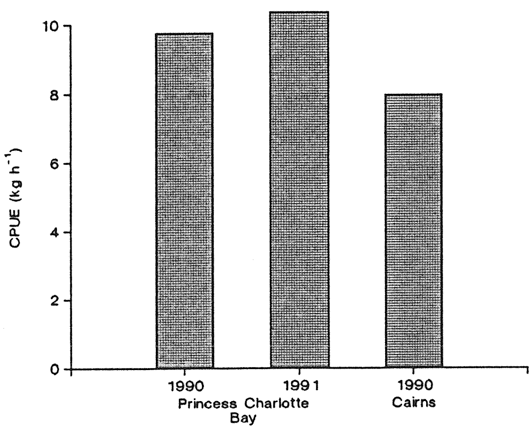

Figure 3.5 Annual commercial CPUE.

Monthly CPUE in Princess Charlotte Bay was greatest at the start of the fishing season and decreased through the remainder of the year, with minor peaks in September 1990 and August 1991 (Figure 3.6). The peak in CPUE in Princess Charlotte Bay was greater in 1991 than in 1990 (Figure 3.6). Peaks in CPUE may reflect an increased abundance of commercial prawns after a closure (Trainor *et al.* 1992). Hillborn and Walters (1991) argue that CPUE is an aggregate of spatial patterns of abundance, spatial patterns of fishing effort, and the relationship between abundance and capture success on a particular site, and may not accurately reflect abundance levels. Monthly CPUE near Cairns in 1990 increased greatly between March and April, and peaked in May (Figure 3.6), following a "self-imposed" closure (i.e. very low effort levels) early in 1990. It is important to note that inferences from two years data may be misleading because annual abundances can fluctuate greatly.

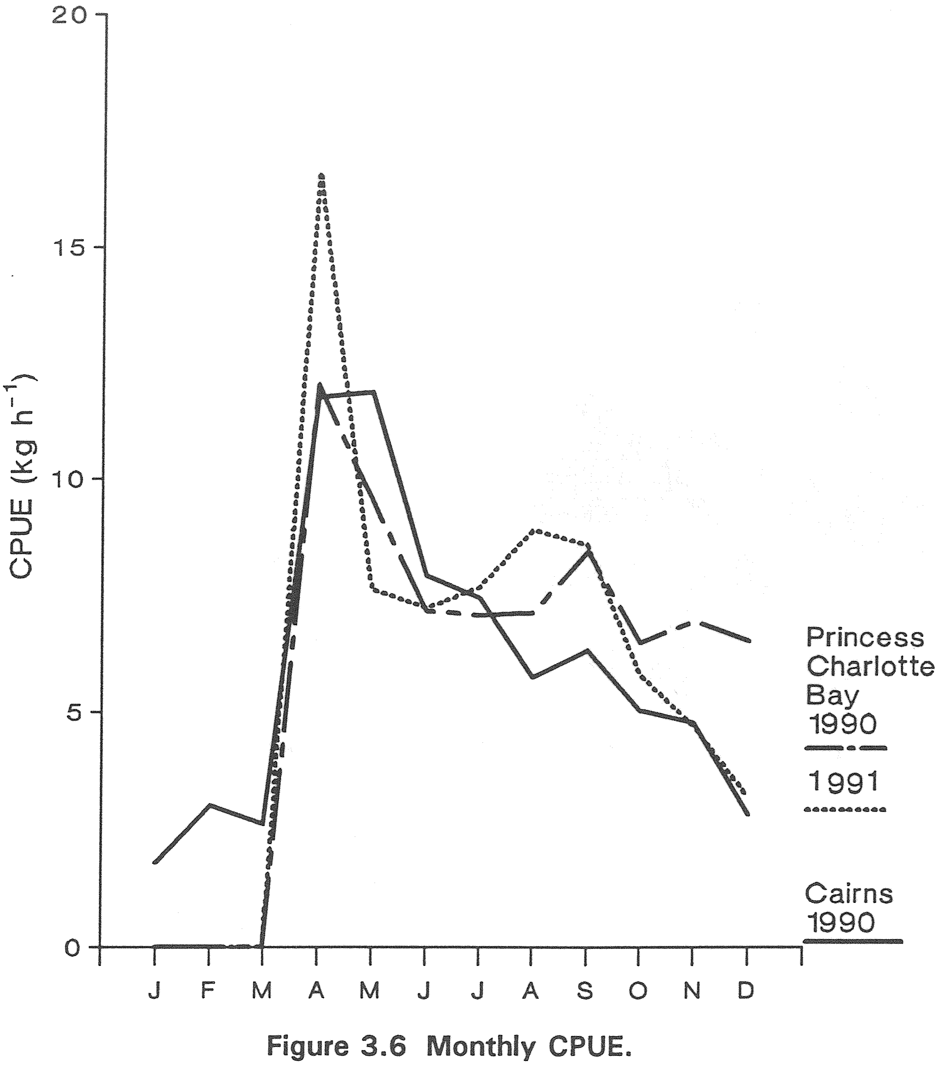

Figure 3.6 Monthly CPUE.

Species composition. Tiger prawns made up 57% of the commercial catch in Princess Charlotte Bay in 1990, and 65% in 1991 (Figure 3.7). The proportion of endeavour prawns in the commercial catch decreased from 36% in 1990 to 30% in 1991 (Figure 3.7). The proportion of king prawns also decreased marginally between years, from 7% in 1990 to 5% in 1991 (Figure 3.7). These proportions are similar to those reported by Trainor *et al.* (1992), who concluded that catch composition in Princess Charlotte Bay had not varied markedly since 1988. Tiger prawns also represented the largest proportion

(53%) of the commercial catch near Cairns in 1990 (Figure 3.7). The proportion of banana prawns in the catch near Cairns (12%) was far greater than in Princess Charlotte Bay (Figure 3.7). Endeavour and king prawns made up 32% and 2% respectively of the catch near Cairns (Figure 3.7). Proportions of each species in our survey catch are given in Section 4.

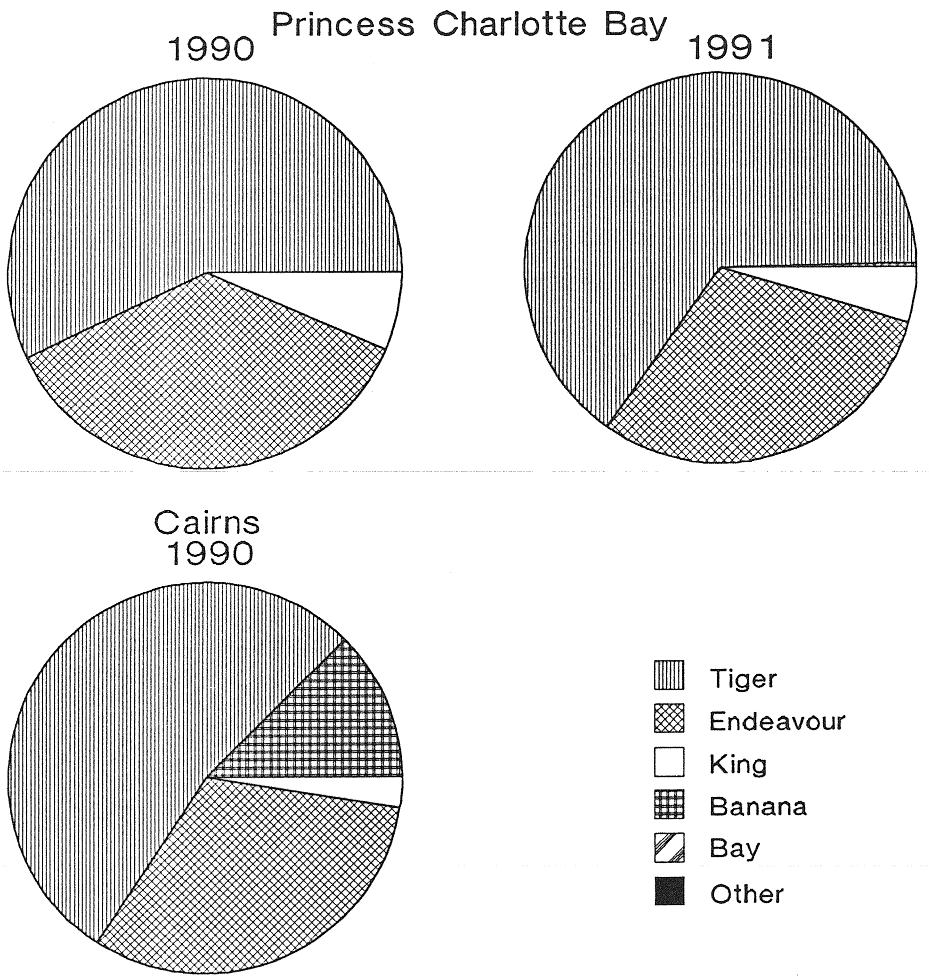

Figure 3.7 Species composition of commercial catches from Princess Charlotte Bay and near Cairns.

4 ADULT PRAWN STUDIES

4.1 Abstract

Adult prawns were sampled monthly by trawl in Princess Charlotte Bay during 1990 and 1991, and near Cairns in 1990. The same eight species of commercial prawns were found in both areas, but the proportion of each species differed between areas. There were differences in spatial distribution between species, but most prawns in Princess Charlotte Bay were caught in waters between 10 m and 30 m deep. A decrease in the catch rates of most species in 1991 in Princess Charlotte Bay may have been related to increased rainfall and decreased water temperature. Catches were greatest in March in Princess Charlotte Bay, and in April near Cairns. Recruitment into the fishery generally occurred during March, approximately six months after the peak spawning period for most species. The beginning of the spawning period coincided with a rise in water temperature.

4.2 Introduction

Scientific study of penaeid prawn life cycles and populations has a long history, due to the importance of these animals as a food source. Prawns have complex seasonal life-history patterns, which vary within and between species, probably due to the influence of different environmental conditions on the various life history stages (Dall *et al.* 1990). Environmental factors such as temperature and rainfall affect life history timing, and may vary with season, latitude and depth (Dall *et al.* 1990).

Most prawns inhabit inshore tropical and sub-tropical waters (Dall *et al.* 1990). Within these relatively shallow waters, the distribution of prawn species may be associated with particular depth ranges. Somers (1987) found that the catch rates of commercial prawn species in the Gulf of Carpentaria varied with depth, and that some species were more likely to be found in particular depth ranges than others.

Studies of commercial prawns were made in Princess Charlotte Bay and near Cairns between 1985 and 1989, but were generally restricted to the duration of the seasonal closure of the fishery. Brown tiger prawns were the most numerous of several species of major commercial importance found in Princess Charlotte Bay (Coles *et al.* 1985a, Coles *et al.* 1987a, Lee Long *et al.* 1991). Near Cairns in 1985/86, Coles *et al.* (1987a) found that grooved tiger, brown tiger and blue endeavour prawns made up approximately 85% of the catch. Lee Long *et al.* (1991) sampled the same area in 1989 and found that while catches of grooved tiger prawns were still greater than those of any other species, greater numbers of red endeavour prawns were caught than either brown tiger or blue endeavour prawns.

Patterns in the catch, species composition, distribution and reproduction of adult commercial prawns in Princess Charlotte Bay and near Cairns are described in this chapter.

4.3 Methods and materials

4.3.1 Sites

Twelve sampling grids defined by arbitrary area constraints and by depth contours were chosen in the Princess Charlotte Bay area (Figure 4.1). Four pairs of grids in the middle of Princess Charlotte Bay were defined by depth contours at 5, 10, 15, 20 and 30 m. There was also one grid in water deeper than 30 m between Corbett Reef and Clack Reef, one grid in Bathurst Bay in water between 5 m and 15 m deep, and two grids near the Cliff Isles in water between 5 m and 10 m, and 10 m and 15 m depth. Waters shallower than 5 m and deeper than 40 m were not sampled. Near Cairns, a series of grids between Double Island and White Cliffs were defined by the 5, 10 and 15 m depth contours (Figure 4.2). This sampling strategy was designed to complement a similar study in the Bowen-Mackay area, so that future comparison between the two studies would be facilitated.

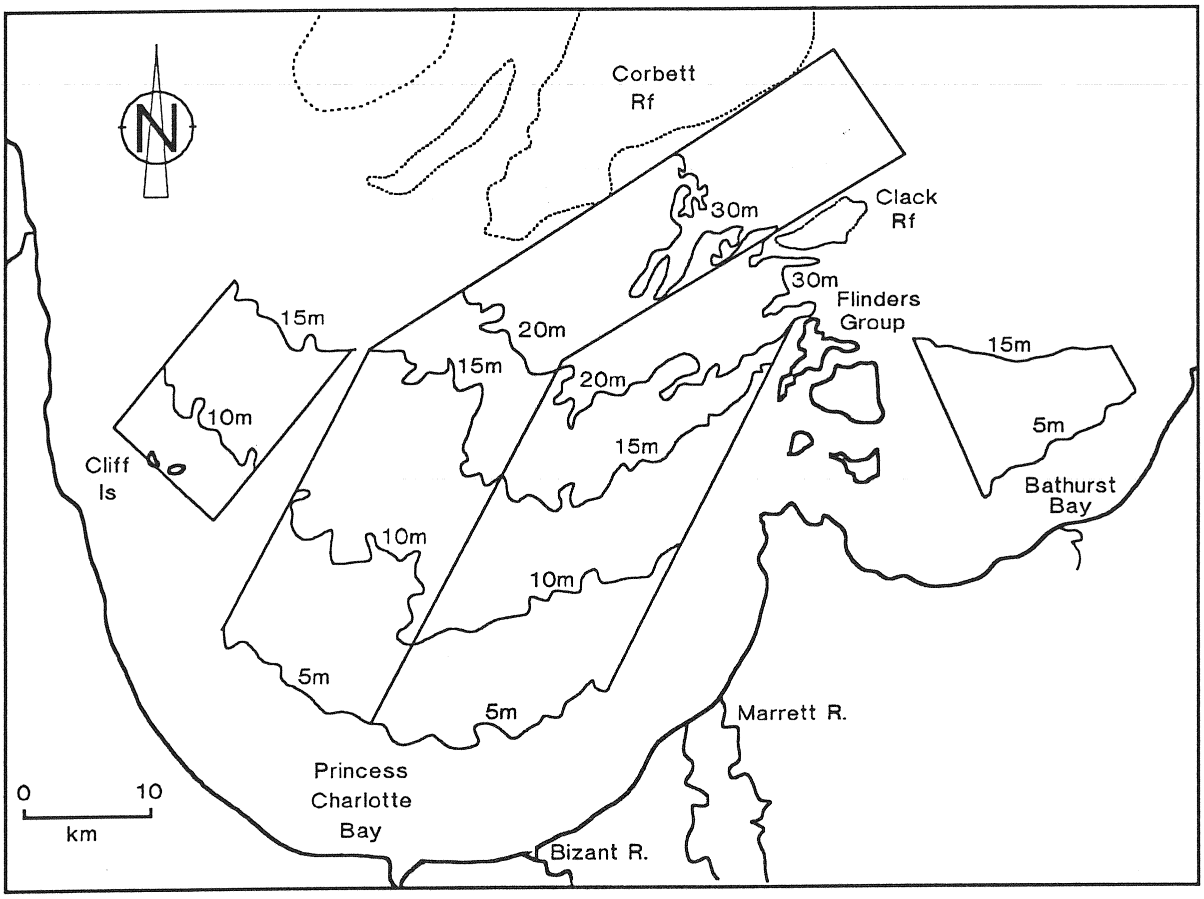

Figure 4.1 Sampling grids in Princess Charlotte Bay.

4.3.2 Operations

Three 20-min trawl shots were made at approximately 6 km h^{-1} at random locations in each grid. A 15-m commercial fishing vessel, the FV "Marshelly", was chartered to sample in Princess Charlotte Bay. The "Marshelly" towed four "Sandokan" nets of two different sizes. Samples were taken from two of these nets, both of which had a 10.1-m headline length and 41.3-mm mesh. The RV "Lumaigul" was used for sampling near Cairns. This 12.5-m vessel towed two

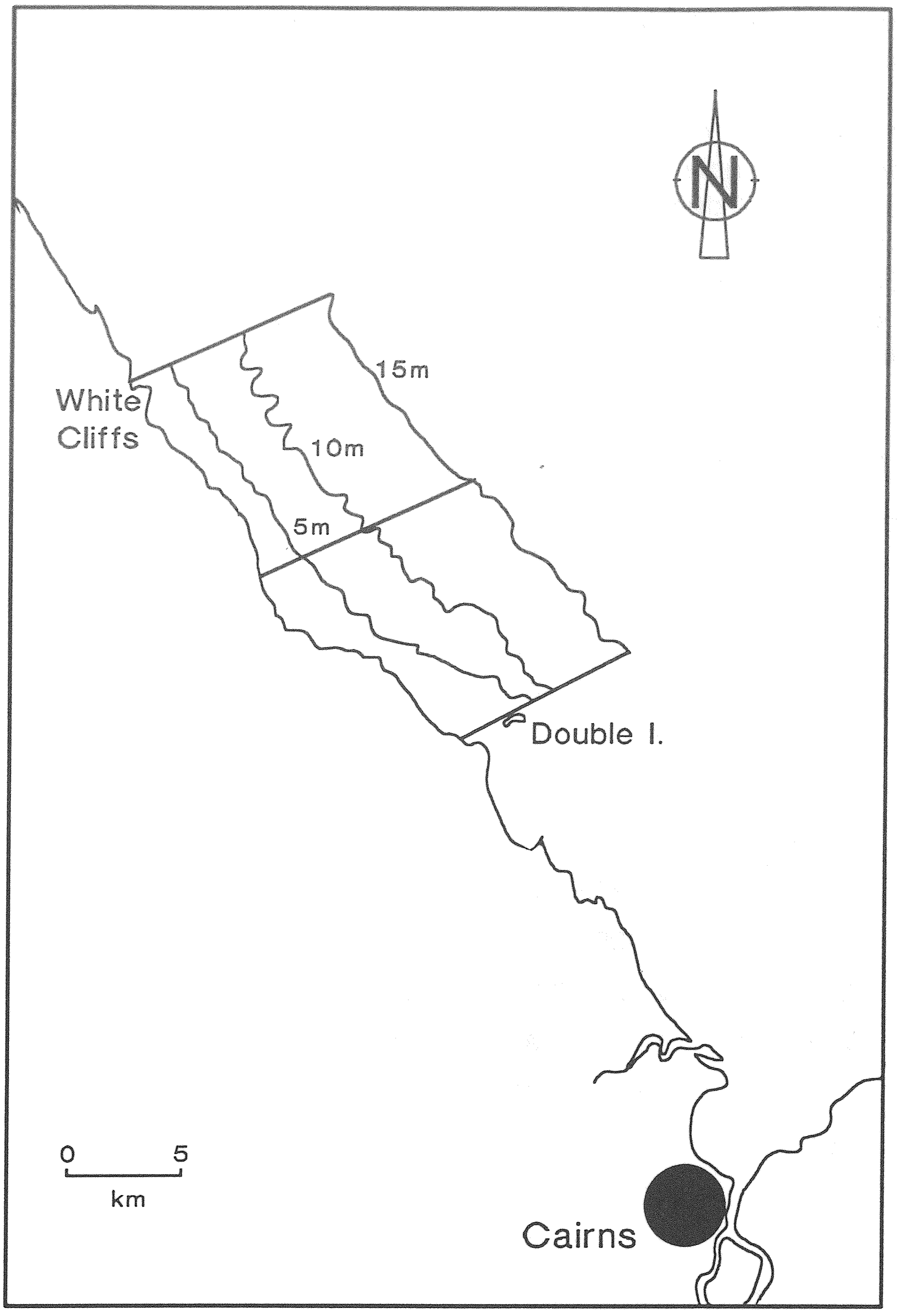

Figure 4.2 Sampling grids near Cairns.

5.5-m headline length "Florida Flier" nets, one with 47.6-mm mesh and one with 31.8-mm mesh. Samples were taken from both nets.

All commercial prawn species were sorted from the catch, frozen on board and transported to the Northern Fisheries Centre in Cairns. There, they were identified, and the sex, carapace length (measured to the nearest 0.1 mm with dial callipers), and wet weight (measured to the nearest 0.1 g with an electronic balance) was determined for each prawn. The reproductive status of each female was determined according to the criteria of Tuma (1967), and all mature (stage III or IV) females were examined for the presence of spermatophores. Female endeavour prawns have an open thelycum, which leads to the loss of spermatophores during handling (Keating *et al.* 1990), so these were examined prior to freezing and transportation to determine whether they were inseminated.

Samples were collected at night, each month near the time of the new moon. Night-time new moon sampling was conducted to maximise catches and to reduce any variation in catch rate associated with changes in moon phase. A total of 846 trawls were made in Princess Charlotte Bay between January 1990 and December 1991 (Table 4.1). Trawl shots were missed in Princess Charlotte Bay in December 1990 due to Cyclone "Joy", and in March 1991 due to gear failure. Near Cairns, 189 trawls were made between January 1990 and November 1990 (Table 4.1). In November 1990, three grids near Cairns were not trawled due to gear failure. No samples were taken near Cairns in December 1990 due to Cyclone "Joy".

Table 4.1 Adult prawn sampling periods.

		Princess Charlotte Bay		Cairns	
Cruise	New moon	Duration	Number of trawls	Duration	Number of trawls
1	27/01/90	25-28/01/90	36	30-31/01/90	18
2	25/02/90	23-26/02/90	36	26-27/02/90	18
3	27/03/90	27-30/03/90	36	28-29/03/90	18
4	25/04/90	24-27/04/90	36	24-26/04/90	18
5	24/05/90	21-25/05/90	36	23-24/05/90	18
6	23/06/90	23-25/06/90	36	21-25/06/90	18
7	22/07/90	21-24/07/90	36	23-24/07/90	18
8	20/08/90	18-21/08/90	36	20-21/08/90	18
9	19/09/90	18-21/09/90	36	20-21/09/90	18
10	19/10/90	20-23/10/90	36	17-18/10/90	18
11	17/11/90	17-20/11/90	36	15-16/11/90	9
12	17/12/90	17-18/12/90	21		
13	15/01/91	14-19/01/91	36		
14	14/02/91	13-16/02/91	36		
15	16/03/91	15-19/03/91	33		
16	14/04/91	10-15/04/91	36		
17	14/05/91	09-12/05/91	36		
18	12/06/91	07-11/06/91	36		
19	11/07/91	06-09/07/91	36		
20	10/08/91	07-10/08/91	36		
21	08/09/91	05-08/09/91	36		
22	07/10/91	05-08/10/91	36		
23	06/11/91	04-07/11/91	36		
24	06/12/91	05-08/12/91	36		

Position fixes were made by either GPS (Global Positioning System) or radar, and the distance travelled was calculated for each trawl. Each distance trawled was multiplied by two-thirds of the headrope length for swept area calculations (we assumed that approximately two-thirds of the headrope was in contact with the sea bottom during trawling), and prawn numbers were converted to number ha^{-1}. Depth was measured with an electronic depth sounder at the beginning and end of each shot, and an average depth was calculated for each shot .

A bottom water sample was taken each month in each grid in Princess Charlotte Bay, whereas surface water samples were taken near Cairns. Water temperature was measured to the nearest 0.1°C with either a mercury or an electronic thermometer. Daily rainfall measurements were obtained from the Bizant Ranger's Station (Queensland National Parks and Wildlife Service), approximately 25 km south of Princess Charlotte Bay (Figure 2.1), and from the Cairns airport.

4.3.3 Analyses

Spawning index. Size at first maturity (the size at which 1% of the population was mature) was determined for each species. Monthly spawning indices (*S*) were calculated for each species using the following formula:

$$S = nri$$

where n is the number of adult females (i.e larger than size at first maturity) per hectare,
r is the proportion of mature adult females, and
i is the proportion of inseminated mature adult females.

4.4 Results and discussion

4.4.1 Spatial patterns

Overall species composition. The same eight species of commercial prawns were found in Princess Charlotte Bay and near Cairns. The proportion of each, however, differed between areas. More than 93% of the total number of commercial prawns caught in Princess Charlotte Bay were represented by four species: the blue endeavour prawn (33.6%), the brown tiger prawn (29.3%), the grooved tiger prawn (17.1%) and the western king prawn (13.4%) (Figure 4.3). The red spot king prawn made up 3.5%, the red endeavour prawn 1.9%, the white banana prawn 1%, and leader prawn 0.1% of the survey catch respectively (Figure 4.3). Severely damaged prawns which could not be identified to specific level represented 0.1% of the catch. Near Cairns, brown tiger prawns made up only 3.4% of the survey catch, while the red endeavour prawn was the most common species in our samples, making up 39% of the catch (Figure 4.3). Grooved tiger prawns represented 32.8%, blue endeavour prawns 12.8%, white banana prawns 8%, western king prawns 1.9%, leader prawns 1.5%, and red spot king prawns 0.6% of the catch respectively (Figure 4.3). One striped prawn (*Penaeus canaliculatus* Olivier, 1811) was found near Cairns but was omitted from analyses.

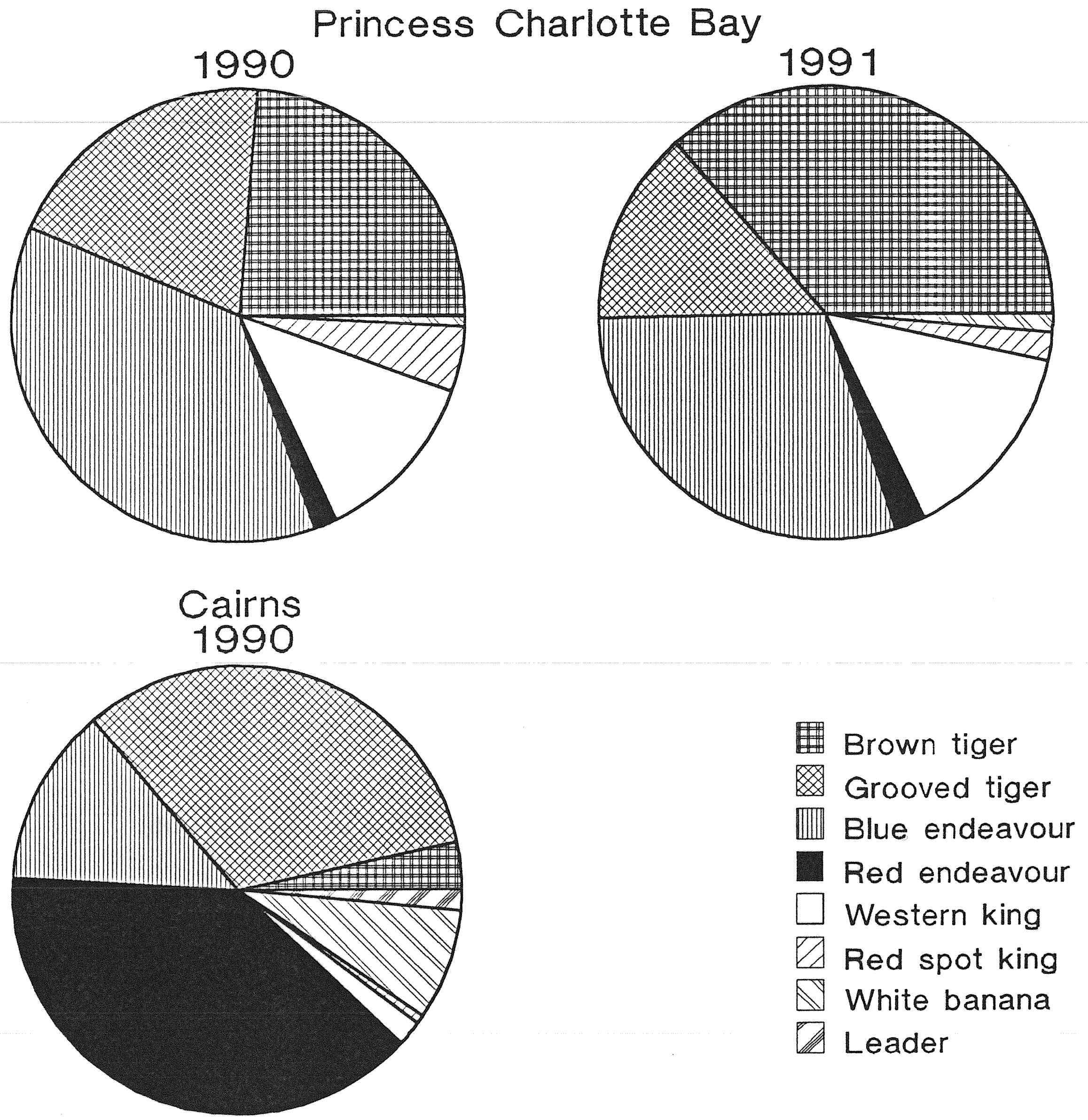

Figure 4.3 Species composition in Princess Charlotte Bay and near Cairns.

The proportions in which these eight prawn species occurred in our samples were different to those found by Coles et al. (1987a) in Princess Charlotte Bay and near Cairns. It is possible that changes in species composition occurred in the period between the two studies, as there were differences in species composition near Cairns between 1985/86 (Coles *et al.* 1987a) and 1989 (Lee Long *et al.* 1991). We believe, however, that differences in the area sampled and duration of our study and those of previous studies may be more important. We sampled a larger area in Princess Charlotte Bay, and a smaller area near Cairns, than was sampled in previous studies.

Trawl operators generally refer collectively to brown and grooved tiger prawns as "tiger prawns". The proportion of "tiger prawns" in our samples was smaller than in commercial catches taken between 1988 and 1990 in Princess Charlotte Bay (Trainor *et al.* 1992). It is important to note that fishers do not keep all sizes of prawns captured (we did), and that fishers try to "target" particular prawn species, especially the valuable tiger prawns.

Catch rates of commercial prawns in our samples in Princess Charlotte Bay were generally greatest in waters between 10 m and 30 m deep (Figure 4.4). It is likely, however, that factors other than depth also influenced the spatial distribution of prawns. Sediment particle size (especially mud content), and to a lesser extent organic content, have been used to explain the spatial distribution of prawns (Dall *et al.* 1990). Somers (1987) related the spatial distribution of commercial prawns in the western Gulf of Carpentaria to both depth and substrate type. Frankel (1974) found that mud content in Princess Charlotte Bay ranged from "pure" in shallow waters, to "low" in deeper, inter-reef waters. The size of most species increased with depth both in Princess Charlotte Bay and near Cairns, although large and small individuals of most species occurred in most depths (Appendix A).

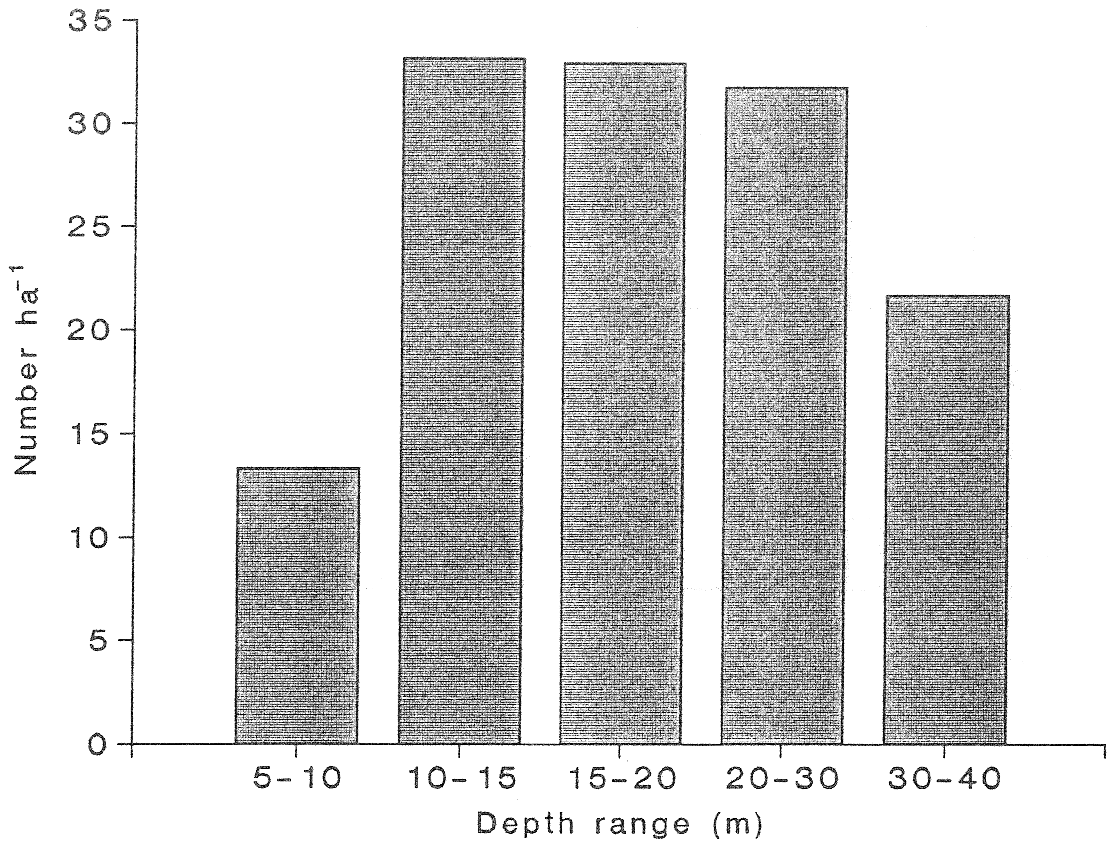

Figure 4.4 Total catch in each depth range in Princess Charlotte Bay.

It is difficult to make direct comparison of the spatial distribution of prawns within Princess Charlotte Bay with that near Cairns. The sampling area near Cairns was more restricted spatially than in Princess Charlotte Bay, and it is likely that differences in species composition between the two areas were due, at least in part, to the restricted range of depth (and possibly substrate type) sampled near Cairns.

Brown tiger prawn. Catch rates of brown tiger prawns were greatest in the 15 m to 20 m depth range both in Princess Charlotte Bay and near Cairns, and were greater than any other species in waters between 10 m and 20 m deep in Princess Charlotte Bay (Figure 4.5). Brown tiger prawns caught near Cairns were generally larger than those caught in the same depth range in Princess Charlotte Bay (Appendix A).

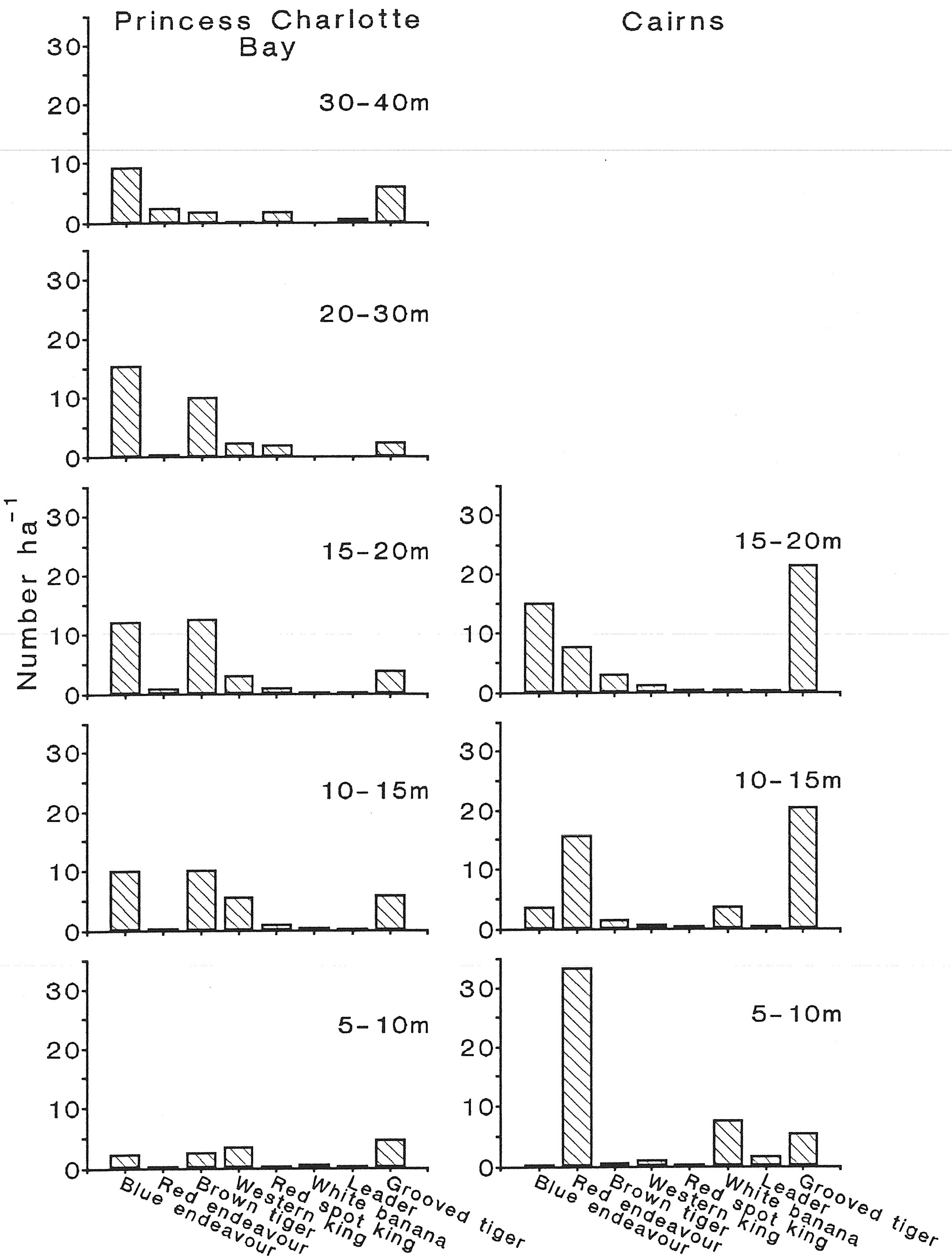

Figure 4.5 Species composition in each depth range in Princess Charlotte Bay and near Cairns.

Grooved tiger prawn. Grooved tiger prawn catches in Princess Charlotte Bay were greatest in waters deeper than 30 m, and were greater than for any other species in waters shallower than 10 m (Figure 4.5). Somers (1987) found that grooved tiger prawns occurred in deeper water than brown tiger prawns in the western Gulf of Carpentaria. Such a distinction is not so clear in Princess Charlotte Bay, where catches of brown tiger prawns were greater than grooved tiger prawns over most depths, but more grooved tiger prawns were caught in both the deepest and shallowest waters (Figure 4.5). This implies that grooved tiger prawns are more tolerant to extremes of depth than brown tiger prawns in

Princess Charlotte Bay. Catch rates of grooved tiger prawns increased with depth near Cairns (Figure 4.5). The size of grooved tiger prawns tended to increase greatly with depth in Princess Charlotte Bay and near Cairns, and was similar in corresponding depth ranges in both areas (Appendix A).

Blue endeavour prawn. In both Princess Charlotte Bay and near Cairns, catch rates of blue endeavour prawns were very low in the shallowest waters (Figure 4.5). Catches of blue endeavour prawns were greatest in waters between 20 m and 30 m deep, and were greater than any other species in waters deeper than 20 m in Princess Charlotte Bay (Figure 4.5). Blue endeavour prawns in Princess Charlotte Bay tended to increase in size from the shallowest water up to 15 m depth, but beyond this depth, their size distribution was relatively constant (Appendix A).

Red endeavour prawn. In Princess Charlotte Bay, red endeavour prawn catch rates were greatest in the deepest waters, but near Cairns, catches were greatest in the shallowest waters (Figure 4.5). The few red endeavour prawns that were caught in the shallowest water in Princess Charlotte Bay were smaller than those caught in the same depth range near Cairns (Appendix A). Somers (1987) found that red endeavour prawns were most abundant in deeper water in the western Gulf of Carpentaria. It appears that the spatial distribution of red endeavour prawns varies greatly between localities.

Western king prawn. In Princess Charlotte Bay, western king prawn catch rates were greatest in depths of 10 m to 15 m (Figure 4.5). Western king prawns were captured in low numbers throughout the depth range near Cairns, and in even lower numbers in the deepest waters in Princess Charlotte Bay (Figure 4.5). The increase in size of western king prawns with depth was more evident in Princess Charlotte Bay than near Cairns (Appendix A).

Red spot king prawn. In Princess Charlotte Bay, red spot king prawn catches were greatest in waters deeper than 20 m (Figure 4.5). The depth distribution of both king prawn species in Princess Charlotte Bay was similar to that reported by Somers (1987) in the western Gulf of Carpentaria. The catch of each species was greatest in different depth ranges: red spot king prawn catches were greatest in water deeper than 20 m, and western king prawn catches were greatest in waters between 10 m and 15 m deep (Figure 4.5). There was, however, much overlap in the distributions of these species in Princess Charlotte Bay. Western and red spot king prawns also occur together in near-reef waters off the central Queensland coast (Robertson and Dredge 1986). Red spot king prawns were, like western king prawns, captured in low numbers throughout the depth range near Cairns (Figure 4.5). While the size of red spot king prawns tended to increase with depth in Princess Charlotte Bay, a relatively large proportion of small individuals was caught in waters deeper than 20 m (Appendix A). These small prawns may have recruited into the fishery from nearby reef platforms (Section 5.4.2).

White banana prawn. Catch rates of white banana prawns were greatest in the shallowest waters, and catch rates were higher near Cairns than in Princess Charlotte Bay (Figure 4.5). Somers (1987) found that white banana prawns in the western Gulf of Carpentaria were restricted to relatively shallow, muddy waters.

Leader prawn. Leader prawns were found in low numbers in Princess Charlotte Bay across a broad range of depths, although none were captured in depths between 20 m and 30 m (Figure 4.5). Catch rates of leader prawns near Cairns were, like those of white banana prawns, greatest in the shallowest waters (Figure 4.5). The largest individuals of any species caught were leader prawns, and most of those caught were greater than 40 mm carapace length (Appendix A). It is likely that leader prawns grow to relatively large sizes in estuarine and shallow coastal waters near Cairns and in Princess Charlotte Bay.

4.4.2 Temporal patterns

Overall species composition. The total number of commercial prawns in our samples peaked in March of both years in Princess Charlotte Bay, but was 26% lower in 1991 than in 1990 (Figure 4.6). Near Cairns, the total number of commercial prawns in our samples peaked in April 1990, a month later than in Princess Charlotte Bay (Figure 4.6). Minor peaks also occurred near Cairns in July and October (Figure 4.6). For most species, the difference between highest and lowest catch rates were more marked in Princess Charlotte Bay than near Cairns (Figures 4.7 and 4.8). Generally, peaks in the number of small prawns caught occurred in March in Princess Charlotte Bay (Figure 4.7, Appendix B), and in March/April near Cairns (Figure 4.8, Appendix B), which indicates peak recruitment occurred for most species in March.

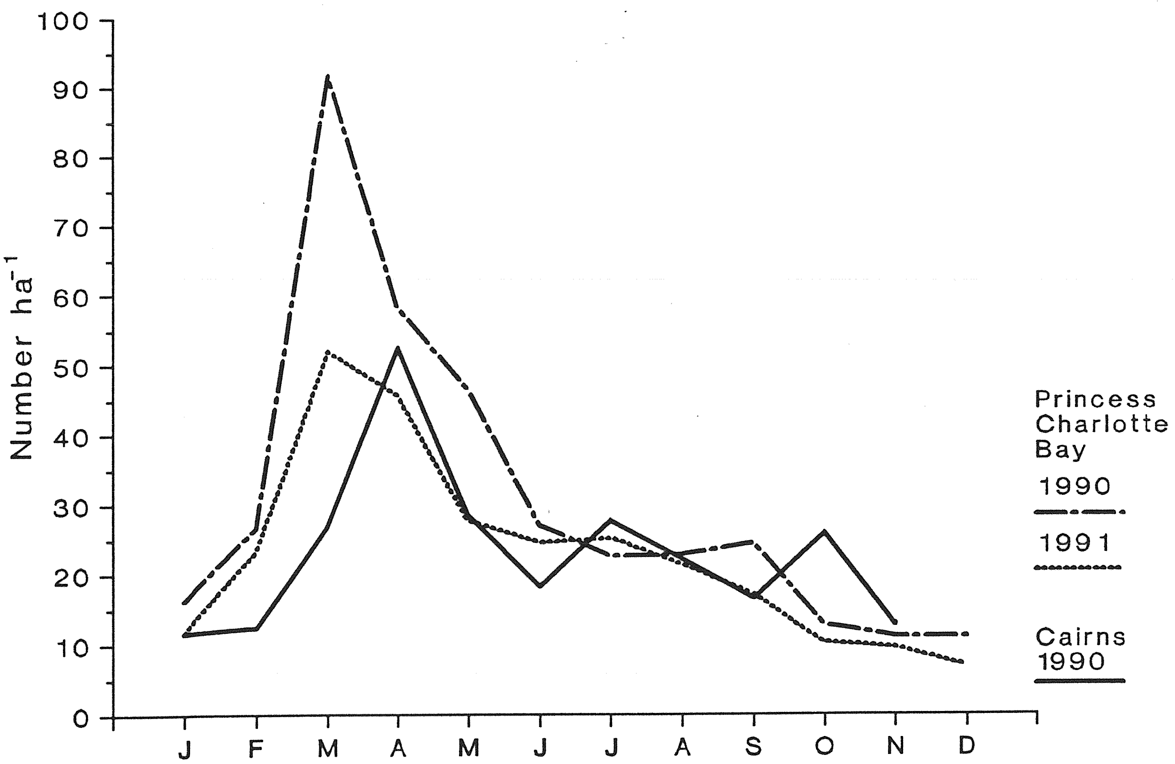

Figure 4.6 Monthly catch rate in Princess Charlotte Bay and near Cairns.

In our samples from Princess Charlotte Bay, the numbers of all species except brown tiger prawns and white banana prawns decreased between years (Figure 4.7). Fishing effort was greater at the beginning of the 1991 fishing season than at the beginning of the 1990 season (Section 3.4.1), but it is unlikely that this alone caused the decrease in total commercial prawn numbers in our samples between years. No effort is expended during seasonal closures, yet our total catch was far lower during the 1991 closure than during that of the previous year (Figure 4.6). Furthermore, fishing effort declined markedly between 1988 and 1990 (Trainor *et al.* 1992), so any effect of effort on the subsequent year's recruitment should have decreased between 1989 and 1991. It is likely that environmental conditions adversely effected prawn survival and/or catchability (brown tiger and white banana prawns excepted) more in 1991 than in 1990 (see also Sections 4.4.4 and 4.4.5).

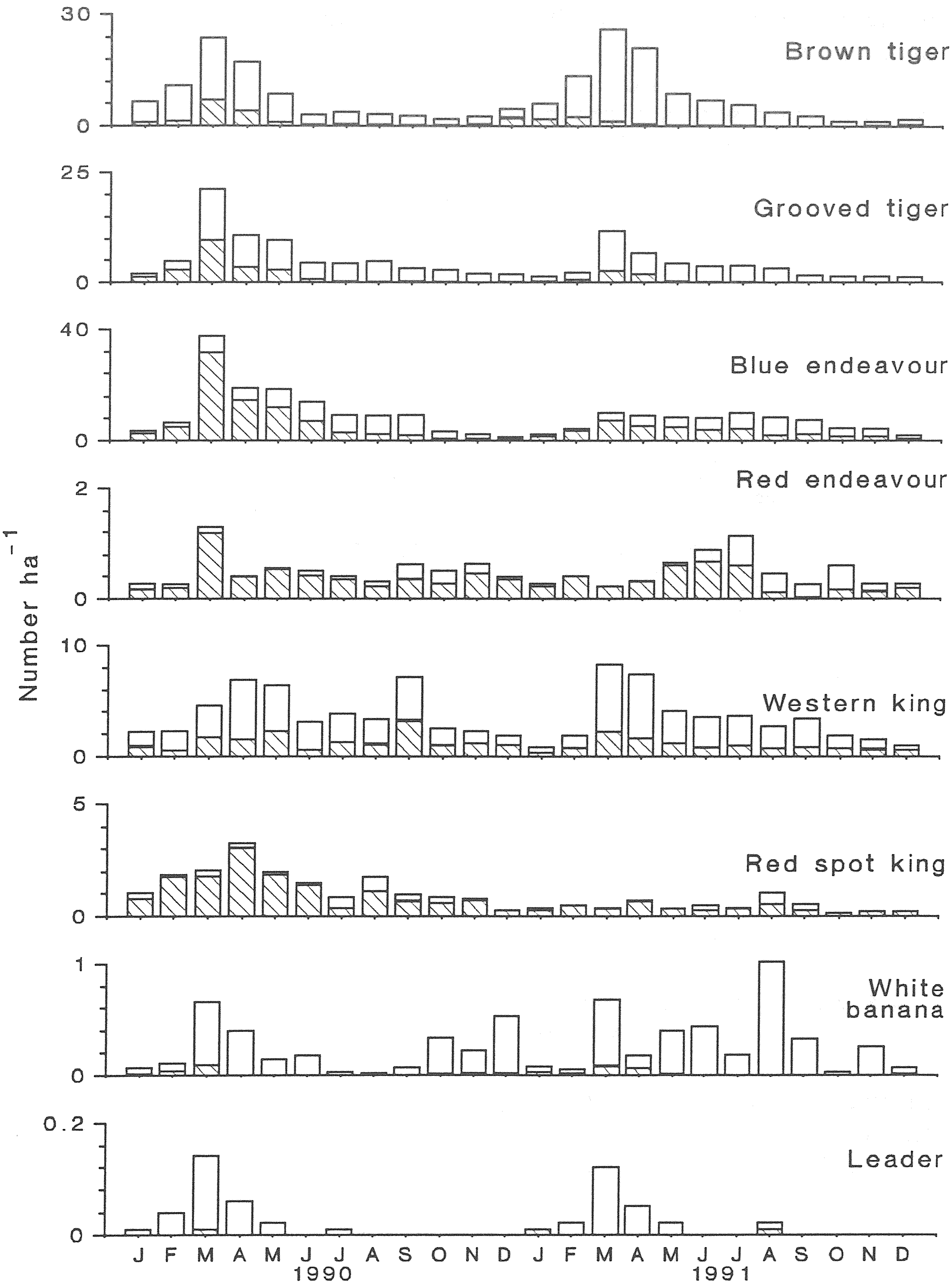

Figure 4.7 Monthly catch for each species in Princess Charlotte Bay. Hatched areas represent prawns below export size.

Brown tiger prawn. Compared with most other commercial prawns, the pattern of catch for brown tiger prawns in our samples from Princess Charlotte Bay was remarkably similar between years. In both years, brown tiger prawn numbers rose sharply after January (when the fishery was closed) to a peak in March, and then fell during April (when the fishery opened) (Figure 4.7). Near Cairns, brown tiger prawn catches peaked in August, but were similarly high in several other months between April and October (Figure 4.8). The catch rate of small (below export size) brown tiger prawns in Princess Charlotte Bay was greatest in March 1990. In 1991, the catch rate of small brown tiger prawns peaked in February, with similar catches in December 1990 and January 1991 (Figure 4.7). Catches of small brown tiger prawns near Cairns were greatest between January and April (Figure 4.8). Female brown tiger prawns were generally larger, and occurred across a broader range of sizes, than males in Princess Charlotte Bay (Appendix B).

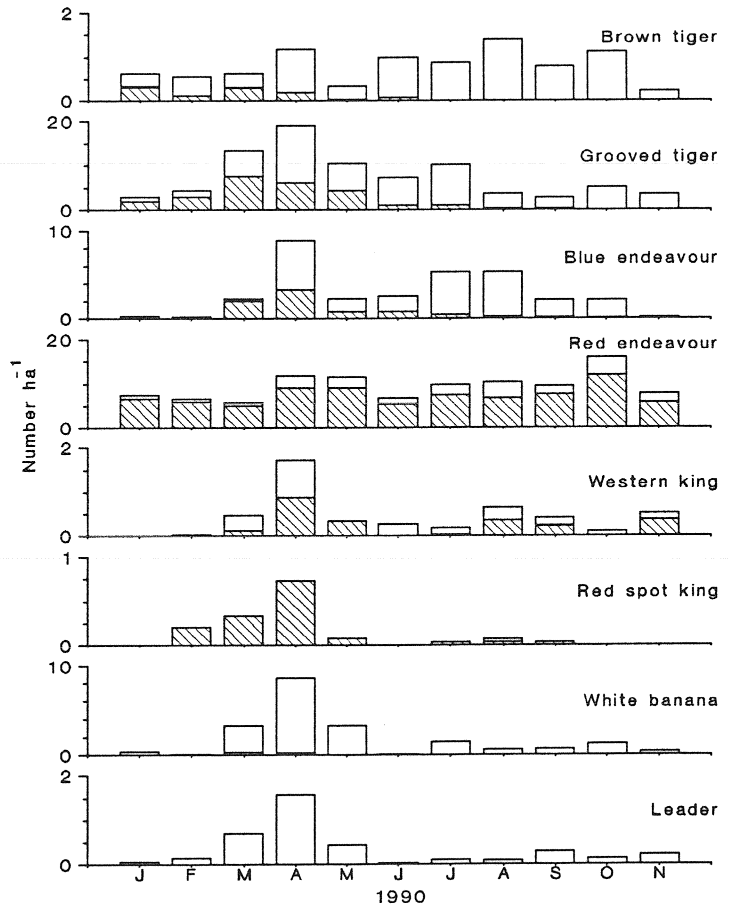

Figure 4.8 Monthly catch for each species near Cairns. Hatched areas represent prawns below export size.

Grooved tiger prawn. Numbers of grooved tiger prawns in our Princess Charlotte Bay samples peaked at a similar level to brown tiger prawns in March 1990 (Figure 4.7). In 1991, the March peak was much lower than that for brown tiger prawns (Figure 4.7). The catch rate of small grooved tiger prawns peaked in March of 1990 (the same as small brown tiger prawns), and in March/April of 1991 (later than brown tiger prawns) (Figure 4.7). The recruitment period for grooved tiger prawns was more restricted in 1991 than in 1990 (Figure 4.7, Appendix B). The pattern of grooved tiger prawn catches near Cairns (Figure 4.8) was similar to that for Princess Charlotte Bay during

1990. In both years in Princess Charlotte Bay, and in both areas, two cohorts of grooved tiger prawns were discernible. In 1990, a group of larger, and presumably older, prawns was caught in January and February in Princess Charlotte Bay, and between January and April near Cairns (Appendix B). In 1991, the older cohort was caught in Princess Charlotte Bay between January and June (Appendix B). The older cohort consisted almost entirely of females, and there was little difference in size between sexes for the younger cohort until June/July in both areas and years (Appendix B). This suggests that males reached their maximum size much earlier than females, which continued to survive and grow well into the following year.

Blue endeavour prawn. Catches of blue endeavour prawns in Princess Charlotte Bay peaked in March during 1990, and represented the largest catch of any commercial prawn species in our samples (Figure 4.7). A similar peak did not occur the following year, when blue endeavour prawn catches reached only about one-quarter of the March 1990 level, and remained relatively constant between March and August (Figure 4.7). Near Cairns, blue endeavour prawn catches peaked in April of 1990 (Figure 4.8). Most blue endeavour prawns caught in Princess Charlotte Bay and near Cairns were below export size early in the year, but above export size later in the year (Figures 4.7 and 4.8). Female blue endeavour prawns were generally larger than males (Appendix B).

Red endeavour prawn. Red endeavour prawn catches were greatest in March of 1990 and July of 1991 in Princess Charlotte Bay (Figure 4.7). Near Cairns, catches were greatest in October 1990 (Figure 4.8). Most red endeavour prawns caught in Princess Charlotte Bay (Figure 4.7) and near Cairns (Figure 4.8) were below export size, except those caught in Princess Charlotte Bay between August 1991 and October 1991. Near Cairns, female red endeavour prawns were generally larger, and occurred across a broader range of sizes, than males (Appendix B).

Western king prawn. There were two peaks in the number of western king prawns in our 1990 Princess Charlotte Bay samples: one in April (with only slightly fewer individuals in May), and one in September (Figure 4.7). More small western king prawns - especially males - were caught during September 1990 than during April 1990 in Princess Charlotte Bay (Appendix B). In 1991, the first peak occurred slightly earlier (March/April) than in 1990, and the September peak was much smaller than the previous year's (Figure 4.7). Catches of western king prawns near Cairns were greatest in April 1990 (Figure 4.8).

Red spot king prawn. In 1990, the largest catches of red spot king prawns in our Princess Charlotte Bay survey occurred in April, and there was also a minor peak in catch rate in August (Figure 4.7). In 1991, the minor peak occurred in April, while the greatest catches were made in August (Figure 4.7). There were 69% fewer red spot king prawns sampled in Princess Charlotte Bay during 1991 than in 1990, which represented the largest proportional decrease in numbers between years for any species in our survey (Figure 4.7). Catches of red spot king prawns, almost all of which were below export size, were greatest in April 1990 near Cairns (Figure 4.8). Most red spot king prawns in Princess Charlotte Bay were also below export size (Figure 4.7), although small numbers of very large individuals were caught early in both years (Appendix B).

White banana prawn. There seemed little pattern to our small catches of white banana prawns in Princess Charlotte Bay (Figure 4.7). Near Cairns, where the white banana prawn was more common, catches were greatest in April 1990 (Figure 4.8). Few white banana prawns below export size were caught (Figures 4.7 and 4.8). Postlarval white banana prawns settle in mangrove-lined, muddy estuaries (Dall *et al.* 1990) such as those in Princess Charlotte Bay and near Cairns, and may take longer (and hence grow larger) than other species to reach the fishery as recruits. The largest white banana prawns were caught during the second half of the year in both areas (Appendix B). In Princess Charlotte Bay, there did not seem to be a strong correlation between catches of white banana prawns (Figure 4.7) and the amount of rainfall in any given month (Section 4.4.5). Increased rainfall in 1991 (Section 4.4.5), however, could have caused the increase in numbers of white banana prawns between years. Staples (1985) found that emigration of juvenile white banana prawns in the south-eastern Gulf of Carpentaria increased in years of increased rainfall.

Leader prawn. Our catches of leader prawns were greatest in March of both years in Princess Charlotte Bay (Figure 4.7). Near Cairns, where leader prawns were more common, catches were greatest in April 1990 (Figure 4.8). We captured no leader prawns below export size near Cairns (Figure 4.8). Almost all of the very large leader prawns were female (Appendix B). Relatively few leader prawns were caught during our survey, but most occurred during the wet season, when water temperatures were relatively high (Section 4.4.4).

4.4.3 Reproduction

The spawning index peaked between March and April, and between August and November for most species, both in Princess Charlotte Bay (Figure 4.9) and near Cairns (Figure 4.10). In general, the later peak spawning period corresponded with the period when the largest females were caught, and was approximately six months before recruitment into the fishery occurred (Section 4.4.2). March/April spawning coincided with a fall in water temperature from wet season maxima, while the later spawning peak coincided with a rise in water temperature from dry season minima (Section 4.4.4). Crocos (1987) found that for grooved tiger prawns in the north-western Gulf of Carpentaria, the proportion of spawners increased with rising water temperature.

The spawning index for brown tiger prawns in Princess Charlotte Bay was greater than that for other species throughout most of the year (Figure 4.9), which indicates that spawning was continuous. Buckworth (1985) and Keating *et al.* (1990) also found a large proportion of mature female brown tiger prawns year-round. Recruitment of brown tiger prawns into the Princess Charlotte Bay fishery, however, did not occur all year (Section 4.4.2), which indicates that factors other than spawning affected the timing of recruitment. Factors such as temperature and rainfall can affect life history timing (Dall *et al.* 1990). The September/October 1990 peak in brown tiger prawn spawning in Princess Charlotte Bay (Figure 4.9) corresponded with settlement of juveniles in October/November (Section 5). Brown tiger prawns also spawned throughout most of the year near Cairns, although an August spawning peak was evident (Figure 4.10).

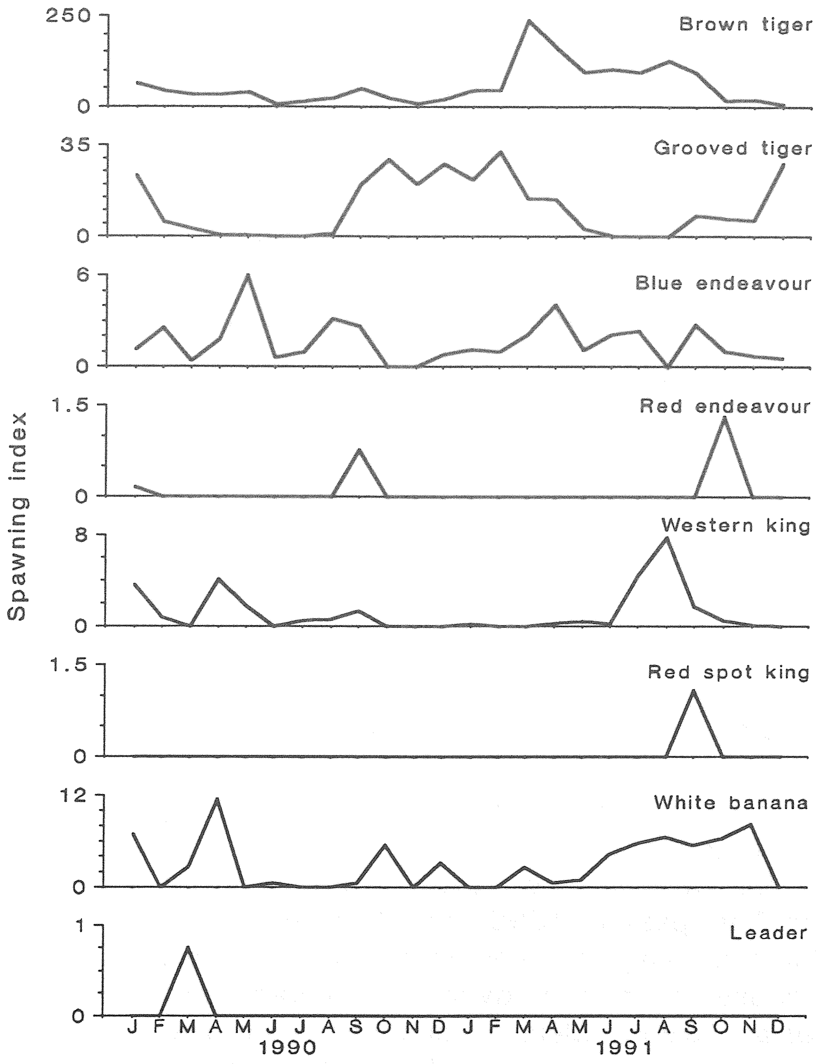

Figure 4.9 Monthly spawning index for each species in Princess Charlotte Bay.

The spawning period for grooved tiger prawns in Princess Charlotte Bay and near Cairns began in August/September, but it continued for longer than most other species (Figures 4.9 and 4.10). The duration of subsequent recruitment in Princess Charlotte Bay, however, was not extended (Section 4.4.2). High levels of fishing effort at the beginning of the 1991 season (Section 3) may have obscured any recruitment which occurred after April.

The spawning index for blue and red endeavour prawns was relatively low (Figures 4.9 and 4.10). This was most likely due to an underestimate of insemination. Endeavour prawns were examined for the presence of spermatophores before freezing and transportation, but spermatophores may have been dislodged during capture and/or when catches were sorted. The largest of several peaks in the spawning index for blue endeavour prawns in Princess Charlotte Bay occurred in April 1991 (Figure 4.9). Spawning peaks for blue endeavour prawns near Cairns occurred in April and August (Figure 4.10). The largest spawning peak for red endeavour prawns occurred in April with smaller peaks in February, August and October (Figure 4.10).

A major spawning peak for white banana prawns near Cairns occurred in August, and a minor spawning peak occurred in March/April (Figure 4.10).

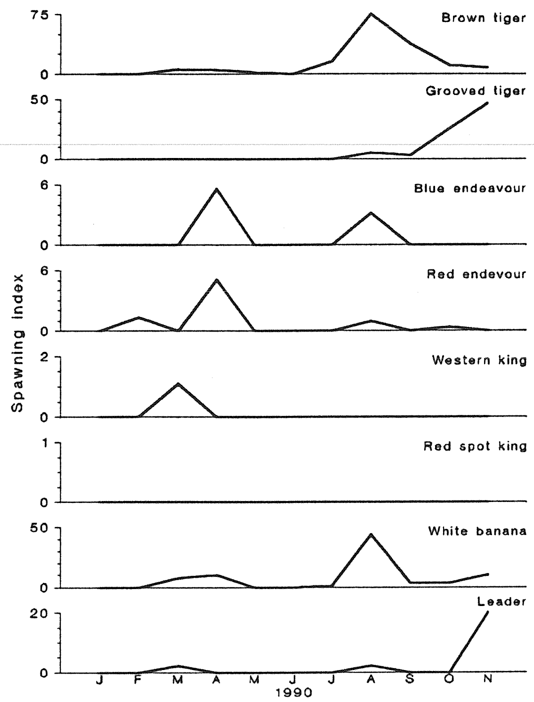

Figure 4.10 Monthly spawning index for each species near Cairns.

Bimodal peaks in spawning activity were evident for blue and red endeavour, western king and white banana prawns (Figures 4.9 and 4.10). The later spawning peak for western king prawns in Princess Charlotte Bay was smaller than the March/April peak in 1990, while the reverse occurred in 1991 (Figure 4.9). Bimodal spawning is common in tropical prawns, but environmental changes can cause life history dynamics to vary, both within and between species (Dall *et al.* 1990). Clear bimodal spawning peaks were not evident for all species. It does not necessarily follow that spawning and recruitment is unimodal in these species, as basic life history dynamics may be severely distorted in heavily exploited prawn stocks (Garcia 1988).

4.4.4 Temperature

Average bottom water temperature in Princess Charlotte Bay changed by approximately 6°C between wet season maxima and dry season minima, and was slightly higher during 1990 than in 1991 (Figure 4.11). Average surface water temperature near Cairns was similar to the average bottom water temperature in Princes Charlotte Bay during 1990, although dry season minima were slightly lower, and wet season maxima slightly higher, near Cairns (Figure 4.11). These differences could have been influenced by differences in sampling technique (i.e. bottom versus surface water samples). Warmer water temperatures in 1990 may have contributed to greater catches of prawns in that year than in 1991. Williams (1969 cited in Dall *et al.* 1990) found that commercial catches of several prawn species in North Carolina waters were greater in warmer years. Increases in commercial prawn catches with temperature may be due to increased catchability. Hill (1985) found that the duration of nocturnal emergence of brown tiger prawns increased at higher temperatures. Catch rates of commercial prawns in our samples (Section 4.4.2) were generally, although not uniformly, greater during periods of warmer water.

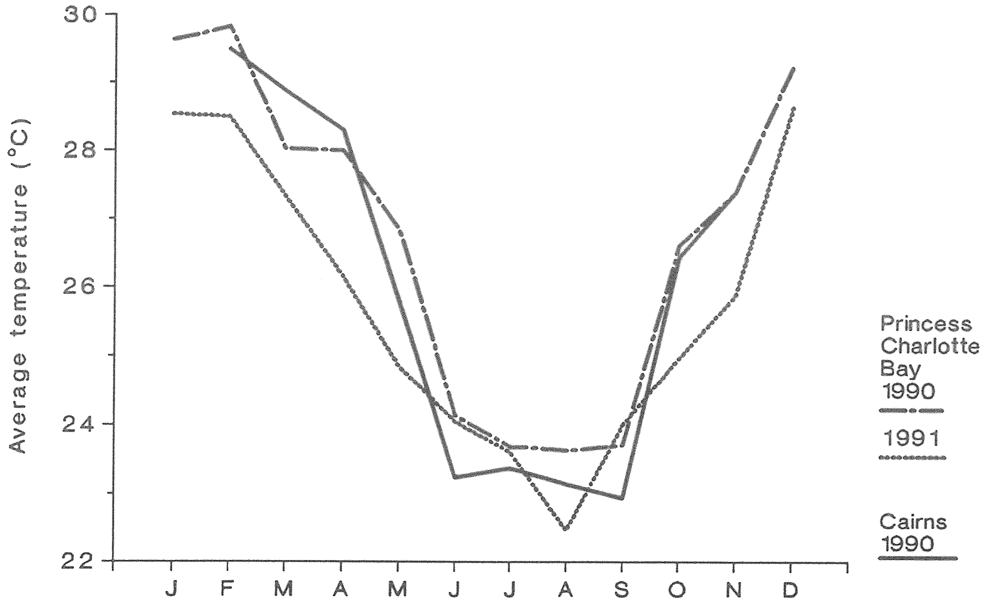

Figure 4.11 Average monthly water temperature in Princess Charlotte Bay and near Cairns.

4.4.5 Rainfall

Generally, we caught more commercial prawns during the wet season (Section 4.4.2), but the catch rates of particular species did not usually coincide with rainfall (Figure 4.12). More rain fell in Princess Charlotte Bay during the 1991 wet season, which was shorter and occurred earlier, than that of 1990 (Figure 4.12). The decrease in commercial prawn numbers in our samples between years may be related to the increase in rainfall, as there is generally a negative correlation between commercial penaeid catches and rainfall in high rainfall areas (Dall *et al.* 1990). Rainfall peaked in April 1990 near Cairns, a month later than in Princess Charlotte Bay (Figure 4.12). The catch rate of commercial prawns in our Cairns samples also peaked in April, again a month later than in Princess Charlotte Bay (Section 4.4.2).

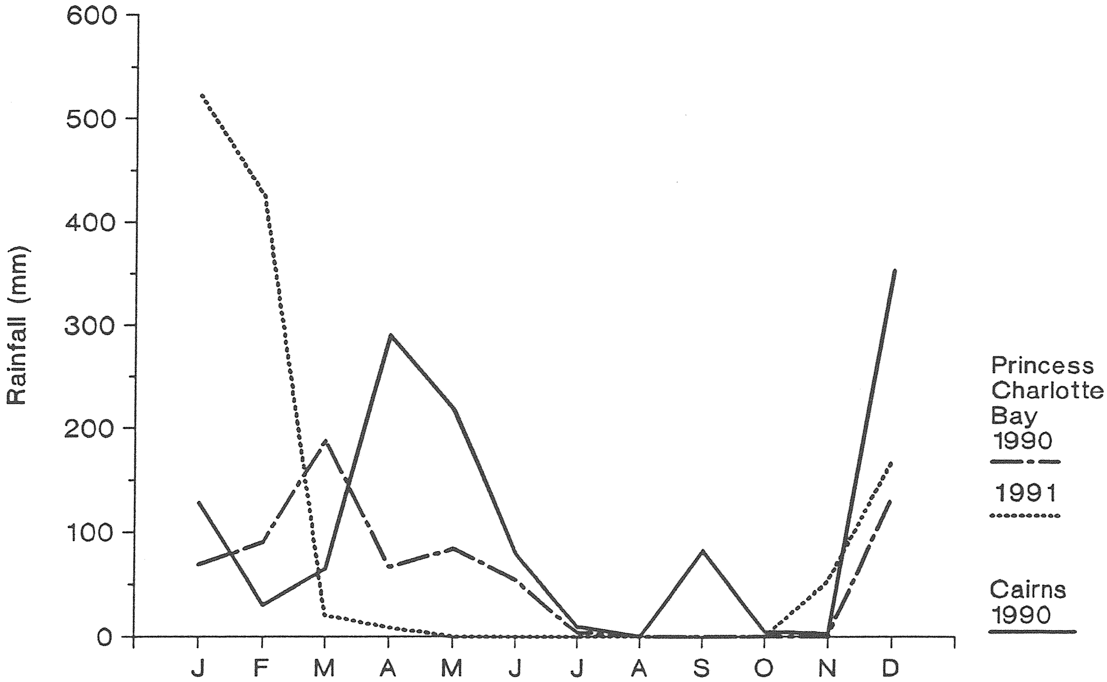

Figure 4.12 Monthly rainfall in Princess Charlotte Bay and near Cairns.

5 JUVENILE PRAWN STUDIES

5.1 Abstract

Juveniles of eight commercial prawn species were found on a range of habitats in the Princess Charlotte Bay area between October 1990 and June 1991. Six of these species were found on one site in Cairns harbour between July 1989 and November 1990. Blue endeavour and brown tiger prawns were the most abundant species and occupied the broadest range of nursery sites in Princess Charlotte Bay, while blue endeavour, grooved tiger and brown tiger prawns represented 97% of the catch on the Cairns site. The spatial distribution of juvenile blue endeavour prawns in Princess Charlotte Bay correlated significantly with percentage cover of seagrass. Juvenile red spot king prawn abundance in Princess Charlotte Bay was equally influenced negatively by muddy sediments, and positively by coarse sand sediments. Peak settlement times for juvenile prawns differed between the major commercial species, but most juvenile prawn settlement in Princess Charlotte Bay occurred from November to May. Most settlement in Cairns harbour corresponded with early (March/April) spawning peaks, but survival from later spawning peaks appeared low.

5.2 Introduction

It is important to base management decisions on accurate assessments of the life cycle timing of major commercial prawn species (Coles and Lee Long 1985, Rothlisberg *et al*. 1985). Knowledge of the timing of postlarval settlement and juvenile emigration is fundamental to our perception of prawn life histories. Postlarvae of the genus *Penaeus* typically appear in nursery areas three to four weeks after spawning has occurred, and juveniles remain there for approximately three months before migrating offshore and recruiting into the fishery (Garcia 1985). This generalised life cycle may, however, vary between species and regions.

Seagrass areas form important nursery habitats for commercial prawns in many regions of northern Australia (Young and Kirkman 1975, Staples 1984, Coles *et al.* 1987b). Within seagrass nursery areas, different juvenile prawn species may be associated with particular habitats. Coles *et al.* (1990b) found brown tiger and blue endeavour prawns mainly on sub-tidal seagrass, while western king prawns occurred mainly on intertidal seagrass, at Mornington Island in the Gulf of Carpentaria. Juvenile red spot king prawns were found mainly on reef-top seagrass beds in north-east Queensland waters (Coles *et al.* 1987b). Spatial variation in the distribution of juvenile prawns on seagrasses may influence the priority given to protecting these areas (Coles *et al*. in press). Seagrasses occur in several different habitats in Princess Charlotte Bay: in coastal waters, adjacent to islands, and on top of reefs (Coles *et al.* 1985b). Substrate (Staples *et al.* 1985) and salinity (Young 1978) may also influence the spatial distribution of juvenile prawns.

Regular juvenile prawn sampling has been conducted on seagrass beds in Cairns harbour since 1980. *Zostera capricorni* Aschers. was the most common, and had the greatest biomass, of eight seagrass species in Cairns harbour (Coles *et al.* in press). Juvenile brown and grooved tiger and blue endeavour prawns were the most abundant of nine commercial prawn species found on these beds by Coles *et al.* (in press). The period of greatest abundance for brown and grooved tiger prawns was contracted, while the period of peak abundance for blue endeavour prawns was prolonged, in Cairns harbour (ibid.).

In this chapter, we assess the importance of different seagrass habitats as commercial prawn nursery grounds in Princess Charlotte Bay and near Cairns, and determine the timing of larval settlement and adolescent emigration.

5.3 Methods and Materials

5.3.1 Site selection

Eight sites were selected by day-time dive survey on a range of habitats between Pipon Islets and Claremont Point in the Princess Charlotte Bay area (Figure 5.1). Each site was marked with buoys. Site suitability was determined by several criteria, including presence of seagrass, protection from adverse weather conditions and the amount of trawlable ground present. The Pipon Islets site was on the leeward edge of a reef-flat, adjacent to a sand cay which was densely covered with mangroves. Water depth was shallow to intertidal. The Cliff Isles site was also in shallow water adjacent to an island with mangrove stands. The Flinders Island and Stokes Bay sites were both situated in sheltered embayments, although the former was in water approximately 7 m deep, while the latter was in 3 m of water and adjacent to mangroves. Water depth at the Rocky Islets site, which was situated close to a small island, ranged from approximately 3 m to 7 m. Water depth at the coastal sites at Bathurst Head and Bathurst Bay was 2 m to 3 m. The Claremont Point site was adjacent to Obree Reef in 3 m of water. Juvenile prawns were sampled from one site in Cairns harbour established prior to this study (Figure 5.2).

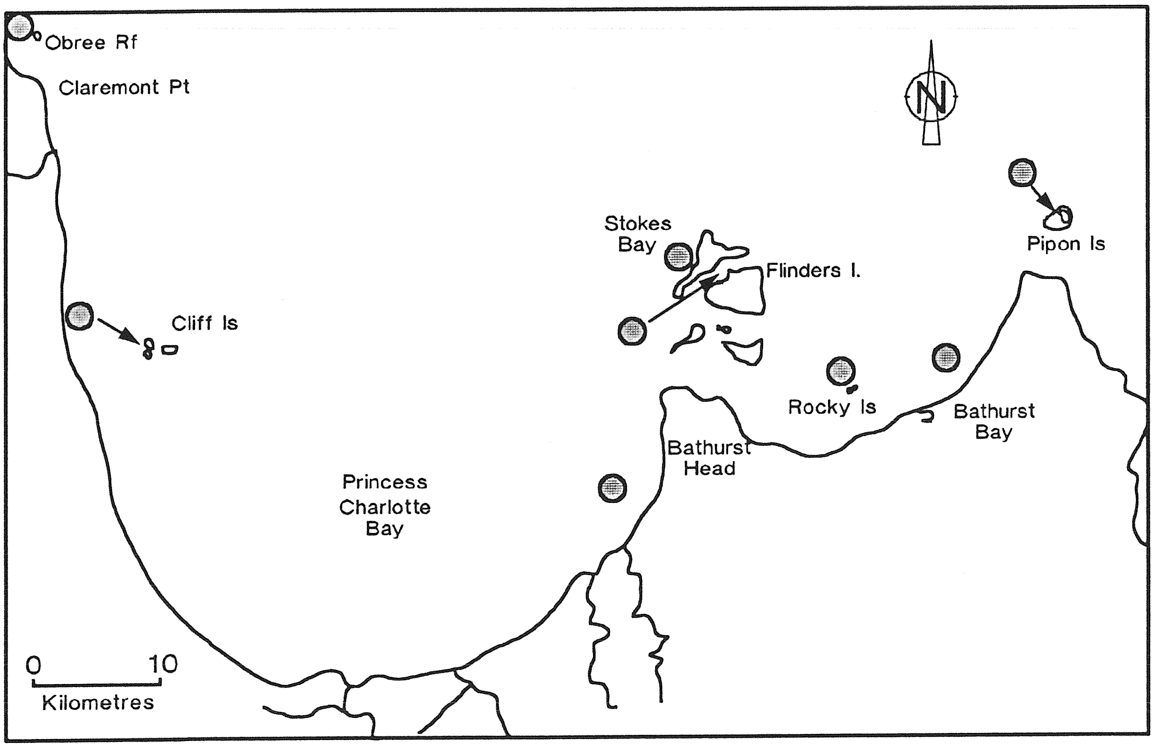

Figure 5.1 Juvenile prawn sampling sites in Princess Charlotte Bay.

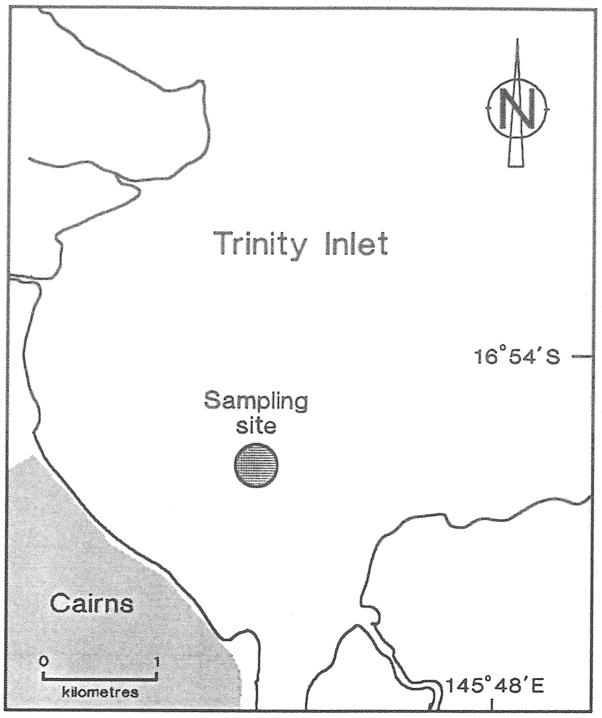

Figure 5.2 Juvenile prawn sampling site in Cairns harbour.

5.3.2 Operations

Hand samples of seagrass were collected by divers from each site in Princess Charlotte Bay in October 1990, November 1990 and June 1991 and returned to the laboratory to determine species composition. A diver swam along the length of each site and visually estimated the percentage cover of seagrass each month. A conical dredge (McLoughlin and Young 1985) was used to take sediment samples at each site in July 1991 for particle size analysis. Sediment was separated into particle sizes of 2.0 mm to 0.2 mm (coarse sand), 0.2 mm to 0.02 mm (fine sand), 0.02 mm to 0.002 mm (silt), and < 0.002 mm (clay), using the hydrometer method. "Mud" was defined as the silt and clay fractions combined.

Juvenile prawns were collected with a 1.5-m x 0.5-m beam trawl fitted with a 2-mm mesh net (Coles and Lee Long 1985). The beam trawl was towed at approximately 0.5 ms^{-1} by a 4.7-m dinghy. Three trawls were made at each site along a 100-m transect marked with floats and net lights at each end. All sites were sampled monthly near the time of the new moon (Table 5.1). Night-time sampling was conducted near the time of the new moon in an attempt to maximise catches and to reduce any variation in catch rate associated with changes in the moon phase.

Samples were placed in plastic bags, frozen and returned to the laboratory. Commercial penaeid prawns were identified to species level where possible. Prawns smaller than 5 mm carapace length (CL) are difficult to identify accurately and some were classified simply as postlarval "tigers" (i.e. these were brown and/or grooved tiger prawns). The CL of each prawn was measured to the nearest 0.1 mm with dial callipers, and the sex of sufficiently developed prawns was determined.

Table 5.1 Juvenile prawn sampling periods.

Princess Charlotte Bay			Cairns		
New moon	Duration	Number of trawls	New moon	Duration	Number of trawls
19/10/90	24-28/10/90	15	03/07/89	04/07/89	4
17/11/90	20-25/11/90	21	02/08/89	03/08/89	4
17/12/90	17-18/12/90	9	31/08/89	30/08/89	4
15/01/91	16-20/01/91	21	30/09/89	02/10/89	4
14/02/91	19-21/02/91	24	30/10/89	31/10/89	4
16/03/91	17-19/03/91	24	28/11/89	29/11/89	4
14/04/91	10-12/04/91	24	28/12/89	28/12/89	4
14/05/91	9-12/05/91	24	27/01/90	29/01/90	4
12/06/91	7-11/06/91	24	25/02/90	23/02/90	1
			27/03/90	27/03/90	4
			25/04/90	24/04/90	4
			24/05/90	23/05/90	4
			23/06/90	21/06/90	4
			22/07/90	24/07/90	4
			20/08/90	21/08/90	4
			19/09/90	17/09/90	4
			19/10/90	22/10/90	5
			17/11/90	15/11/90	4

Samples were taken in Cairns harbour as part of an ongoing study initiated in 1980, but only data from the period July 1989 to November 1990 is included in this report. Data was unavailable from Cairns harbour for the same period as was sampled in Princess Charlotte Bay. Sampling was conducted at the Bathurst Head, Flinders Island, Stokes Bay, Rocky Islets and Pipon Islets sites from October 1990 to June 1991, at the Bathurst Bay and Claremont Point sites from November 1990 to June 1991, and at the Cliff Isles site from February 1991 to June 1991. Only the sites at Bathurst Head, Flinders Island and Stokes Bay were sampled in December 1990, due to Cyclone "Joy". The sampling period was considered sufficient to both determine the time of peak settlement and compare the relative importance of selected nursery habitats.

5.3.3 Analyses

We used the beam trawl efficiency factors established by Watson *et al.* (in press(a)) for juvenile brown tiger, grooved tiger and blue endeavour prawns, to calculate total numbers ha^{-1} from our samples. For other species, we used an average of the three efficiency factors.

Spatial and temporal relationships between seagrass and sediment parameters and the total abundances (ha^{-1}) of each prawn species were examined using simple parametric correlations (STATISTIX, Analytical Software).

Data from all sites in Princess Charlotte Bay were pooled to assess the timing of juvenile prawn settlement, on the assumption that differences in settlement times between sites were minimal.

5.4 Results and discussion

5.4.1 Habitat characteristics

Sediment. Fine sand made up the largest proportion of the sediment at the Bathurst Head, Bathurst Bay, Flinders Island and Rocky Islets sites (Figure 5.3). Sediment at the Cliff Isles site had similar proportions of fine and coarse sand (Figure 5.3). Coarse sand was the dominant sediment grade at Claremont Point and on the reef-flat at Pipon Islets (Figure 5.3). The largest proportion of silt and clay (i.e. mud) was found at Rocky Islets, while the smallest proportion of each was found at Pipon Islets (Figure 5.3). The substrate on the Cairns site appeared to be muddier than on any of the sites in Princess Charlotte Bay (personal observation).

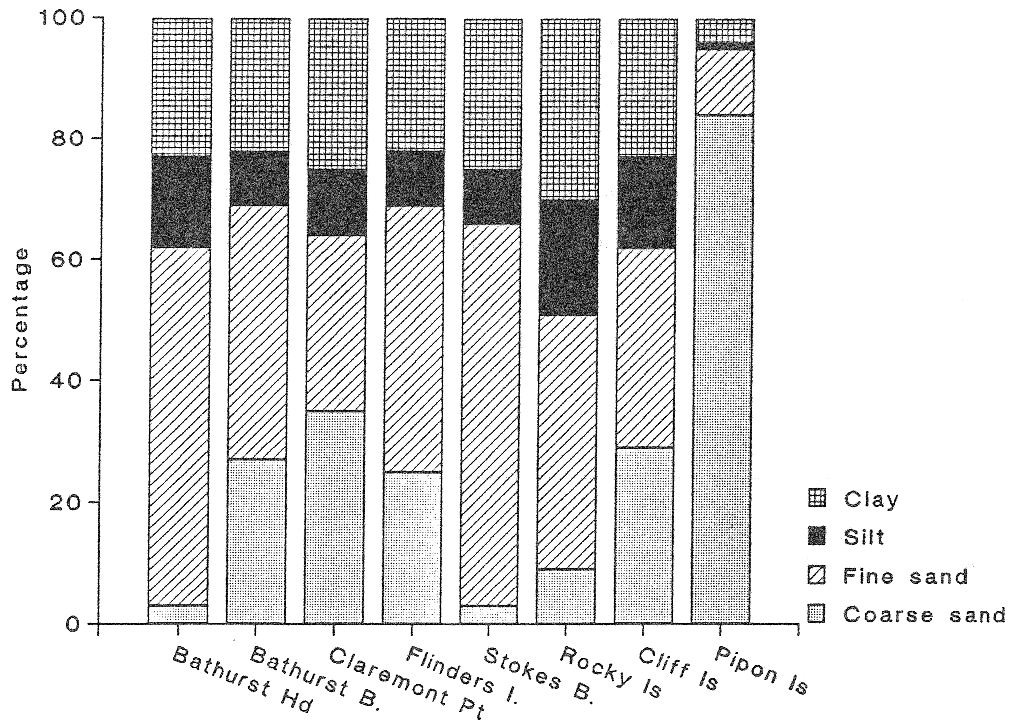

Figure 5.3 Sediment composition of juvenile prawn sampling sites in Princess Charlotte Bay.

Vegetation. Eleven seagrass species were found on our juvenile prawn sites in Princess Charlotte Bay (Table 5.2), eight of which were found in the same area by Coles *et al.* (1987b). We found *Cymodocea rotundata* Ehrenberg and Hemprich ex Aschers. and *Thalassia hemprichii* (Ehrenb.) Aschers. on the reef flat at Pipon Islets, a previously unsurveyed site. *Halophila minor* (Zoll.) den Hartog was not recognised as a valid species at the time of Coles' *et al.* (1987b) survey. Coles *et al.* (1987b) recorded *Enhalus acoroides* (L. f.) Royle from the Flinders Group, but we found none on our sites (Table 5.2). Seagrass percentage cover was greatest at Pipon Islets, Stokes Bay and Flinders Island (Figure 5.4), sites which were characterised by the presence of "robust" seagrass species (Lanyon 1986) such as *Cymodocea* spp. *and Thalassia hemprichii* (Table 5.2). The average seagrass cover at the other sites was < 20% (Figure 5.4). Seagrass at these sites consisted mainly of "delicate" species (Lanyon 1986) such as *Halodule* spp. and *Halophila* spp., although *Cymodocea serrulata* (R. Br.) Aschers. and Magnus was present at most sites (Table 5.2). Seagrass species richness was greatest at Stokes Bay, and least at Pipon Islets (Table 5.1). Mangrove stands were adjacent to the sites at Flinders Island, Cliff Isles and Pipon Islets. The Cairns juvenile prawn site was located at the entrance to an extensive, mangrove-lined inlet system, and was covered by a dense (50% to 100% cover) *Zostera capricorni*-dominated seagrass bed (Coles *et al.* in press).

Table 5.2 Seagrasses found at juvenile prawn sites in the Princess Charlotte Bay area.

Seagrass	Bathurst Head	Bathurst Bay	Claremont Point	Flinders Island	Stokes Bay	Rocky Islets	Cliff Isles	Pipon Islets
Cymodocea rotundata								*
C. serrulata		*	*	*	*	*	*	
Halodule uninervis (thin)			*					
H. uninervis (wide)		*	*		*	*		
Halophila decipiens	*					*		
H. minor							*	
H. ovalis	*	*	*	*	*	*		
H. ovata			*		*	*	*	
H. spinulosa			**	**	*			
H. tricostata	*	*		*				
Syringodium isoetifolium				*	*	*	*	
Thalassia hemprichii					*		*	*

* laboratory identification
** field identification

5.4.2 Spatial patterns

Princess Charlotte Bay. Juveniles of eight commercial prawn species were found (Figure 5.5). We found these same eight species in the fishery (Section 4.4.1). Blue endeavour and brown tiger prawns were the most abundant species, and occupied the broadest range of sites (Figure 5.5). This was also found by Coles *et al.* (1987b) in their survey of juvenile prawns between Cairns and Cape York. The largest numbers of juvenile prawns were caught at Flinders Island, Stokes Bay and Pipon Islets (Figure 5.5), the sites with the densest seagrass cover (Figure 5.4). Correlations between prawn abundance and habitat parameters were significant only for blue endeavour and red spot king prawns (Appendix C).

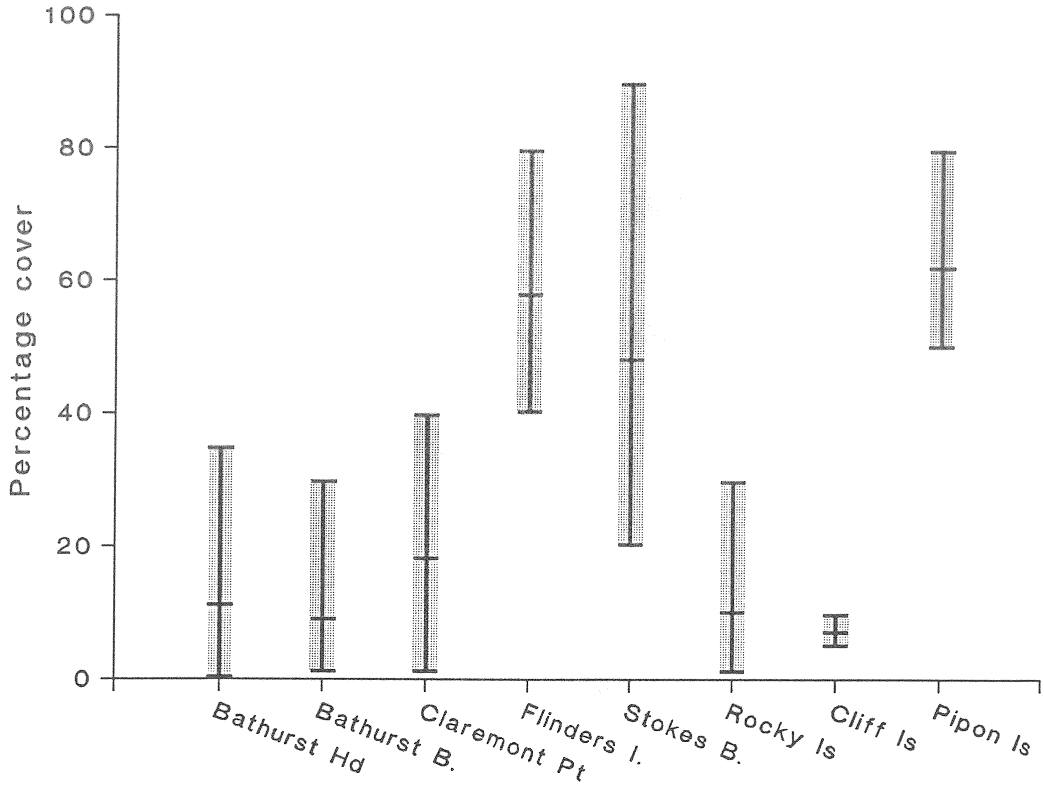

Figure 5.4 Ranges and means of seagrass cover on juvenile prawn sampling sites in Princess Charlotte Bay.

Brown tiger prawns were found at all sites, but were most abundant at Cliff Isles, Bathurst Bay, Claremont Point and Flinders Island (Figure 5.5). Sediment composition was similar at these sites (Figure 5.3), but seagrass cover was greater at Flinders Island than at the other three sites (Figure 5.4).

The spatial distribution of grooved tiger prawns appeared similar to that of brown tiger prawns. Grooved tiger prawns were found at Bathurst Bay and Flinders Island (Figure 5.5), sites with similar sediment composition but different seagrass density. These sites had similar sediment composition to Cliff Isles and Claremont Point, where numerous postlarval "tiger" prawns occurred (Figure 5.5).

The largest numbers of blue endeavour prawns, the most abundant juvenile prawn species, occurred at Flinders Island, Stokes Bay and Pipon Islets (Figure 5.5), the sites with the greatest percentage cover of seagrass. Blue endeavour prawn abundances correlated significantly with percentage cover of seagrass ($r = 0.7735$). Seagrass percentage cover significantly regressed against total abundance of blue endeavour prawns ($F = 8.934$, $df = 6$, $p < 0.05$) and explained 60% of the variation in total abundance of this species (based on R^2). The distribution of blue endeavour prawns was, therefore, significantly influenced by percentage cover of seagrass.

Red endeavour prawns were found at sites where blue endeavour prawn numbers were lowest (Figure 5.5), and seagrass cover was sparse (Figure 5.4). The habitat requirements of these similar species may be different. These differences between species in habitat preferences can not be easily explained here, but may evolve because of factors such as competitive pressures (Krebs 1985).

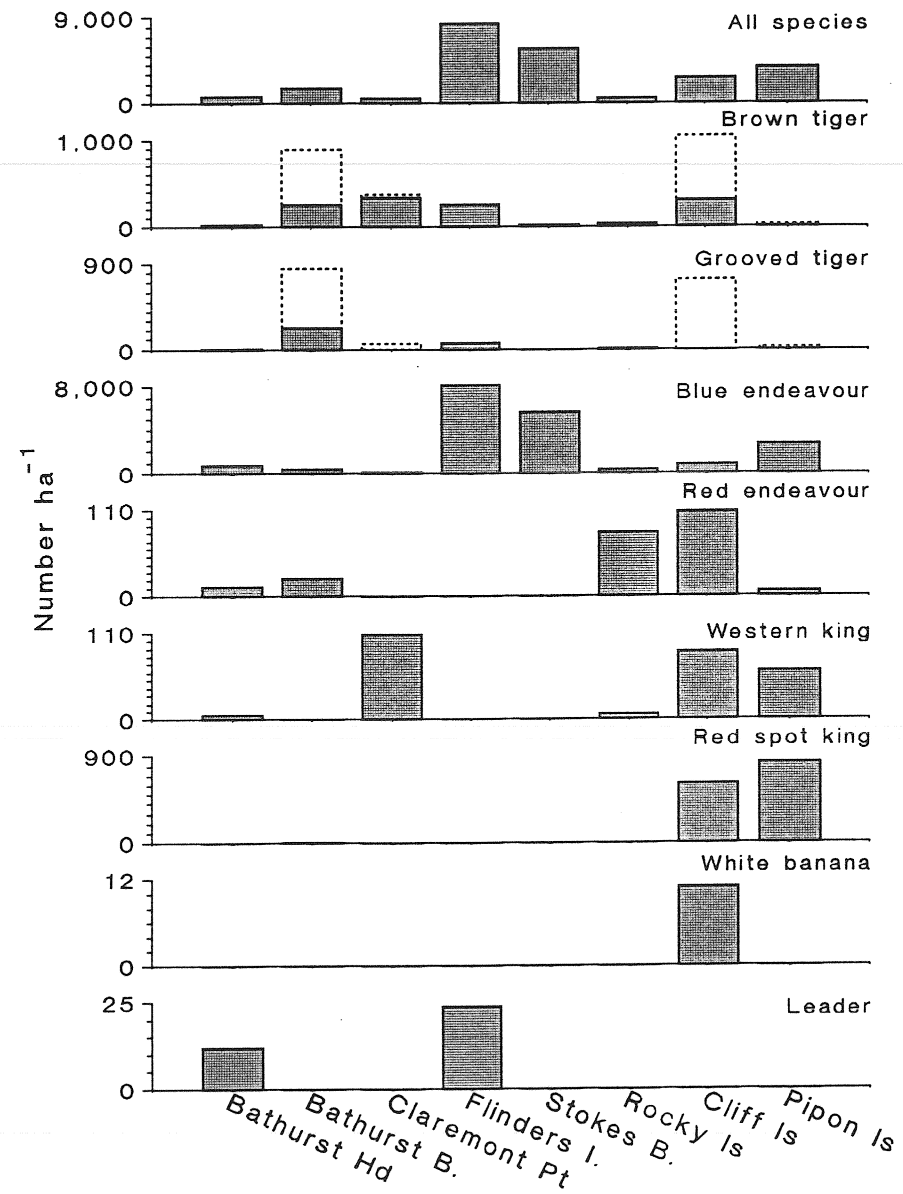

Figure 5.5 Abundance of juvenile prawns in Princess Charlotte Bay. Dotted lines = "Tigers".

Red spot king prawns occurred only on the reef-flat at Pipon Islets, and at Cliff Isles (Figure 5.5). The total abundance of juvenile red spot king prawns was equally influenced negatively by muddy sediments, and positively by coarse sand sediments (Appendix C). Juvenile red spot king prawns appear to recruit into fisheries in inter-reef waters from nearby reef-flat nursery habitats (Robertson and Dredge in prep), but may also settle in suitably "reef-like" habitats inshore (Coles *et al.* 1987b). The Cliff Isles site had the third-largest proportion of coarse sand (Figure 5.4), and like the coarse-sand site at Pipon Islets, was adjacent to a mangrove stand.

The habitat requirements of juvenile western king prawns appeared to be similar to those of juvenile red spot king prawns. Western king prawns were found at Claremont Point, Cliff Isles and Pipon Islets (Figure 5.5), all sites with relatively high proportions of coarse sand (Figure 5.3). The Claremont Point site was adjacent to Obree Reef (Figure 5.1). Coles *et al.* (1990a) found that juvenile western king prawns were common on low seagrass biomass, sandy sediment habitats.

Only one juvenile white banana prawn and few juvenile leader prawns were found (Figure 5.5), which reflects the low proportions of these species in adult catches (Section 4.4.1). Juvenile white banana prawns are usually found on bare, muddy substrates adjacent to mangrove stands (Staples 1984). No juvenile white banana or leader prawns were found by Coles *et al.* (1987b) in their survey of seagrass beds between Cairns and Cape York.

Cairns. Juveniles of six commercial prawn species were caught on the Cairns site (Figure 5.6). Of these, 97% were represented by three species (in descending order of abundance): blue endeavour, brown tiger and grooved tiger prawns (Figure 5.6). Juvenile red endeavour prawns, the most numerous species in adult samples near Cairns (Section 4.4.1), were relatively rare (Figure 5.6). Only small numbers (1.8 per trawl) of red endeavour prawns were found on our Cairns site by Coles *et al.* (in press), while Heasman (1983) found that most juvenile red endeavour prawns occurred in Trinity Inlet, upstream of our site. Juvenile white banana prawns were also rare in our samples, and no red spot king or leader prawns were found. These species most likely occurred as juveniles on habitats other than that sampled by us (e.g. mangrove-lined estuaries, reef-flats). The small numbers of juvenile western king prawns found reflects the low numbers of this species in the fishery near Cairns (Section 4). It is also possible that juvenile western king prawns occurred on sandier habitats (Coles *et al.* 1990a) in the Cairns area.

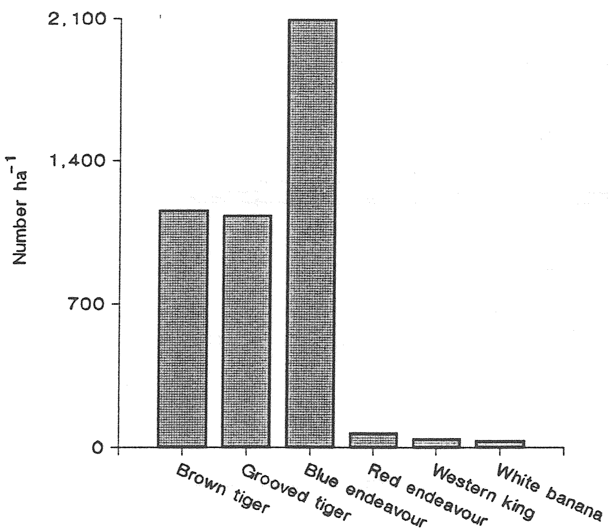

Figure 5.6 Abundance of juvenile prawns in Cairns harbour.

5.4.3 Temporal patterns

Discussion of juvenile leader prawns from Princess Charlotte Bay and Cairns harbour, and of white banana prawns from Princess Charlotte Bay, has been omitted from this section due to the small numbers of these species in our samples (Section 5.4.2). The timing of peak settlement and emigration for most species conformed to the generalised life-cycle outlined by Garcia (1985).

Princess Charlotte Bay. There was no significant correlation between abundance and monthly seagrass percentage cover for any prawn species in Princess Charlotte Bay (Appendix C).

Brown tiger prawns were most abundant on the nursery sites in November, when most individuals were smaller than 6 mm CL (Figure 5.7). These recently-settled juveniles were probably spawned in September/October 1990 (Section 4.4.3), and appeared in the fishery in early 1991 (Section 4.4.2). It is likely from this life-cycle timing that juvenile brown tiger prawns were also abundant in nursery areas in October 1990 (Figure 5.7), but the sites on which these animals were usually most common were not established at that time. By January 1991, most juvenile brown tiger prawns were larger than 15 mm CL, while the following month most were smaller than 10 mm CL (Figure 5.7), which indicates that emigration, and settlement of a new cohort, occurred in the intervening period. Postlarval juvenile brown tiger prawns were present throughout the sampling period (Figure 5.7), which implies that spawning was continuous (Section 4.4.3).

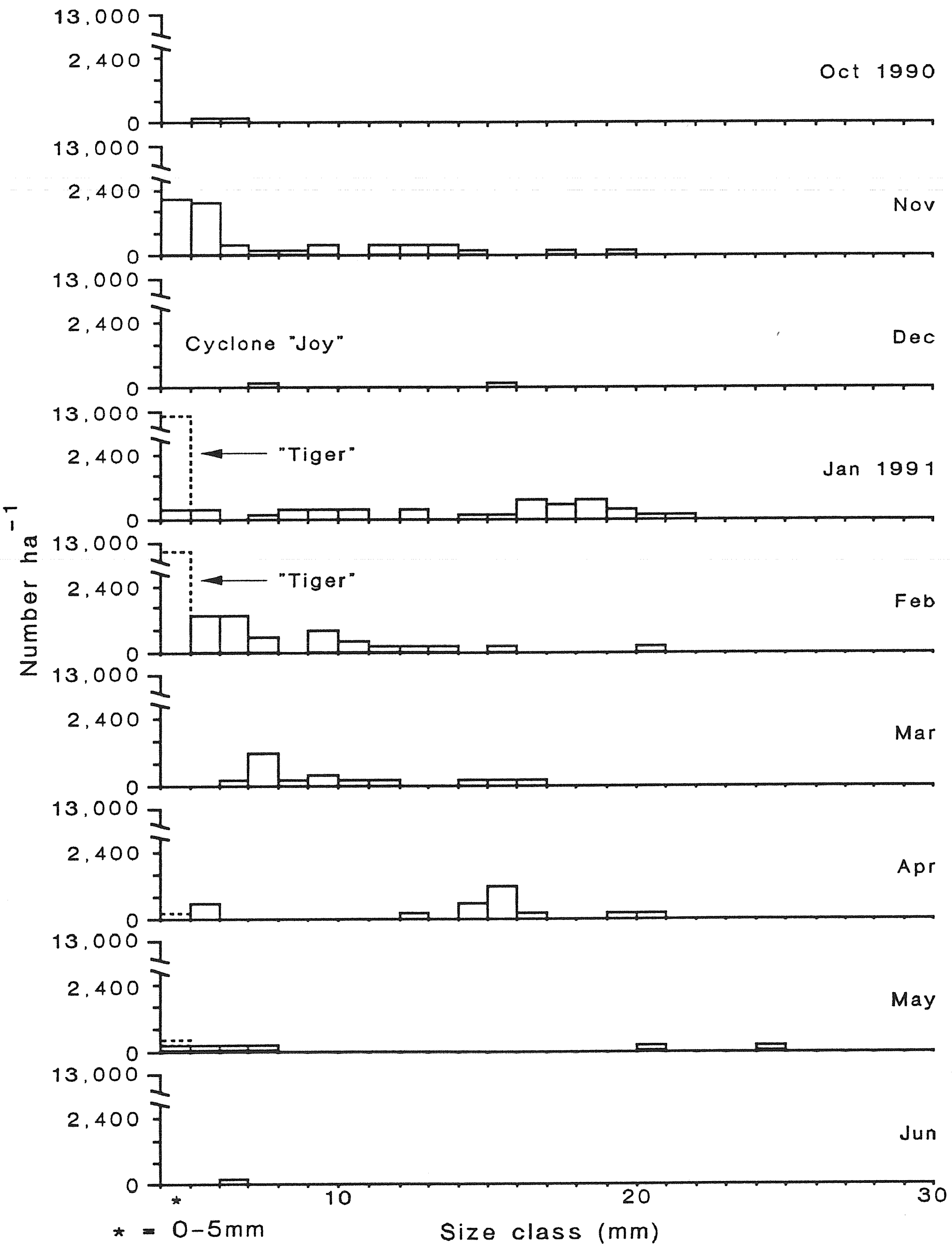

Figure 5.7 Juvenile brown tiger prawn size frequencies in Princess Charlotte Bay.

Settlement of juvenile grooved tiger prawns began in November 1990 (Figure 5.8), which corresponds with spawning in September/October (Section 4.4.3). Numerous postlarval "tiger" prawns occurred on the nursery sites in January and February 1991 (Figures 5.7 and 5.8). In 1991, grooved tiger prawns recruited into the fishery during March/April, while brown tiger prawns recruited from December 1990 to February 1991 (Section 4.4.2). It is likely, therefore, that the postlarval "tiger" prawns were predominantly grooved tiger prawns. While the nursery period for most grooved tiger prawns was short (two to three months), some stayed on the seagrass beds until May 1991 and grew to large (up to 27 mm CL) sizes (Figure 5.8). Migration may occur at different sizes if juveniles migrate due to an environmental cue which varies (Dall *et al.* 1990).

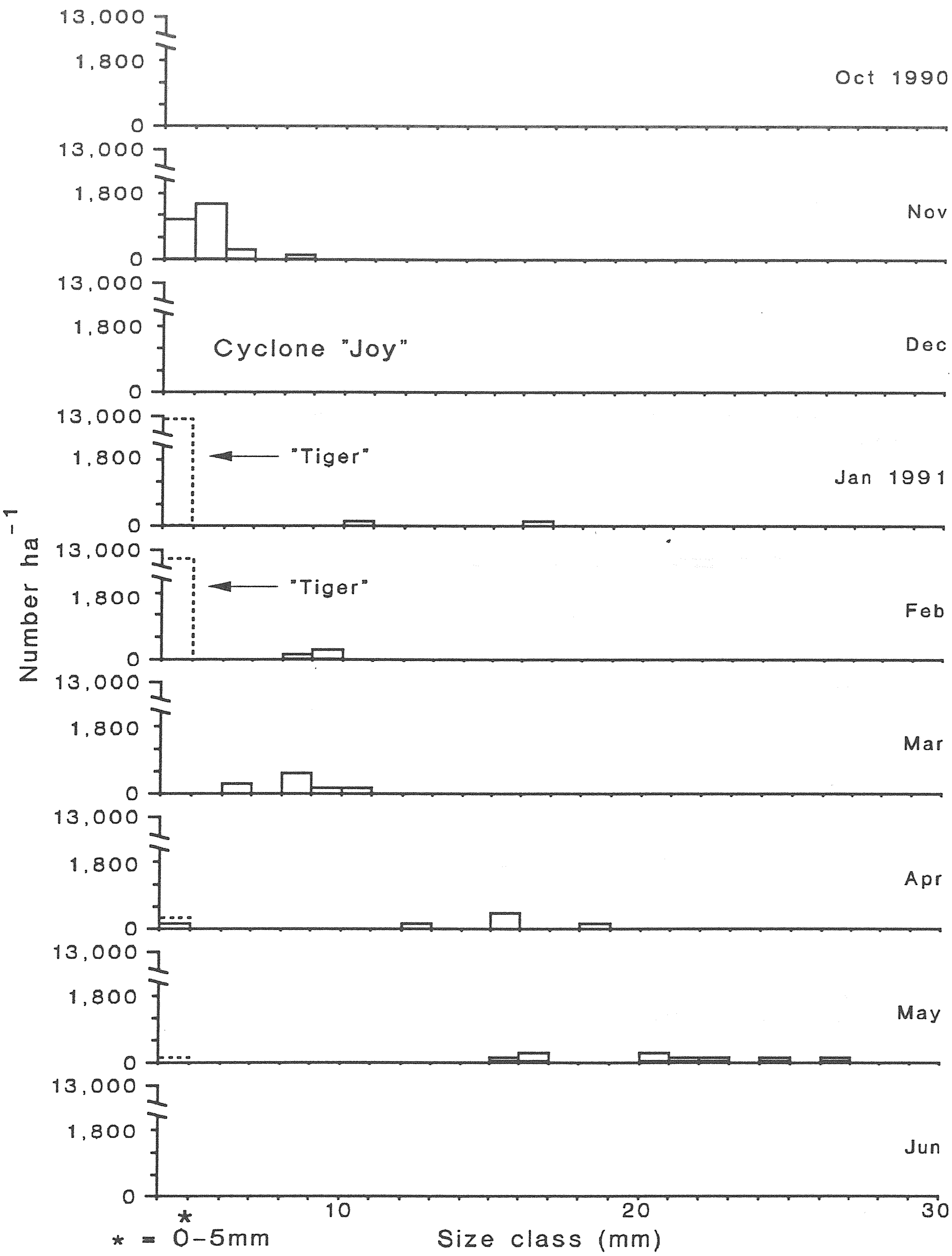

Figure 5.8 Juvenile grooved tiger prawn size frequencies in Princess Charlotte Bay.

Settlement of blue endeavour prawns occurred from March to June, and peaked in April/May (Figure 5.9), which corresponds with peak spawning in March/April (Section 4.4.3). We did not, however, observe a subsequent peak in recruitment in to the fishery (Section 4.4.2), possibly because density-dependent natural mortality was higher in the large numbers of newly-settled blue endeavour prawns in April/May.

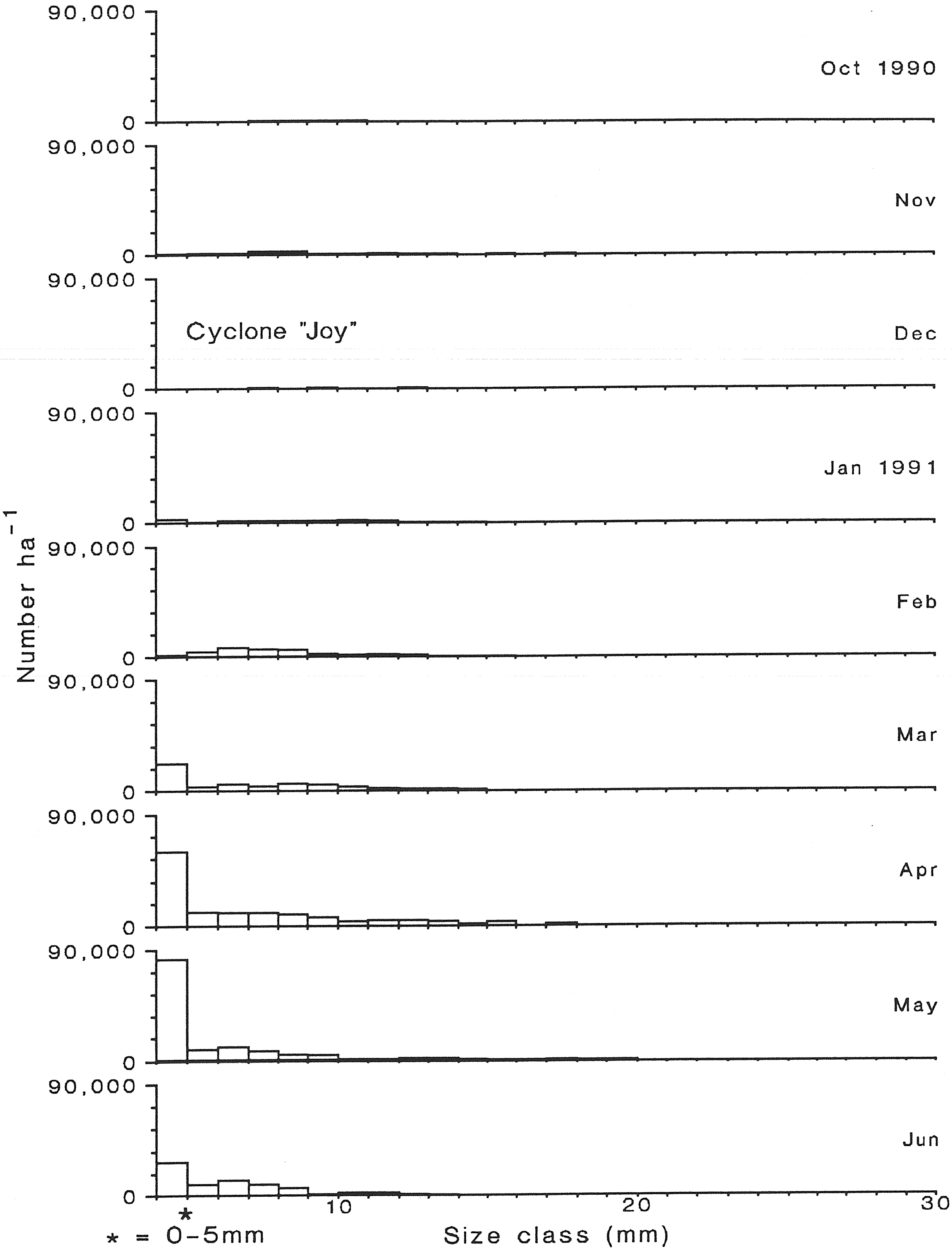

Figure 5.9 Juvenile blue endeavour prawn size frequencies in Princess Charlotte Bay.

Settlement of red endeavour prawns was confined to January and February (Figure 5.10). The smallest red endeavour prawns appeared in the fishery two to three months later (Appendix B). Few juvenile red endeavour prawns were larger than 10 mm CL (Figure 5.10), which indicates that emigration occurred at a relatively small size.

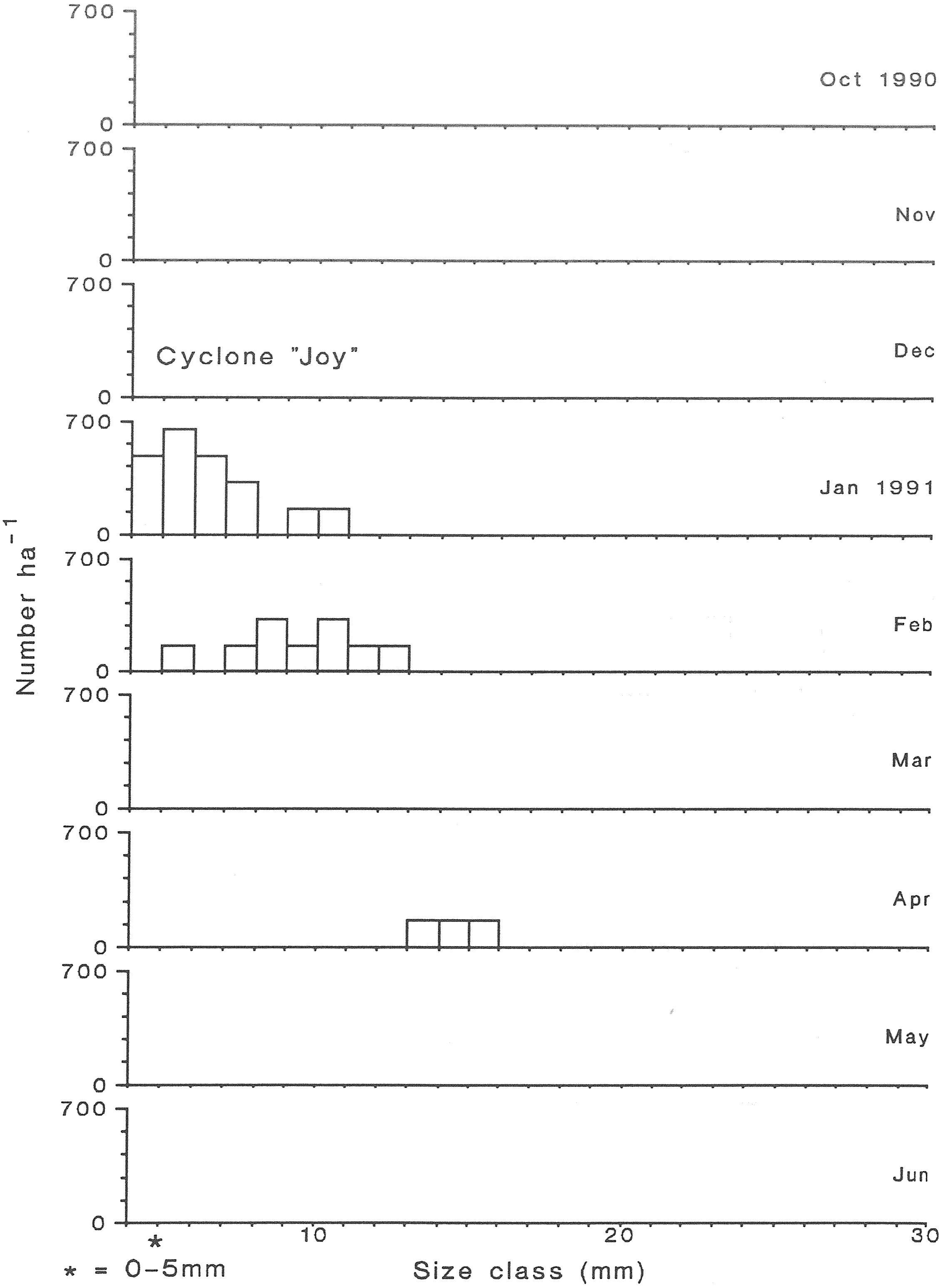

Figure 5.10 Juvenile red endeavour prawn size frequencies in Princess Charlotte Bay.

There were two major settlements of juvenile red spot king prawns. These animals were most abundant at Pipon Islets and Cliff Isles in February, but the number of postlarval (< 5 mm CL) prawns was greatest in May/June (Figure 5.11). The larger individuals present in February at the Cliff isles site may have settled there in December or January, but we can not confirm this because we did not sample at Cliff Isles before February 1991.

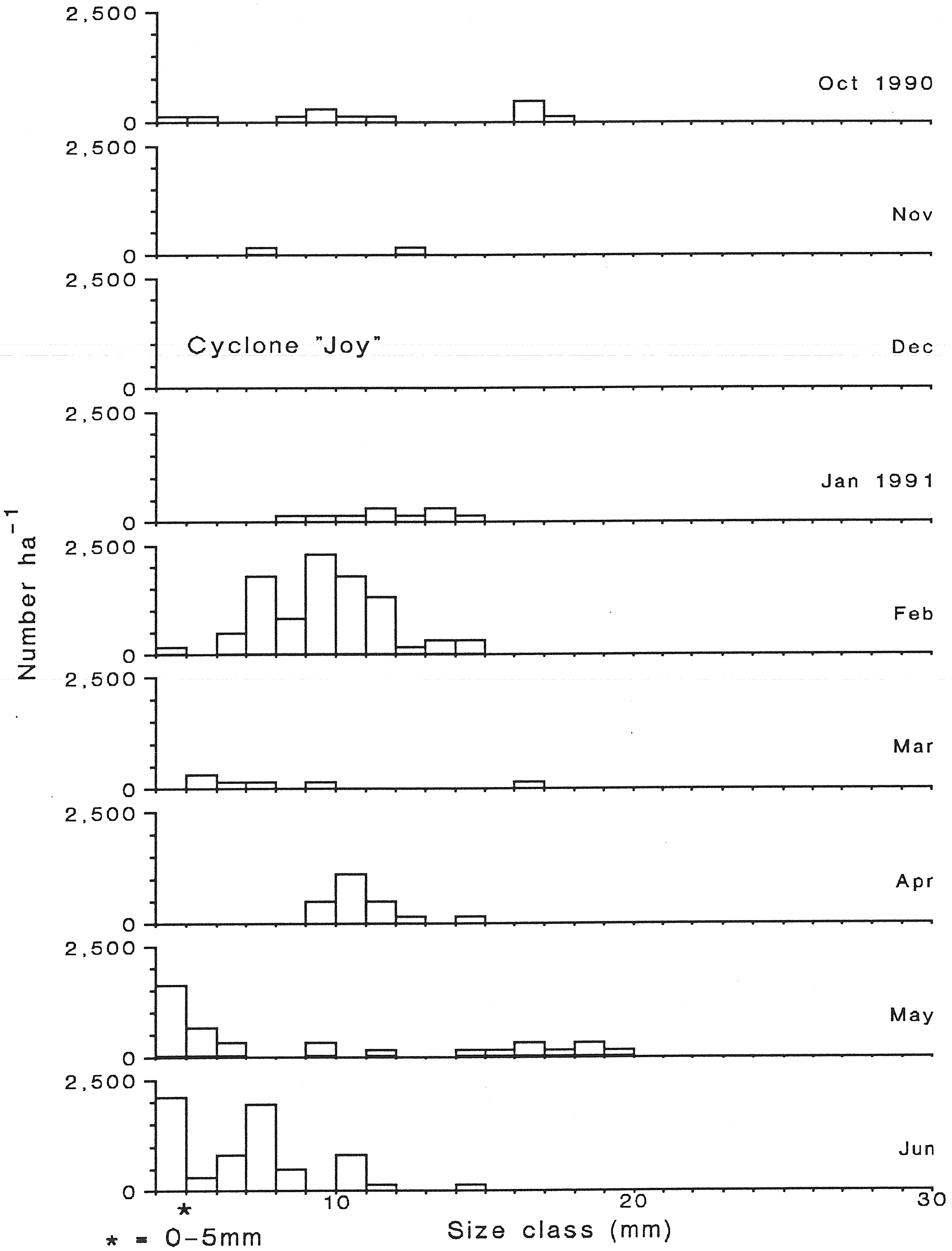

Figure 5.11 **Juvenile red spot king prawn size frequencies in Princess Charlotte Bay.**

Few juvenile western king prawns were caught. No peak settlement time for western king prawns was obvious during our sampling period, although the smallest individuals were found in November 1990 (Figure 5.12). Coles *et al.* (1990b) also found that settlement of juvenile western king prawns was protracted at Mornington Island in the Gulf of Carpentaria. A few large western king prawns (up to 28 mm CL) were present on the seagrass beds in March and April (Figure 5.12).

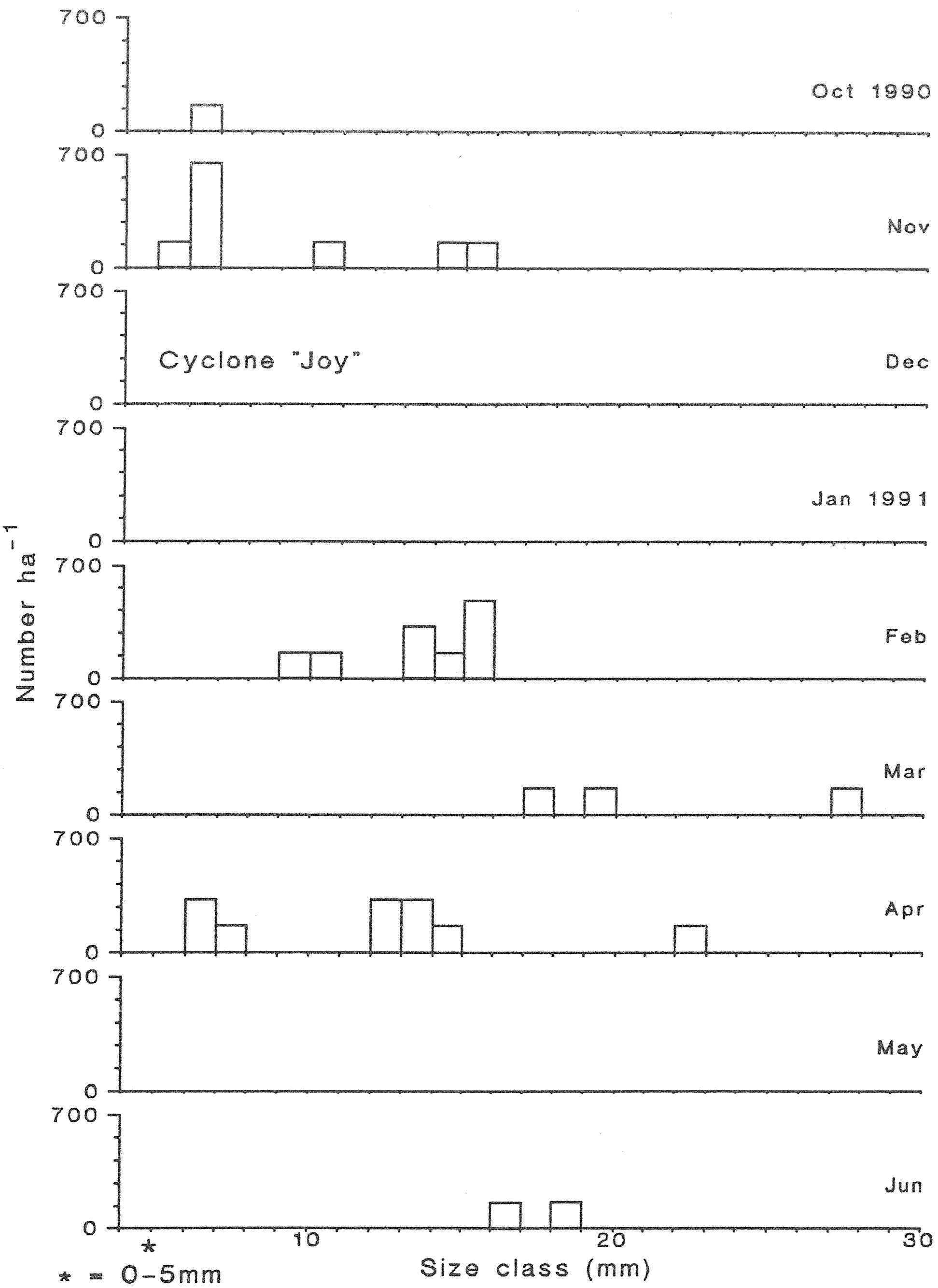

Figure 5.12 Juvenile western king prawn size frequencies in Princess Charlotte Bay.

Cairns. In general, the time of peak settlement for juvenile prawns in Cairns harbour corresponded with early (March/April) spawning activity (Section 4.4.3). Survival from later spawning peaks (Section 4.4.3) for most species seemed low, as little corresponding settlement was evident.

Settlement of brown tiger prawns occurred year-round (Figure 5.13). The largest numbers of juvenile brown tiger prawns were caught in November 1990, although large numbers of small (recently settled) juveniles also occurred in April 1990 (Figure 5.13). Heasman (1983) also found that juvenile brown tiger prawns were highly abundant on this site in November. Coles *et al.* (in press) found, however, that January was the time of peak abundance for juvenile brown tiger prawns in Cairns harbour. It seems likely that there is considerable annual variation in peak settlement time for brown tiger prawns in Cairns harbour. Peak abundance for juvenile brown tiger prawns occurred three months after the August spawning peak, but these juveniles probably resulted from minor spawning in September/October (Section 4.4.3). A major settlement of juvenile brown tiger prawns in April also corresponded with minor spawning activity (Section 4.4.3). It seems likely that survival from the August spawning peak was much lower than from the minor spawning periods. Few prawns survive from the major spawning peak of white banana prawns in the Gulf of Carpentaria (Rothlisberg *et al.* 1985).

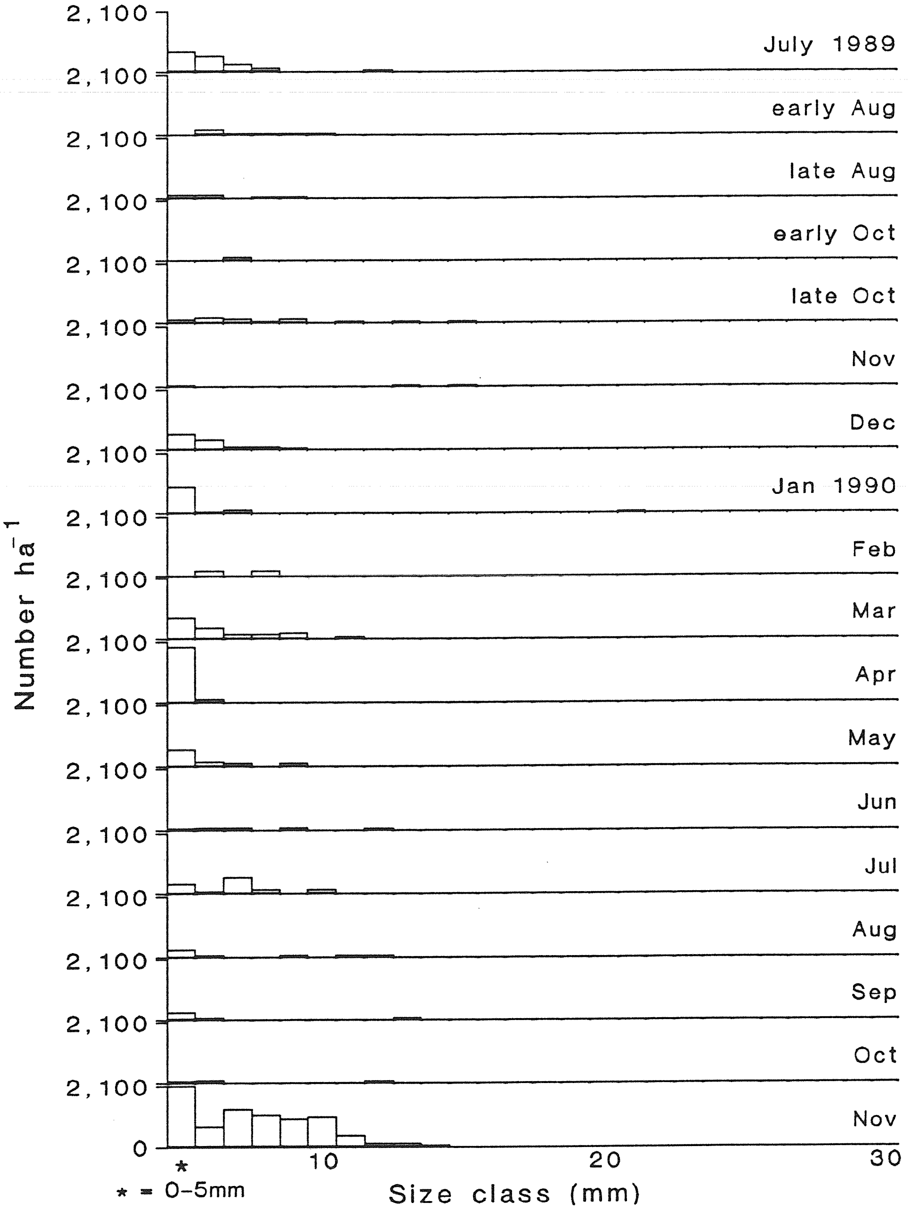

Figure 5.13 Juvenile brown tiger prawn size frequencies in Cairns harbour.

Settlement timing for grooved tiger prawns was more distinct, and occurred later, than for brown tiger prawns. Heasman (1983) and Coles et al. (in press) also found that grooved tiger prawns settled later than brown tiger prawns. We caught most juvenile grooved tiger prawns from December 1989 to June 1990 (Figure 5.14). Peak abundance occurred from March to May 1990, and small juvenile grooved tiger prawns were most abundant in May (Figure 5.14). Coles *et al.* (in press) found that juvenile grooved tiger prawns were most abundant in February, while Heasman (1983) recorded peak abundances from December to March. A spawning peak that would have corresponded with March to May settlement for grooved tiger prawns was not evident early in 1990 (Section 4.4.3). It is not clear why the timing of the life history stages of the grooved tiger prawn did not correspond near Cairns. Life cycles can be modified by fluctuations in environmental factors such as currents, rainfall and temperature (Garcia 1985). Few grooved or brown tiger prawns larger than 10 mm CL occurred on our Cairns site, which contrasts with the relatively large sizes found on our sites in Princess Charlotte Bay. Juvenile grooved tiger prawns in Cairns harbour may respond to emigration cues at smaller sizes than in Princess Charlotte Bay.

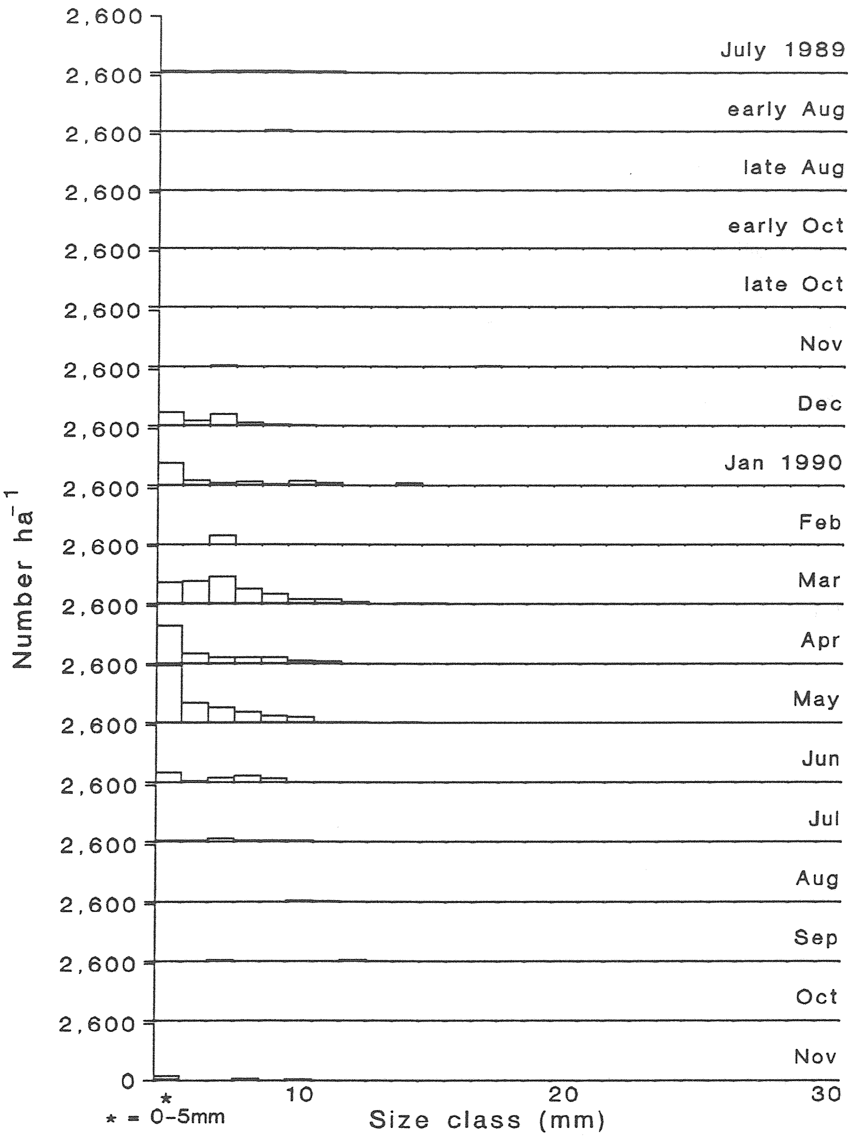

Figure 5.14 **Juvenile grooved tiger prawn size frequencies in Cairns harbour.**

Blue endeavour prawns settled on the Cairns harbour site throughout the sampling period (Figure 5.15). Coles *et al.* (in press) also found that the period of peak abundance for juvenile blue endeavour prawns in Cairns harbour was prolonged. Abundances were greatest in January and April in our samples, and large numbers of small juveniles were present in May (Figure 5.15). This April/May settlement corresponded with a spawning peak in April near Cairns (Section 4.4.3). Survival from the August spawning peak (Section 4.4.3) seemed lower than from the earlier peak, as settlement in September was lower than that in April/May. We found few blue endeavour prawns larger than 10 mm CL (Figure 5.15), which indicates that emigration occurred at a relatively small size.

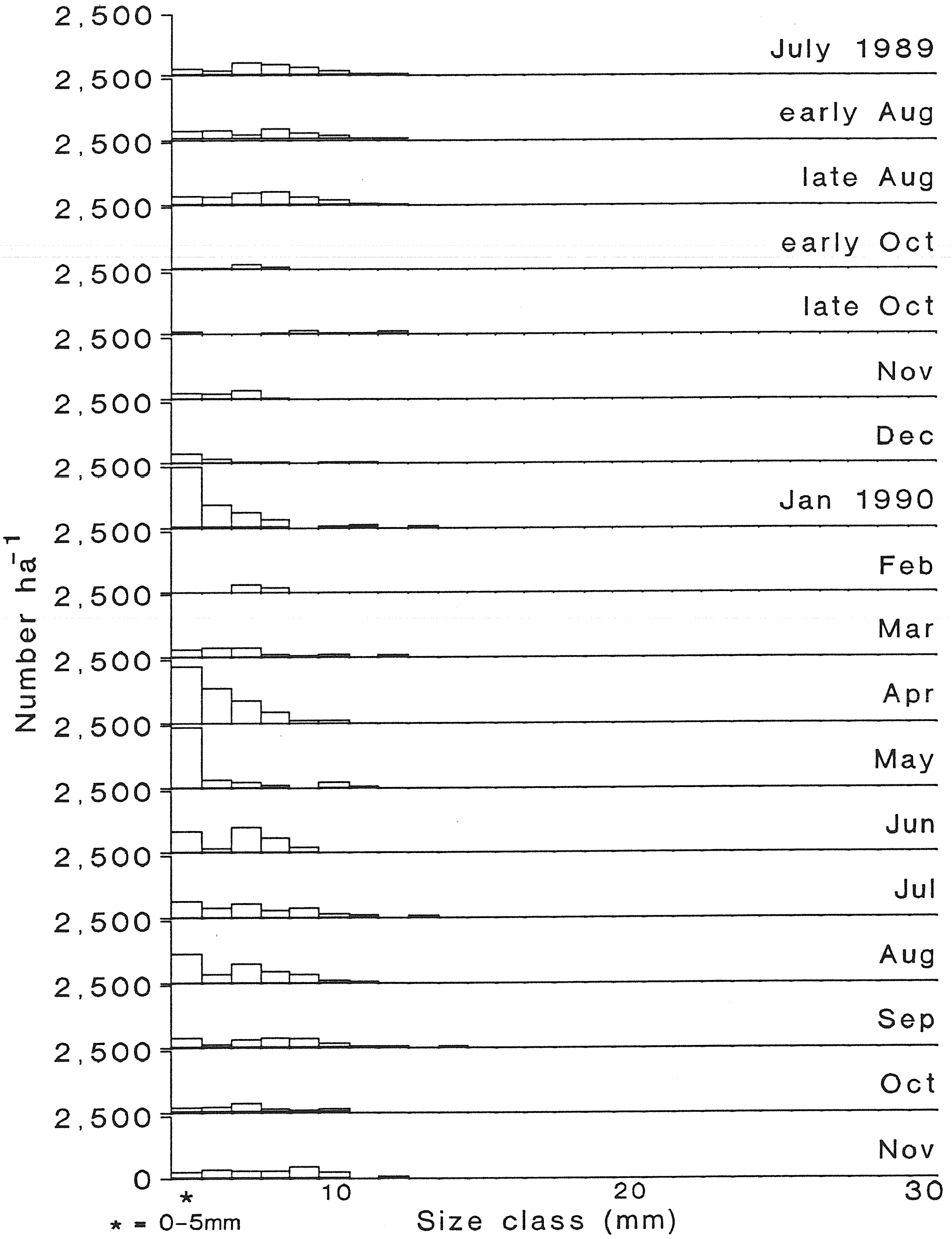

Figure 5.15 **Juvenile blue endeavour prawn size frequencies in Cairns harbour.**

Red endeavour prawn settlement was greatest in January, and larger juveniles were most abundant in March (Figure 5.16), which presumably corresponded with spawning in December 1989. A smaller settlement peak in April (Figure 5.16) may have resulted from spawning in February or April (Section 4.4.3). Although spawning peaks also occurred later in 1990 (Section 4.4.3), we found no juvenile red endeavour prawns on our Cairns harbour site after April. Survival from the later spawning peaks may have been low. A better indication of settlement peaks for this species would have been gained if we had sampled upstream in Trinity Inlet (Heasman 1983).

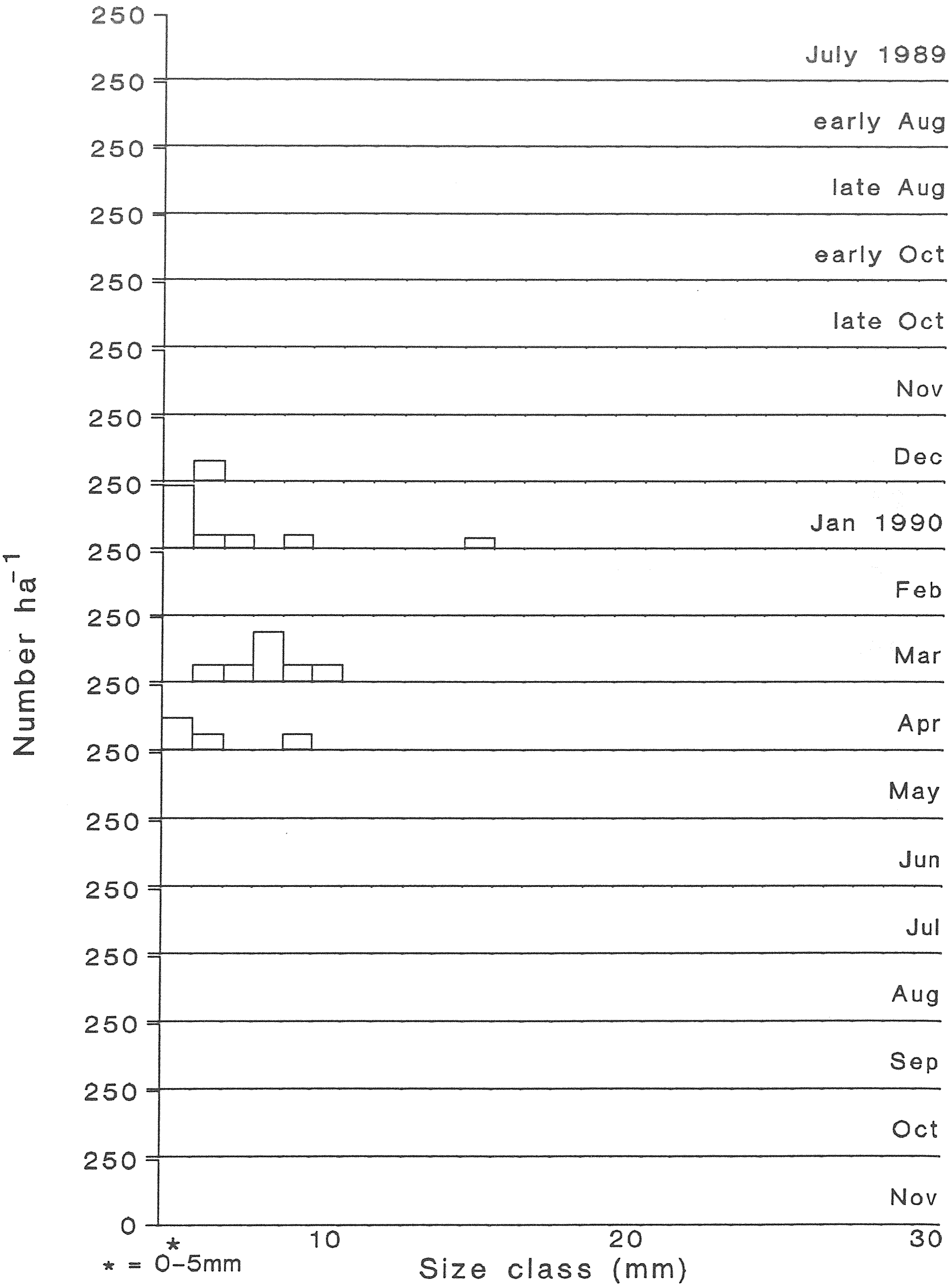

Figure 5.16 Juvenile red endeavour prawn size frequencies in Cairns harbour.

Small numbers of juvenile western king prawns were found between April and November 1990 (Figure 5.17), although settlement was greatest in April, one month after peak spawning (Section 4.4.3).

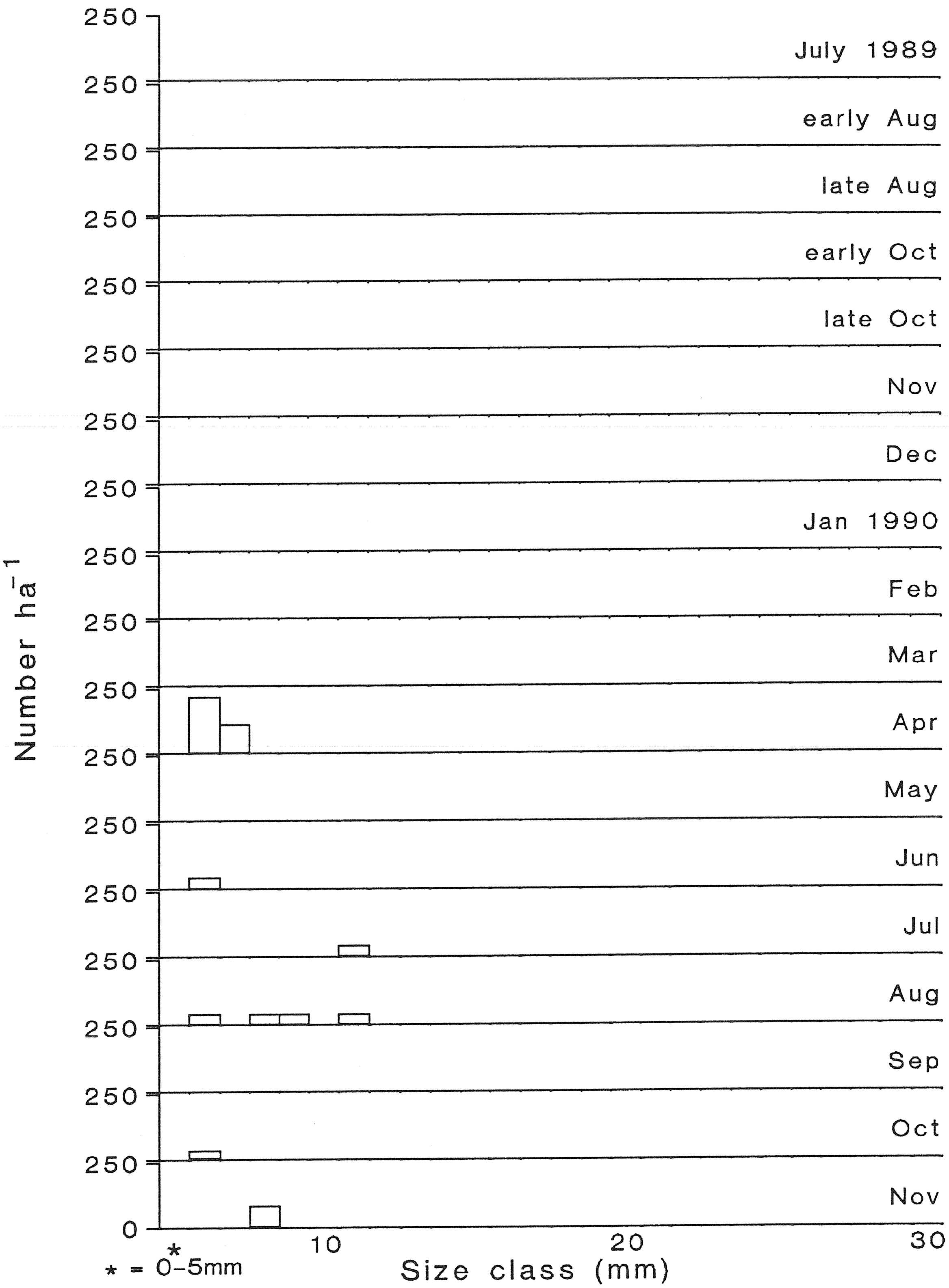

Figure 5.17 Juvenile western king prawn size frequencies in Cairns harbour.

Juvenile white banana prawns were found in small numbers in March and April, with peak settlement in April (Figure 5.18). This corresponded with a minor spawning peak in March/April (Section 4.4.3). Juvenile white banana prawn numbers are, however, usually low on seagrass, and may give little indication of abundance patterns for this species.

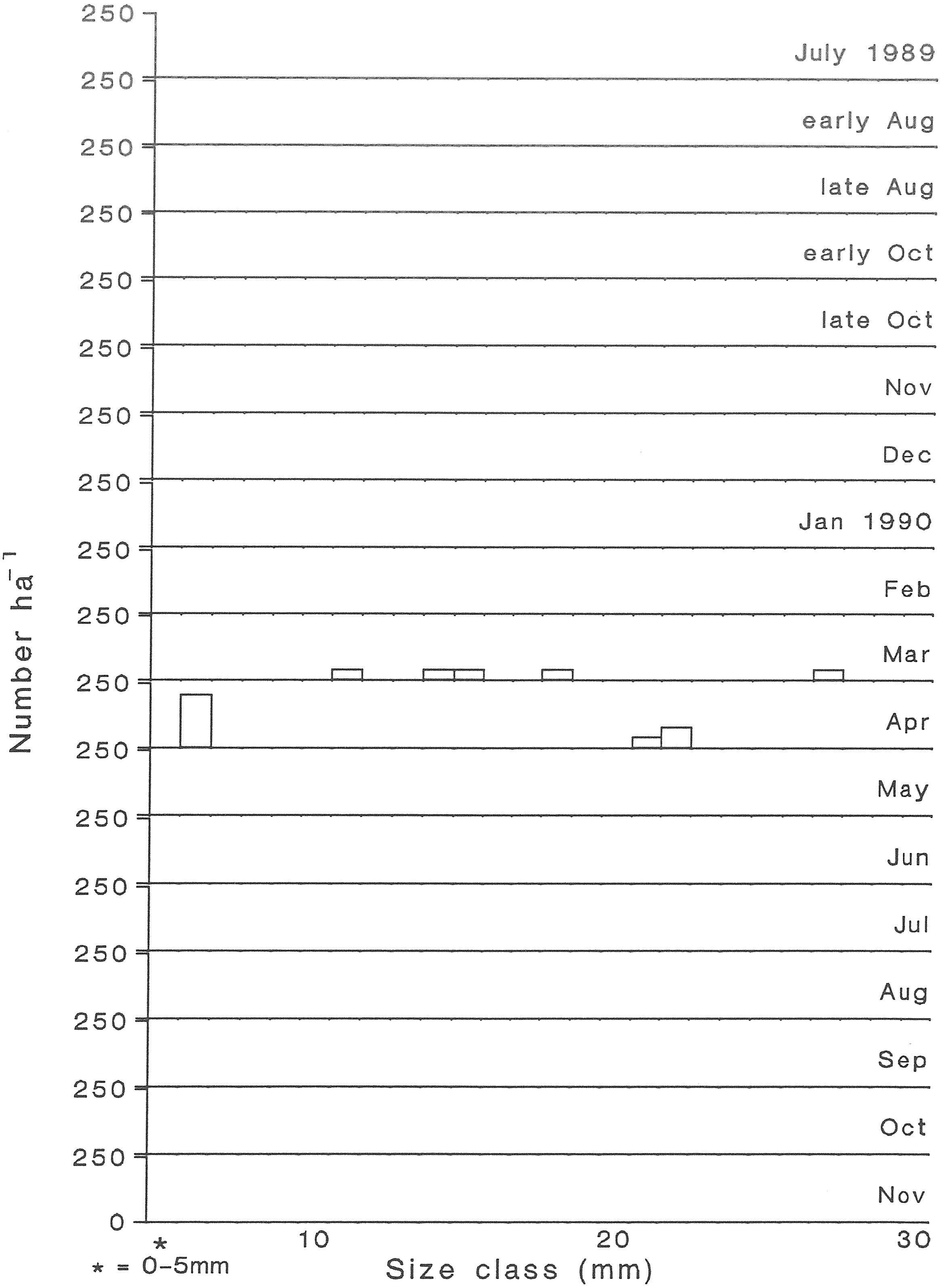

Figure 5.18 Juvenile white banana prawn size frequencies in Cairns harbour.

6 TAGGING STUDIES

6.1 Abstract

More than 16 000 tagged brown tiger prawns were released in Princess Charlotte Bay during the seasonal closures in 1990 and 1991 to provide estimates of parameters for use in modelling procedures. The overall return rate was 9%. Most prawns were recaptured within Princess Charlotte Bay, but there was some southerly movement in 1990, which did not occur in 1991. Fishing effort may have influenced perceived migration patterns. Estimated growth parameters were similar to those found for brown tiger prawns in other parts of northern Australia, but there were differences between release months in the growth coefficient (***K***) for males. Females grew larger than males. The overall instantaneous rate of natural mortality was 0.088 (8.4%) week^{-1} in 1990 and 0.075 (7.2%) week^{-1} in 1991. Variation in natural mortality between years and sexes may have been caused by variable predation rates.

6.2 Introduction

A formidable array of tagging or marking techniques exist so that animals may be recognised when recaptured (Pielou 1983). Plastic streamer tags (Marullo *et al.* 1976) are the device most commonly used for tagging prawns. Information obtained from tagging programs can be used to provide evidence of migration, and to estimate growth and mortality rates (Royce 1972). In some instances, tagging can also be used to estimate population size (Jones 1977). In their review of methods for estimating adult prawn growth, Garcia and Le Reste (1981) concluded that, despite undeniable shortcomings, tagging is the best method available.

Natural mortality is another population parameter required for modelling closure effects. Dredge (1990) applied Ricker's (1975) technique, which is based upon the survival rates of two groups of tagged animals released at known time intervals, to estimate the natural mortality of red spot king prawns. If the groups are equally vulnerable to recapture, survival during periods with no fishing effort (i.e. closures) is directly relative to the rate of natural mortality (Ricker 1975).

The aim of our tagging program was to determine the movement patterns, growth rate and natural mortality rate of brown tiger prawns in Princess Charlotte Bay, so that this information could be used in computer modelling simulations (Section 8).

6.3 Methods and materials

6.3.1 Species and sites

A total of 20 885 individuals of six prawn species (Table 6.1) were tagged and released at five sites (Figure 6.1) in Princess Charlotte Bay and near Cape Flattery. All prawns were captured in the fishery adjacent to the area in which they were released. Most were brown tiger prawns (Table 6.1) and most were released at site A (Figure 6.1). Tagged prawns were released in January, February and March of 1990 and 1991 during the seasonal closure (Table 6.1).

Each month, between 1765 and 3087 tagged brown tiger prawns were released at site A (Table 6.1).

Table 6.1 Summary of tagged prawn release and recapture data.

Release date	Site	Species	Number released	Number returned
28/01/90 - 30/01/90	A	Brown tiger	2386	178
		Blue endeavour	453	4
		Red endeavour	2	0
		Western king	183	0
		Red spot king	113	0
31/01/90	B	Brown tiger	419	10
		Grooved tiger	1	0
		Blue endeavour	222	0
		Western king	50	0
		Red spot king	49	0
27/02/90 - 01/03/90	A	Brown tiger	2388	260
		Grooved tiger	10	0
		Blue endeavour	989	9
		Red endeavour	1	0
		Western king	228	1
		Red spot king	134	0
01/03/90	C	Brown tiger	213	17
		Grooved tiger	1	0
		Blue endeavour	41	1
		Western king	20	0
		Red spot king	32	0
30/03/90 - 31/03/90	A	Brown tiger	1765	154
		Grooved tiger	1	0
01/04/90	B	Brown tiger	399	41
		Blue endeavour	539	6
		Western king	10	0
		Red spot king	10	0
21/01/91 - 23/01/91	A	Brown tiger	3013	238
		Grooved tiger	8	0
16/02/91 - 18/02/91	A	Brown tiger	3087	319
22/02/91	D	Brown tiger	586	37
		Grooved tiger	3	0
13/03/91 - 15/03/91	A	Brown tiger	3081	302
20/03/91	E	Brown tiger	496	51
Total			20883	1628

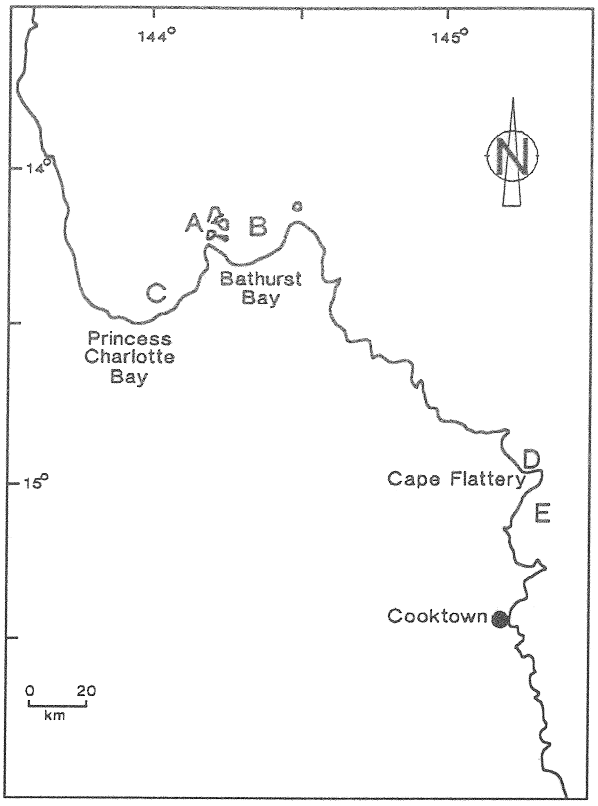

Figure 6.1 Tagged prawn release sites.

6.3.2 Tagging procedure

Hallprint Pty Ltd blue vinyl streamer tags (size 2) were used in 1990. Size 4S tags, which had a slit in the middle notch designed to increase tag retention, were used in 1991. Each tag was smeared with an antibiotic cream (Aureomycin) to prevent infection of the wound (Marullo *et al.* 1976). Tags were consecutively numbered and marked with "QLD. FISH".

The FV "Marshelly", a 14-m commercial trawler, was chartered to collect live prawns. Two 7.3-m nets (51-mm mesh) and two 8.2-m nets (41-mm mesh) were towed for less than 30 minutes each shot to ensure a high survival rate of prawns. Prawns were immediately placed into buckets of seawater and transferred to holding tanks with continuous seawater supply.

Active, intermoult period prawns, free of visible parasites and larger than 18 mm carapace length were tagged through the middle of the first abdominal segment. The carapace length (measured to the nearest 0.1 mm with plastic dial callipers) and sex of each prawn was recorded. Tuma's (1967) criteria were used to stage ovaries from I (immature) to IV (ripe).

Tagged prawns were then placed into a second holding tank with continuous seawater supply. After approximately one hour, prawns that appeared healthy were transferred to a release cage in a tank with continuous seawater supply. When the cage contained approximately 500 prawns it was lowered to the sea floor and the lid of the cage was opened by an attached rope. Several groups of prawns were released each night. Tagging operations were always completed before dawn to allow prawns time to bury before daytime predators became active (Garcia and Le Reste, 1981).

6.3.3 Recaptures

We relied upon the co-operation of the fishing industry to return recaptured tagged prawns. The fishing industry was notified of the tagging program and trawlers were provided with tagged prawn return kits before tagging commenced each year. Trawl operators were requested to record the tagged prawn recapture position and the date of recapture on a pre-printed label supplied in the kit, and forward the recaptured prawn to the Northern Fisheries Centre in Cairns. Additional kits were available from motherships and fuel barges.

The carapace length of each recaptured prawn was measured in the laboratory with dial callipers identical to those used when tagging. Recapture positions were verified on navigation charts and each prawn was assigned a rank according to the quality of the tag return information. Returns with uncertain recapture information were omitted from analyses (e.g. returns with no recapture position were omitted from movement analyses).

6.3.4 Fishing effort

Distribution of fishing effort in 30′ x 30′ grids along the east coast of Queensland from Cape Direction to Cairns was obtained from the Queensland Department of Primary Industries CFISH logbook database (Section 3).

6.3.5 Analyses

As the number of grooved tiger, blue endeavour, western king and red spot king prawns returned was low (Table 6.1), and to obviate any between-site variability, only brown tiger prawns released at site A were included in analyses.

Size at release. Tagged prawns were divided into 1-mm carapace-length size classes and Kolmogorov-Smirnov tests (STATISTIX, Analytical Software) were used to determine if there were any significant differences in size class distribution at release between sexes and months.

Return rate. Hill and Wassenberg (1985) found that tag-induced mortality was significantly greater in prawns smaller than 19 mm carapace length than for prawns larger than 24 mm carapace length. Kolmogorov-Smirnov tests were used to determine if there were any size-related differences in return rates. STATISTIX two by two contingency tables were used to determine whether there were differences in return rates between sexes and years.

Time at liberty. STATISTIX t-tests were used to determine if time at liberty was independent of sex and month of release. Contour plots of time at liberty were generated using SURFER (Golden Software).

Movement. T-tests and STATISTIX one-way ANOVA's were used to test for differences in distance moved between sexes and month of release for each year. Data was natural log transformed to normalise it. General movement trends were examined graphically.

Growth. Prawns at liberty for less than 30 days were omitted from growth analyses, as the type of model used was not suitable for predicting growth increments of prawns with short periods at liberty relative to the intermoult period (Kirkwood and Somers, 1984). Penn (1975) found that the growth of western king prawns was retarded for approximately 30 days after tagging. The period between last release and the opening of the fishing season in 1990 was 15 days, while in 1991 it was 24 days. We therefore selected a minimum time at liberty of 30 days to make both years more comparable.

Individual growth increments of prawns were used to assign growth parameters to the von Bertalanffy growth model. The form of the model used was:

$$y = (L_\infty - x_1)(1 - e^{-Kx_2})$$

where y is the growth increment
x_1 is the initial size
x_2 is the time at liberty
L_∞ is the asymptotic length, and
K is the growth coefficient, which describes the rate at which L_∞ is approached.

The minimisation subroutine LMM (Osborne, 1976) was used to obtain estimates of L_∞ and K. This model was fitted for each sex and month of release and the residual sums of squares were compared to determine which groups (sexes and months) should be considered separately. The model was refitted to calculate parameter estimates for the appropriate groups. Residuals were plotted against normal scores, time at liberty, initial size and fitted values to assess the normality of the residuals, whether there were any systematic departures from the fitted curves and whether there were any trends in the residual variances.

Because of the generally high negative correlation between estimates of K and L_∞ (Kirkwood and Somers, 1984), joint 95% confidence regions were calculated and compared graphically to determine if there were any significant differences in the estimated parameters between data sets.

Mortality. We used Ricker's (1975) method to estimate natural mortality:

$$M = ln\left(\frac{T_1 * R_2}{T_2 * R_1}\right)$$

where M is the instantaneous rate of natural mortality
T_1 is the total number of tagged prawns released at time 1
T_2 is the total number of tagged prawns released at time 2
R_1 is the number of tagged prawns recaptured from release 1
R_2 is the number of tagged prawns recaptured from release 2.

Separate estimates of natural mortality were made for each year; estimates were made for males and females both separately and combined.

Prawns released in March were not included in mortality estimates because the return rate for these animals was lower than for those released in February in both years (Section 6.4.6). To estimate natural mortality using Ricker's (1975) equation it is assumed that the return rate for later releases of prawns is greater than that for earlier releases.

6.4 Results and discussion

6.4.1 Size at release

There were significant differences between sexes in the size distribution in both 1990 ($D = 0.59$, $p < 0.05$) and 1991 ($D = 0.52$, $p < 0.05$). For each sex, the size class distribution also differed significantly between months in both years, except for males released in January 1991 compared with males released in February 1991 (Appendix D, Table C.1). Sample sizes were large and these differences within a sex, whilst significant, were generally small (Figure 6.2).

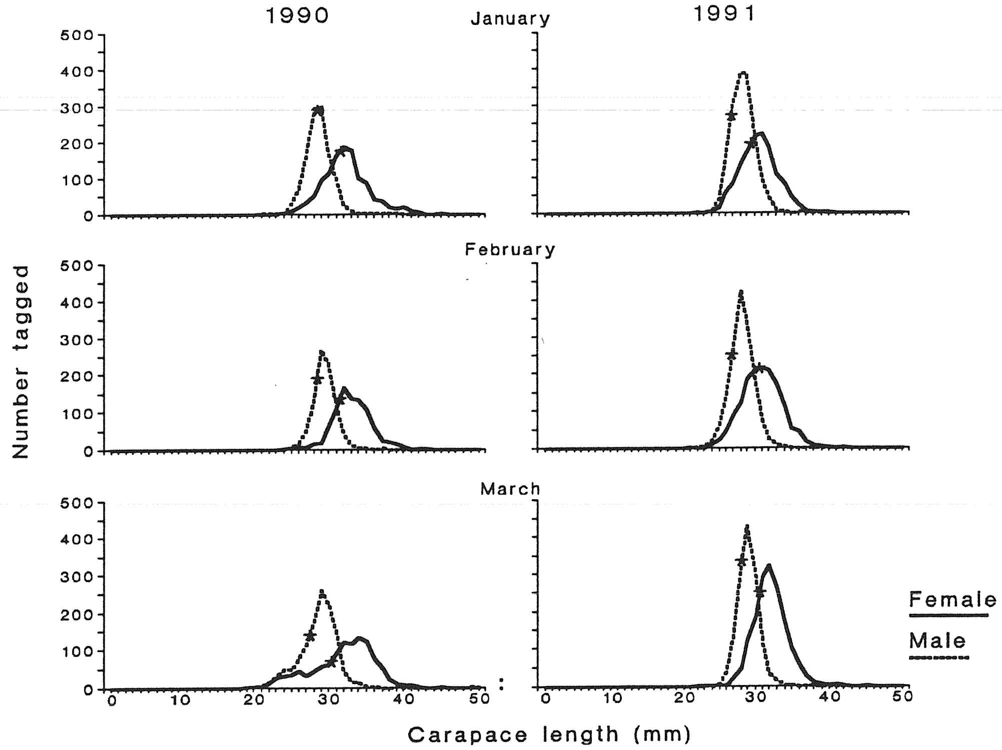

Figure 6.2 Tagged prawn size frequencies. (* mean carapace length)

6.4.2 Return rate

Of the 6 539 brown tiger prawns released in 1990 and the 9 131 released in 1991 at site A, 591 and 859 respectively were returned. All fifteen prawns recaptured by the survey vessel during the seasonal closures were re-released, but none were subsequently recaptured. The return rate for males (10.2%) was significantly higher than that for females (7.9%) in 1990 ($\chi^2 = 9.39$, $p < 0.05$), but in 1991, the return rate for males (8.7%) was significantly lower than that for females (10.1%)($\chi^2 = 4.11$, $p < 0.05$). The return rate for females released in 1991 was significantly higher than the previous year ($\chi^2 = 9.53$, $p < 0.05$), while the return rate for males released in 1991 was significantly lower than the previous year ($\chi^2 = 4.22$, $p < 0.05$).

There were significant differences in return rate across the size distribution for males released in March 1990 and in February 1991 (Appendix D, Table D.2). These differences may have been due to increased tag-induced and/or natural mortalities in smaller animals, as males released in March 1990 and February 1991 had the smallest mean carapace lengths of any group tagged (Figure 6.2).

Return rates for species other than brown tiger prawns ranged between 0 and 0.9% (Table 6.1), and were so low as to preclude these species from analyses. These low return rates may have occurred because the fishery mainly targets tiger prawns (Trainor *et al.* 1992), however, return rates for tagged blue endeavour prawns are usually low. The return rate for this species in the Gulf of Carpentaria (Buckworth 1989) was 2.4%, and was 2.0% in Torres Strait (Watson and Turnbull unpublished data). A study of tag-induced mortality in blue endeavour prawns is warranted.

6.4.3 Time at liberty

The longest time at liberty recorded was 434 days for a male released in February 1991. The average time at liberty for both sexes in 1990 was 67 days, and in 1991 was 63 days for males and 58 days for females. Males released in March 1991 were at liberty for an average of 43 days, which was significantly greater than the average of 38 days for females released in that month ($t = 2.44$, $p = 0.015$).

In 1990, time at liberty generally increased with distance recaptured south of the release area (Figure 6.6.3). In 1991, time at liberty was generally greatest within the confines of Princess Charlotte Bay (Figure 6.3). Differences between years in contour plots of time at liberty reflect differences in movement (Section 6.4.4). The contours near Cape Tribulation in 1990 and Cape Flattery in 1991 resulted in each case from one recaptured prawn.

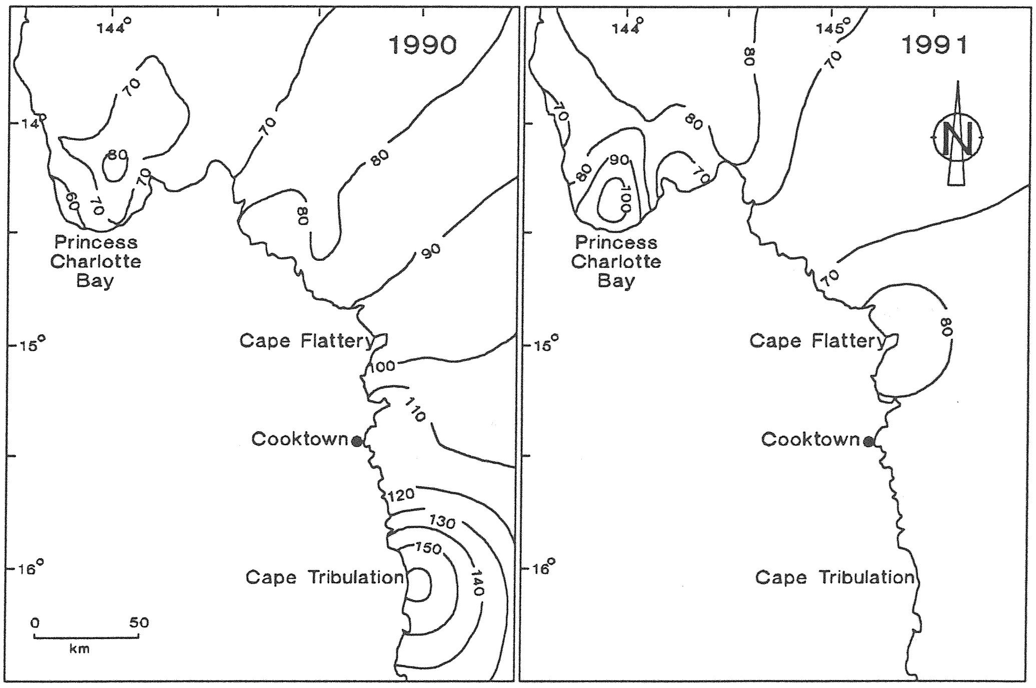

Figure 6.3 Contour plots of days at liberty.

6.4.4 Movement

Most prawns were recaptured within Princess Charlotte Bay in both years, but there was more movement out of Princess Charlotte Bay in 1990, when prawns were recaptured as far south as Cape Tribulation (Figure 6.4). Almost 4% of prawns were recaptured south of Cape Melville in 1990, with another 9% recaptured in Bathurst Bay, east of the release area (Figure 6.4). In 1991, only one prawn was recaptured in Bathurst Bay, and one prawn was recaptured south of Cape Melville (Figure 6.4). There was very little northerly movement in either year (Figure 6.4), even though the amount of effort north of Princess Charlotte Bay was similar to that to the south (Section 3.4.1). The permanent closure from the Marrett River to Cliff Isles (Figure 4.1) prohibited the recapture of any prawns that may have moved to the shallow waters at the bottom of Princess Charlotte Bay. Fine-scale logbook information is required for more detailed analysis of the movement patterns of tagged prawns in Princess Charlotte Bay.

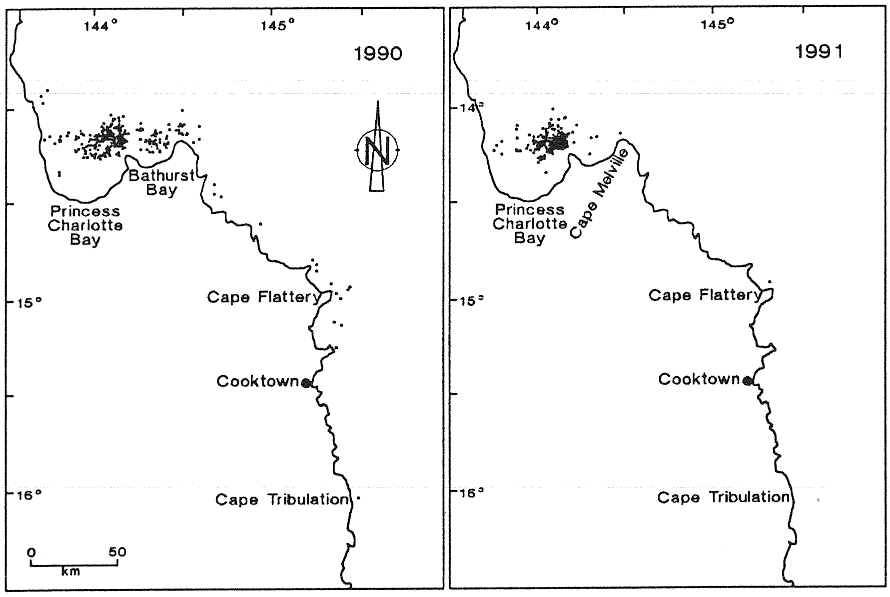

Figure 6.4 Tagged prawn recapture positions.

The accuracy of tagged prawn recapture positions is determined by the distance trawled by the vessel that recaptures the prawn. Trawlers in the Princess Charlotte Bay area generally cover distances of approximately 11 km per trawl shot, so recaptures made within 11 km of their release position can be considered to have made no net movement. In 1990, 45% of prawns moved less than 11 km, while 76% moved less than this distance the following year. The greatest distance moved was 246 km by a male released in January 1990. The average distance moved in 1990 was significantly greater than that moved in 1991 ($t = 20.1$, $p = 0$, $df = 1406$). There were significant differences in the distance moved between months of release in 1991 ($F = 26.11$, $p < 0.001$, $n = 843$), but not in 1990 ($F = 3.6$, $p = 0.054$, $n = 563$). Significantly greater distances were travelled by males than by females released in January 1991 ($t = 2.08$, $p < 0.05$, $df = 232$) and March 1991 ($t = 3.14$, $p < 0.01$, $df = 294$) (Table 6.2). Whilst all significant differences in distance moved occurred in 1991, only males released in January of that year moved an average of more than 11 km (Table 6.2).

Table 6.2 Average distance moved (km) by brown tiger prawns tagged in Princess Charlotte Bay in 1990 and 1991, and standard errors ().

	1990		1991	
Month	Male	Female	Male	Female
January	20.7 (3.1)	14.8 (1.4)	11.4 (1.5)	8.8 (0.7)
February	18.9 (2.1)	19.6 (2.5)	7.4 (0.5)	6.3 (0.4)
March	16.2 (2.1)	16.5 (2.5)	7.5 (0.9)	5.3 (0.4)
All months	18.7 (1.4)	17.4 (1.4)	8.6 (0.6)	6.6 (0.3)

Differences in distance moved between years may have been influenced by differences in fishing effort. In both years, most prawns were recaptured during the first few weeks of the fishing season, when effort was particularly high (Figure 6.5). Fishing effort and, as a result, return rates were, however, much higher at the beginning of the 1991 season than early in the 1990 season (Figure 6.5). After the first 2 weeks of the 1990 season, 49% of the total number of tagged prawns recaptured for the year still had the opportunity to move large distances, while only 14% were left after the same period in 1991 (Figure 6.5). Additionally, there was more effort in logbook grids F11 and G12, where most prawns that moved relatively long distances were recaptured, in 1990 than in 1991 (Section 3.4.1).

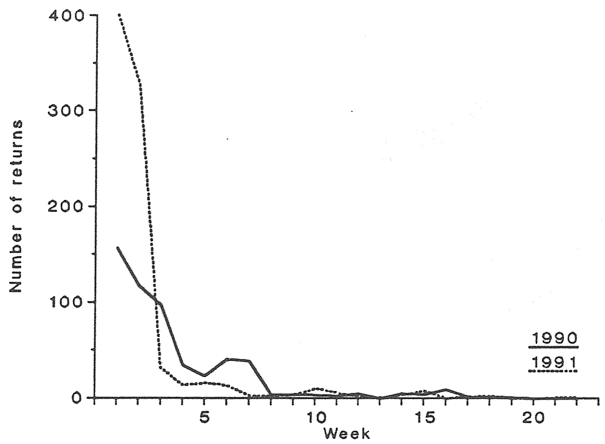

Figure 6.5a Weekly tagged prawn returns during the fishing season.

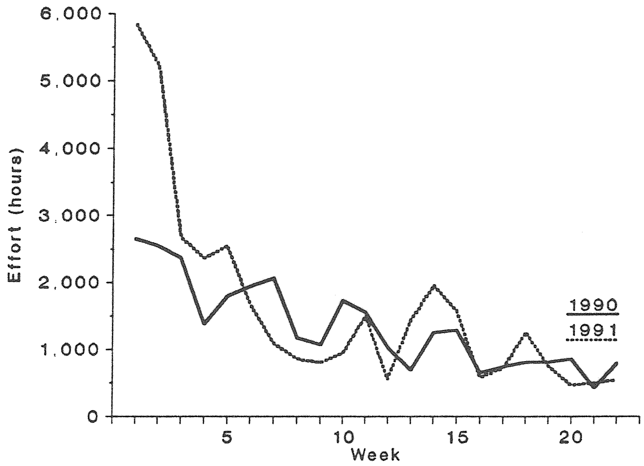

Figure 6.5b Weekly effort (hours).

6.4.5 Growth

Examination of the residual sums of squares from the growth model showed that there were significant differences between release months for males released in 1990 ($F = 8.44$, $p < 0.05$, $df = 4,280$) and 1991 ($F = 4.14$, $p < 0.05$, $df = 4,336$). Growth parameters and 95% joint confidence regions were, therefore, estimated separately for these groups. Females from each month were combined for estimation of growth parameters and joint 95% confidence regions in 1990 ($F = 1.35$, $p > 0.05$, $df = 4,196$) and 1991 ($F = 1.92$, $p > 0.05$, $df = 4,361$).

Estimated growth parameters (Table 6.3) were similar to those found for brown tiger prawns by Kirkwood and Somers (1984) in the Gulf of Carpentaria and Watson and Turnbull (submitted) in Torres Strait. There was no significant difference between years in the estimated growth parameters for females (Figure 6.6, Table 6.3). The growth parameters for males in both years were also similar, but varied with the month in which tagged prawns were released (Figure 6.6, Table 6.2). The growth coefficient (***K***) for males released in January and February 1990 was significantly lower than that of March 1990 (Figure 6.6), when a higher proportion of smaller (18 mm to 23 mm carapace length) males was released (Figure 6.2). The differences in ***K*** for males in 1990 were most likely due to differences in the size of animals tagged, as size range has a critical effect on estimated growth parameters (Dall *et al.* 1990).

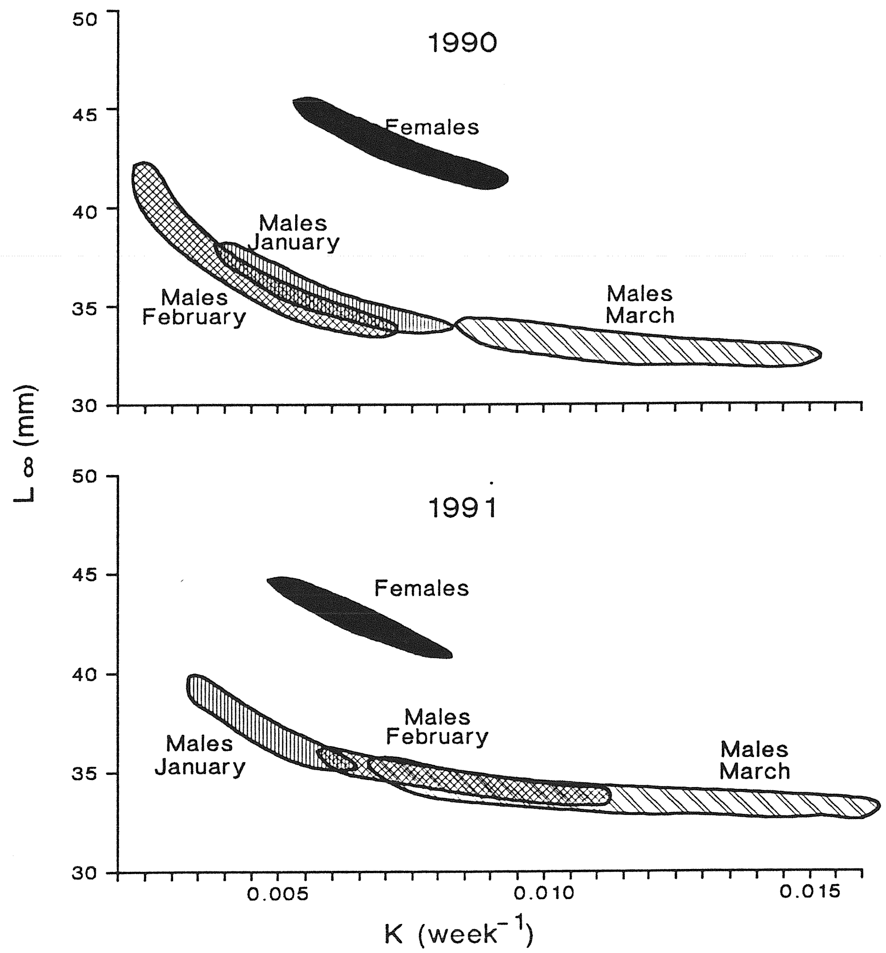

Figure 6.6 95% joint confidence regions for growth parameters.

Table 6.3 Growth parameters and standard errors () for brown tiger prawns tagged in Princess Charlotte Bay.

Sex	Month	K (week^{-1})	L_∞ (mm)
Female	January - March 1990	0.051 (0.005)	42.20 (0.89)
	January - March 1991	0.046 (0.004)	42.52 (0.84)
Male	January 1990	0.041 (0.007)	35.93 (0.93)
	February 1990	0.031 (0.008)	36.40 (1.76)
	March 1990	0.081 (0.011)	32.94 (0.47)
	January 1991	0.031 (0.005)	37.35 (1.29)
	February 1991	0.058 (0.008)	34.10 (0.66)
	March 1991	0.078 (0.015)	33.30 (0.66)

Differences in size at release do not account for all differences in growth parameters. Although there were size differences between females released in different months, growth parameters were the same (Section 6.4.1). Females may have more uniform growth rates than males over the size range tagged. In 1991, K was lowest for males released in January and highest for those released in March, which indicates that seasonal factors, along with size at release, may have affected growth. Dall *et al.* (1990) suggested that both seasonal factors and size range of prawns tagged can cause growth parameters to vary. The average size of males tagged in 1991 increased between January and March, but there was no significant difference in size at release between males tagged in January and February of that year (Section 6.4.1).

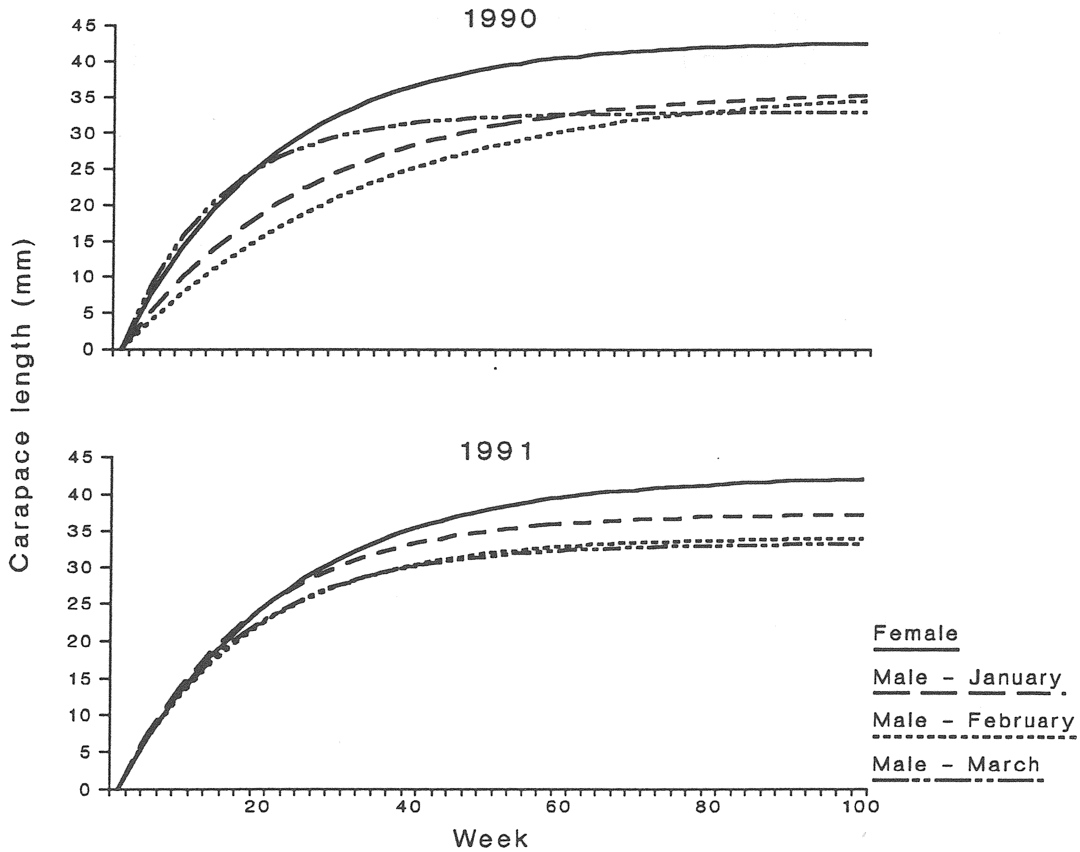

Figure 6.7 Growth curves for brown tiger prawns.

Females grew an average of 0.5 mm week^{-1}, while males grew only 0.3 mm week^{-1}, and estimates of L_∞ for females were larger than those for males in both years (Figure 6.6). Kirkwood and Somers (1984) and Watson and Turnbull (submitted) found a similar relationship for brown tiger prawns in the Gulf of Carpentaria and Torres Strait respectively. Sexual dimorphism in growth parameters is common in penaeid prawns (Dredge 1990). There was, however, no significant difference in K between sexes (Figure 6.6). Fitted von Bertalanffy growth curves (Figure 6.7) provide further comparisons between sexes and years. These curves were fitted with the assumption of zero length at hatching.

Our growth parameter estimates are most applicable to brown tiger prawns of the size-range tagged (Figure 6.2) and in the season of the study (summer/wet season). Season and size-range, along with location, reproductive status and, indeed, the methods of estimation and parameterization used can all influence estimated growth parameters (Dall *et al.* 1990).

6.4.6 Natural mortality

The overall instantaneous natural mortality rate was 0.088 (8.4%) week-1 in 1990, and 0.075 (7.2%) week-1 in 1991. This is within the range of 2% to 10% suggested by Dall *et al.* (1990) for adult penaeid prawns, and similar to the natural mortality rate of 0.072 week-1 for red spot king prawns estimated by Dredge (1990).

There was considerable variability in the rate of natural mortality between years and sexes. The rate for males was 0.065 week-1 in 1990 and 0.095 week-1 in 1991, while for females it was 0.121 week-1 in 1990 and 0.043 week-1 in 1991. As predation is probably the major cause of natural mortality in adult prawns (Dall *et al.* 1990), it is likely that fluctuations in predation on prawns contributed to the variation in natural mortality estimates between years.

We were unable to use data from prawns released in March in natural mortality calculations, as these animals had lower return rates than those released in February 1990, and January and February 1991 (Table 6.1). According to Hill and Wassenberg (1985), the catchability of brown tiger prawns is reduced for approximately 14 days after tagging due to a decrease in nocturnal emergence. In 1990, the period between the last release in March and the opening of the fishing season was 15 days. It is therefore probable that many prawns released in March 1991 were not available to the fishery at the beginning of the season, when effort was greatest (Figure 6.5). In 1991, we increased the period between the final March release and the opening of the fishing season to 24 days, but the return rate was even lower than for March of the previous year. March of both years was the time of peak recruitment for brown tiger prawns (Section 4), and it is possible that increased predation rates during peak recruitment caused higher mortalities than in the preceding months.

Our natural mortality estimates are actually estimates of natural mortality and emigration combined. A small number of brown tiger prawns were recaptured considerable distances from where they were released (Section 6.4.4), so emigration from the fishery can not be discounted. Unfortunately, emigration can not be measured because, by definition, the animals move to areas where they can not be recaptured.

7 MORPHOMETRICS

7.1 Abstract

Length-weight relationships, which were used in modelling procedures, were established for eight commercial prawn species. Commercial prawn species which appeared alike had similar length-weight relationships. Males of most species larger than 16 mm carapace length weighed more than females of the same carapace length. Length-weight relationships were used to convert carapace lengths to commercial grades.

7.2 Introduction

Morphometric relationships such as that between length and weight frequently appear in life history and population dynamics studies (Nielsen and Schoch 1980), and can be used in studies of stock differentiation (Winans 1984). Length-weight relationships have been documented, from information gathered in other waters, for the eight commercial prawn species that occur in Princess Charlotte Bay and near Cairns. Geographic location, however, may have an effect on the length-weight relationship of prawns (Dall *et al.* 1990). The length-weight relationships presented in this chapter serve as useful comparisons with those gathered in other locations.

Carapace length is a frequently-used linear measurement of prawn size, as the carapace is easily measured, and is less susceptible to damage and distortion than many other body parts. The prawn trawl industry, however, uses a series of commercial grades to delineate prawn size. These grades represent the number of similarly-sized prawns that make up one pound or one kilogram ("count per lb" or "count per kg"). Length-weight relationships can be used to convert carapace length to commercial grades.

Length-weight relationships, which were used in modelling procedures (Chapter 8), are described in this chapter.

7.3 Methods and materials

Samples were collected as outlined in Section 4. Carapace length (CL) and total wet weight measurements were log-transformed. Covariances were calculated using STATISTIX (Analytical Software), and a functional relationship was used to estimate the parameters a and b, and the 95% confidence limits of b. A functional relationship was used as there is a certain amount of error in both length and weight measurements. Parameters were back-transformed to fit the allometric equation:

$$Y = aX^b$$

where Y is wet weight (g) and X is carapace length (mm). Parameters were estimated separately for males and females. We used length-weight relationships to convert carapace length to commercial size-grades.

7.4 Results and discussion

Sample sizes for parameter estimates ranged from 2 302 individuals for male blue endeavour prawns, to 23 for female leader prawns (Table 7.1). Carapace lengths ranged between a low of 9 mm for male blue endeavour prawns, to 71 mm for the largest female leader prawns (Table 7.1).

Table 7.1 Length-weight relationship parameters.

Species	Sex	n	a x 10^{-4}	b	b 95% CI	Size range
Brown tiger	Male	1930	15.28	2.85	2.84 - 2.86	14 - 43
	Female	1928	17.22	2.80	2.79 - 2.82	12 - 52
Grooved tiger	Male	1117	12.07	2.91	2.90 - 2.92	13 - 39
	Female	1908	12.43	2.89	2.87 - 2.90	12 - 50
Blue endeavour	Male	2302	6.06	3.13	3.13 - 3.14	9 - 35
	Female	2291	9.95	2.95	2.93 - 2.96	10 - 42
Red endeavour	Male	314	11.38	2.86	2.83 - 2.88	13 - 32
	Female	321	15.87	2.74	2.72 - 2.76	11 - 46
Western king	Male	1372	4.83	3.07	3.06 - 3.09	16 - 39
	Female	1315	9.65	2.86	2.84 - 2.87	15 - 46
Red spot king	Male	679	5.91	3.02	3.01 - 3.04	17 - 38
	Female	873	8.83	2.88	2.87 - 2.89	15 - 47
White banana	Male	241	23.53	2.71	2.68 - 2.74	20 - 34
	Female	296	14.10	2.86	2.81 - 2.90	19 - 43
Leader	Male	25	79.55	2.33	2.21 - 2.45	24 - 49
	Female	23	45.10	2.49	2.43 - 2.54	29 - 71

The length-weight relationship for both male and female western king prawns was similar to those for red spot king prawns (Figure 7.1). Penn (1980) also found similar length-weight relationships for these species, and observed that their general appearance is alike. Brown and grooved tiger prawns also appear alike, and we found very similar length-weight relationships for these species (Figure 7.1). Although blue and red endeavour prawns appear alike, the length-weight relationships for these species were not as similar as between the king prawns, nor between the tiger prawns (Figure 7.1). At any given carapace length, blue endeavour prawns weighed more than red endeavour prawns (Figure 7.1). Sample sizes of red endeavour prawns, however, were much smaller than those of blue endeavour prawns (Table 7.1). There was relatively little variation in the length-weight relationship between sexes for both tiger prawn species, white banana prawns and leader prawns, compared to both endeavour prawn and king prawn species (Figure 7.1).

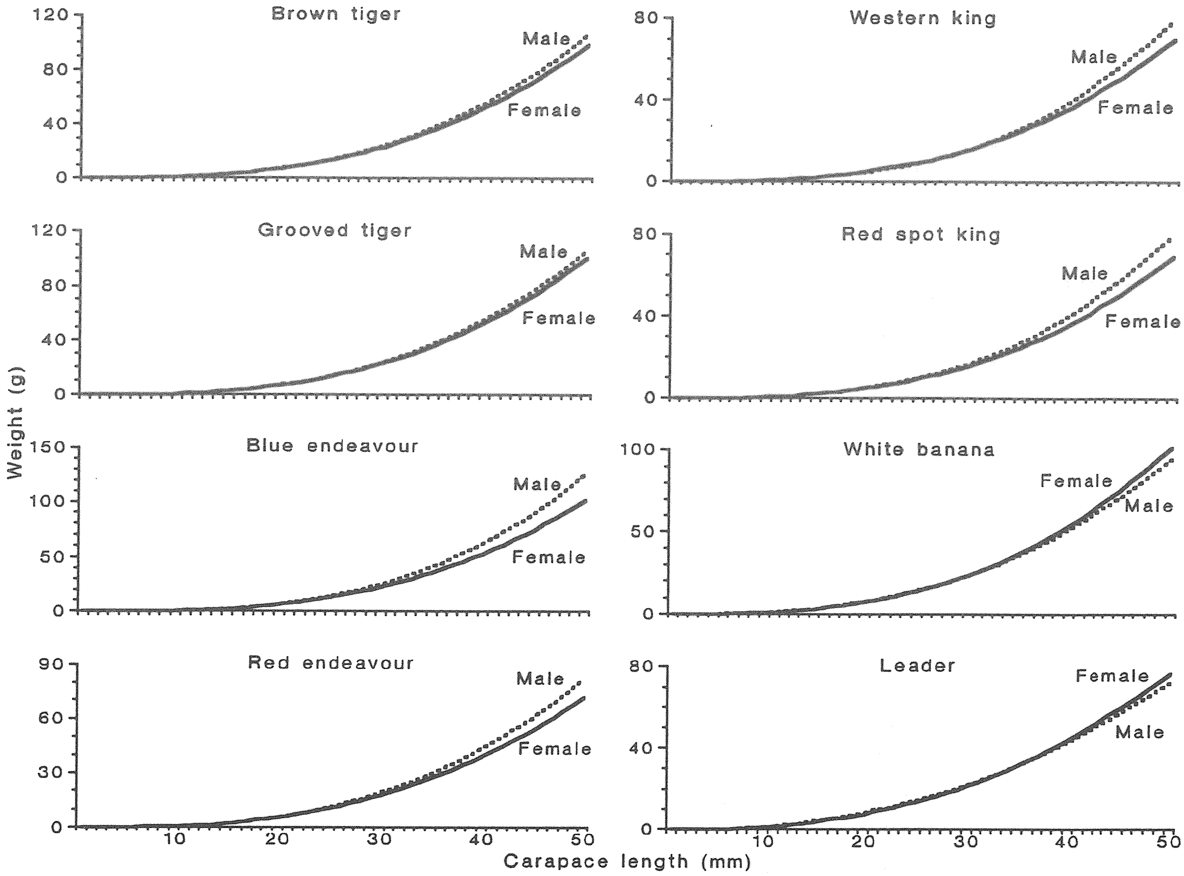

Figure 7.1 Length-weight relationships for each species in Princess Charlotte Bay.

For most species, there was little difference in the length-weight relationship between sexes for prawns smaller than approximately 16 mm carapace length (Figure 7.1). Above this size, males generally weighed more than females of the same carapace length (Figure 7.1). There have been similar findings in other localities. Male western king prawns (Penn and Hall 1974), brown tiger prawns (ibid.) and red spot king prawns (Penn 1980) in Western Australian waters, male white banana prawns in the Gulf of Carpentaria (Munro 1975), and male leader prawns in the Red Sea (Branford 1981), were all heavier than females of equivalent carapace length.

We also found, however, that only those male leader prawns smaller than 35 mm carapace length, and only those male banana prawns smaller than 30 mm carapace length, weighed more than females of equivalent carapace length (Figure 7.1). Above these sizes, females weighed more than males of the same carapace length (Figure 7.1). Sample sizes were, unfortunately, relatively small for these species (Table 7.1).

Carapace lengths derived from length-weight relationships that correspond to commercial grades are given in Table 7.2. These are useful for conversion of data/information between research and industry sources.

Table 7.2 Conversion table for carapace length (mm) to commercial grades (count lb^{-1}).

Species	Sex	Count lb^{-1}								
		5	10	15	20	25	30	35	40	45
Brown tiger	Male	47.3	37.1	32.2	29.1	26.9	25.2	23.9	22.8	21.9
	Female	48.5	37.9	32.8	29.6	27.3	25.6	24.2	23.1	22.2
Grooved tiger	Male	47.4	37.2	32.5	29.4	27.2	25.6	24.3	23.3	22.3
	Female	48.2	37.9	32.9	29.8	27.6	25.9	24.6	23.5	22.5
Blue endeavour	Male	45.0	36.1	31.7	28.9	26.9	25.4	24.2	23.2	22.3
	Female	48.0	37.9	33.1	30.0	27.8	26.1	24.8	23.7	22.8
Red endeavour	Male	51.7	40.6	35.2	31.9	29.5	27.6	26.2	25.0	24.0
	Female	54.5	42.3	36.5	32.9	30.3	28.3	26.8	25.5	24.4
Western king	Male	52.2	41.7	36.5	33.2	30.9	29.1	27.7	26.5	25.5
	Female	54.8	43.0	37.3	33.7	31.2	29.3	27.7	26.5	25.4
Red spot king	Male	52.1	41.4	36.2	32.9	30.6	28.8	27.4	26.2	25.2
	Female	55.0	43.2	37.5	34.0	31.4	29.5	28.0	26.7	25.6
White banana	Male	49.2	38.1	32.8	29.5	27.2	25.4	24.0	22.9	21.9
	Female	48.0	37.7	32.7	29.6	27.3	25.7	24.3	23.2	22.3
Leader	Male	55.1	40.9	34.4	30.4	27.6	25.5	23.9	22.6	21.5
	Female	53.5	40.5	34.4	30.6	28.0	26.0	24.5	23.2	22.1

8 CLOSURE MODELLING

8.1 Abstract

Seasonal closure options for Princess Charlotte Bay in 1990 and 1991, and Cairns in 1990, were evaluated by computer simulation. Appropriate model parameters were gathered from the fishery and the literature. Species which comprised 95% of the commercial catch in Princess Charlotte Bay, and which comprised more than 90% of the commercial catch near Cairns, were modelled. Simulations of closures in Princess Charlotte Bay predicted maximum gains in value ($) of between 5% and 9%. Simulations of the implemented closure regimes predicted similar gains (4% to 8%), which indicated that these regimes were appropriate for Princess Charlotte Bay. Near Cairns, where a seasonal closure was not implemented, simulations predicted maximum gains of less than 1%. More information about the response of fishers to management measures would increase our ability to predict the outcomes of closures.

8.2 Introduction

Seasonal closures are used in prawn fisheries in many parts of the world for various management purposes, including effort limitation, protection of spawners, prevention of growth overfishing, and maximisation of yield and/or value (Watson *et al.* in press(b)).

It is important to evaluate the effectiveness of such management measures. Yield per recruit (Beverton and Holt 1957) can be used as an analytical method of evaluation if closures function as minimum size regulators (Watson *et al.* in press(b)). Such evaluations are, however, inappropriate for fisheries where recruitment is extended and the closure can not be equated to a minimum size regulation. For other fisheries (e.g. the north-east Australian prawn fishery), a more complex dynamic model which can assimilate the relationships between closure length, closure timing, stock dynamics and fleet dynamics, is needed. Such relationships are so complex that an analytical solution is not possible, and a computer simulation approach is required (Watson and Restrepo in press).

In this section, we evaluate the existing closure regime in Princess Charlotte Bay and compare these results with an evaluation of closure options near Cairns.

8.3 Methods and materials

8.3.1 The model

The deterministic computer simulation model described by Watson *et al.* (in press(b)) was used for all closure evaluations. The model, originally developed for simulation of the Torres Strait prawn fishery, produces estimates of the percentage change in several criteria induced by a range of closure regimes compared to a no-closure scenario. Parameter uncertainty is also incorporated, as the model can perform simulations with a range of values assigned to given parameters. All percentage changes quoted in this section refer to changes in the total value ($) of the catch.

8.3.2 Parameters

Several parameters in the Torres Strait-based model (Watson *et al.* in press(b)) needed to be "fine-tuned" (re-parameterised) to make it more applicable to the fishery in Princess Charlotte Bay and near Cairns:

FBase (the no-closure effort pattern).

(i) Princess Charlotte Bay. No logbook data from Princess Charlotte Bay was available for pre-closure (i.e. before 1985) years. We used two sources to determine the effort pattern in Princess Charlotte Bay prior to 1985, which we equated to the likely effort pattern in years with no seasonal closure:

a) Beurteaux and Coles' (1988) analysis of aerial surveillance post-flight reports, and

b) anecdotal information from fishers.

The effort pattern chosen was constant throughout the year, except for December and January, where effort was reduced by 50% to accommodate a Christmas social/refit period.

(ii) Cairns. No closure was implemented near Cairns in 1990 or 1991. We used the average monthly effort pattern for these years (Section 3.4.1) as FBase for near Cairns.

Mortality. An instantaneous natural mortality rate (***M***) of 0.088 week^{-1} in 1990 and 0.075 week^{-1} in 1991 was calculated for commercial-sized brown tiger prawns from tagging experiments (Section 6.4.6). This rate is higher than that suggested by Garcia (1985), (which Watson *et al.* (in press(b)) used), and was applied to all species for modelling purposes. Like Watson *et al.* (in press(b)), we used a size-specific ***M***, which was greater for smaller animals, and less for larger animals. Fishing mortality (***F***) was set equal to natural mortality (Watson *et al.* in press(b), Haynes and Pascoe 1987). The effective ***F*** incorporated a size-specific net selectivity relationship (Watson *et al.* in press(b)). To incorporate the uncertainty associated with estimates of ***M*** and ***F***, simulations were carried out with eleven evenly distributed values of each. These values ranged between 50% and 150% of the estimates of ***M*** and ***F***.

Growth parameters. Length-weight relationships were calculated from data collected in Princess Charlotte Bay (Section 7). The von Bertalanffy parameters K and L_∞ were calculated from Princess Charlotte Bay tag-recapture experiments for brown tiger prawns (Section 6.4.5), while the most appropriate estimates from the literature were used for the remaining species (Table 8.1). No estimates were available for the red endeavour prawn, so Buckworth's (1989) estimates for the closely-related blue endeavour prawn were used.

Saturation (the amount of effort in the first month of the fishing season) was set at three times the average FBase monthly effort. This was calculated from 1988-90 Princess Charlotte Bay logbook data.

Distribution (the proportion of fishing effort which historically occurs during closure months which is expended when the season opens) was set to 1. It is unclear whether seasonal closures reduce or increase annual fishing effort (Nichols 1982).

Table 8.1. Growth parameters used in modelling procedures.

Species	Sex	L_∞	K (month^{-1})	Source
Brown tiger 1990	Female	42.2	0.22	Princess Charlotte Bay
	Male	35.1	0.22	Princess Charlotte Bay
Brown tiger 1991	Female	42.5	0.20	Princess Charlotte Bay
	Male	34.9	0.24	Princess Charlotte Bay
Grooved tiger	Female	51.9	0.18	Gribble and Dredge (1992)
	Male	37.4	0.31	Gribble and Dredge (1992)
Blue endeavour	Female	43.5	0.13	Buckworth (1989)
	Male	31.6	0.25	Buckworth (1989)
Red endeavour	Female	43.5	0.13	Buckworth (1989)[1]
	Male	31.6	0.25	Buckworth (1989)[1]
White banana	Female	40.5	0.54	Gribble and Dredge (1992)[2]
	Male	33.6	0.64	Gribble and Dredge (1992)[2]

[1] Used estimate for blue endeavour prawn.

[2] Gribble and Dredge (1992) used Morgan's (1987) method of combining MPA and tag return data to estimate growth parameters for white banana prawns.

8.3.3 Data

Data from Princess Charlotte Bay and Cairns were modelled separately, as were data from different years in Princess Charlotte Bay. Brown tiger, grooved tiger, and blue endeavour prawns were modelled for Princess Charlotte Bay. Tiger and endeavour prawns make up approximately 95% of the commercial catch in Princess Charlotte Bay (Trainor *et al.* 1992). Grooved tiger, red endeavour, blue endeavour and white banana prawns were modelled for near Cairns. These species make up more than 90% of the catch near Cairns (Sections 3.4.2 and 4.4.1). Only data from grids 3, 4 and 5 in Princess Charlotte Bay (Figure 4.1) were used. Water depth in these grids is less than 10 m, and much of the area is encompassed by a permanent closure from the Marrett River to the Cliff Isles. We considered that this area, which was unaffected by fishing pressure, was a good indicator of year-round recruitment. A similarly good indication of recruitment was not provided by the most inshore grids near Cairns, which were not closed to fishing, so data from all grids near Cairns were used.

8.3.4 Multi-species output

The model predicted the percentage change in value for individual species for each closure scenario. The predicted percentage changes for each species can not simply be added, because the market value of each species is different. The predicted percentage change for one species may, therefore, have a greater effect on the value of the fishery than would the predicted percentage change for another species. We used a weighted average (using relative species value) to combine the predicted percentage change for each species:

Firstly, an initial relative value ***P*** was calculated for each species summed through size classes:

$$P_i = \Sigma w_i v_i$$

where i is the species
w is the total weight in each size class and
v is the dollar value of each size class.

Then the combined (all species) predicted percentage change ***A*** was calculated as a value-weighted average to produce a multi-species output for each closure scenario:

$$A = \frac{\Sigma P_i C_i}{\Sigma P_i}$$

where ***C*** is the percentage change in value for each species predicted by the model.

The combined predicted percentage changes were converted to contour plots to illustrate each closure scenario.

8.4 Results and discussion

8.4.1 Princess Charlotte Bay

Most closure options resulted in losses to the fishery (Figures 8.1 and 8.2). Simulations of extremely long closures predicted losses of more than 40% (Figure 8.2). In both years, however, simulations of the implemented closures predicted gains for the fishery (Figures 8.1 and 8.2). Simulations of the 1990 closure regime (fishery closed from January 1 to April 14) predicted a gain of 4% to 5% (Figure 8.1), while in 1991 (fishery closed from January 1 to April 7) the gain was 7% to 8% (Figure 8.2). There was little difference between these results and simulations of the best closure options, which predicted gains of 5% in 1990 (Figure 8.1) and 9% in 1991 (Figure 8.2). The simulations indicate, therefore, that the current seasonal closure regime is an appropriate management option for Princess Charlotte Bay. The applicability of a closure regime, however, will vary with changes in critical parameters (some of which we are uncertain about), and with annual variation in recruitment. It is also important to note that because some closure scenarios involve more operators than others, any gain in value will benefit the fishery as a whole and individual fishers may not necessarily benefit equally .

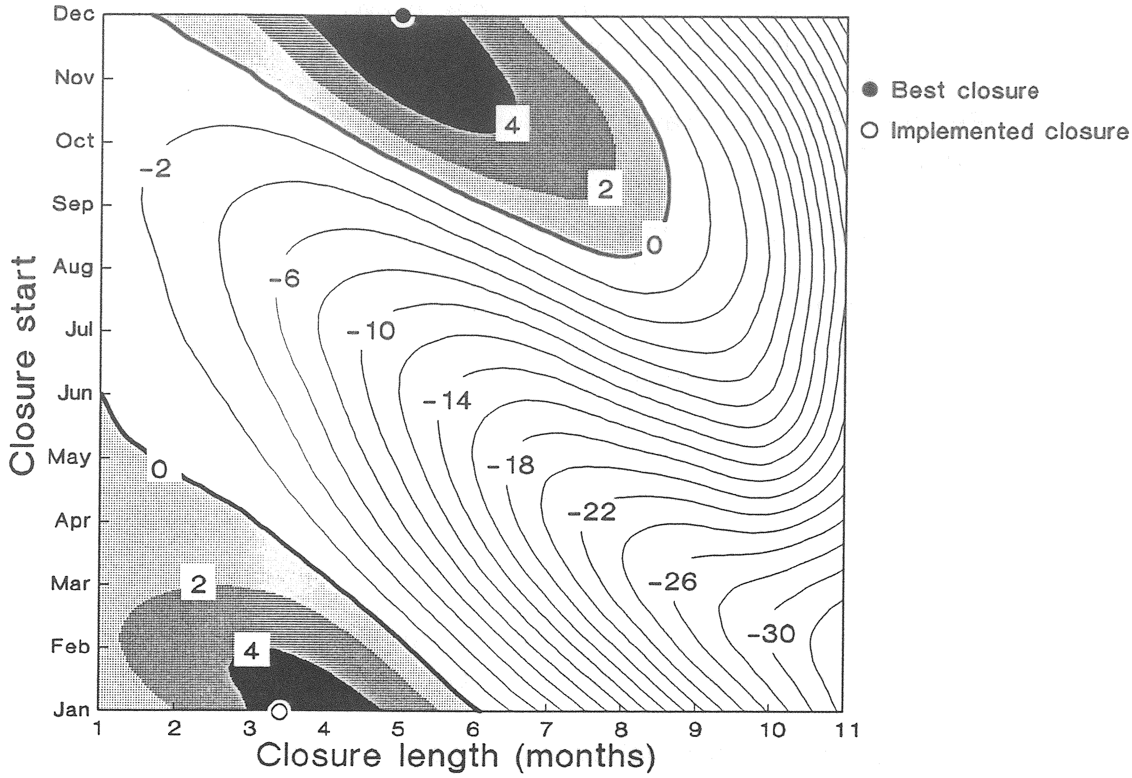

Figure 8.1 Predicted percentage change from simulations of Princess Charlotte Bay closures,1990.

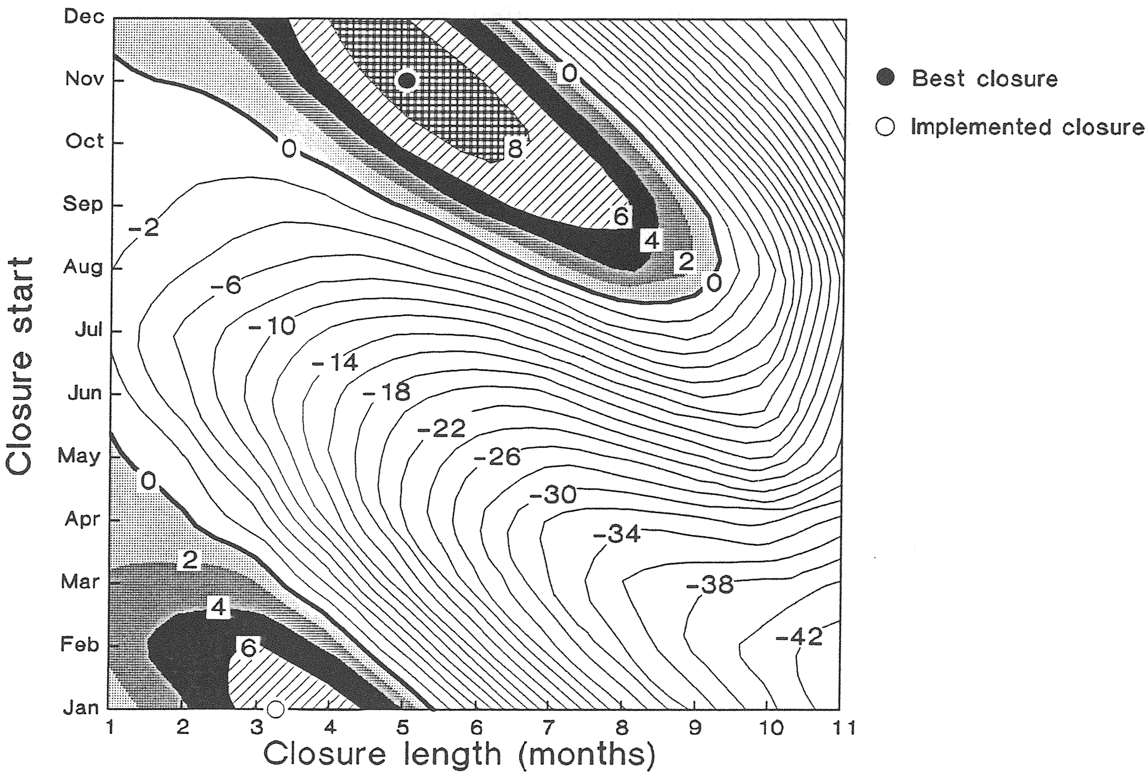

Figure 8.2 Predicted percentage change from simulations of Princess Charlotte Bay closures, 1991.

The range of positive closure options was similar for both years in Princess Charlotte Bay, although the gains predicted for 1991 (Figure 8.2) were greater than those predicted for 1990 (Figure 8.1). Differences were expected, as there were marked changes in the proportion of each species between years (Section 4). The proportion of brown tiger prawns in the fishery increased between years, while the proportion of both grooved tiger and blue endeavour prawns decreased. The domination of brown tiger prawns in 1991 meant that, in effect, Princess Charlotte Bay more closely resembled a single-species fishery than it did in 1990.

The increases in value documented here are relatively small, largely because of the multi-species nature of the fishery. There were differences in the advent and duration of recruitment for different species (Section 4), and optimal closure timing for each species rarely coincided. Value increases for multi-cohort fisheries tend to be much smaller than for single-cohort fisheries (Watson and Restrepo in press). Dredge and Gribble (1991) found that seasonal closures were of little benefit to industry in a multi-species fishery in central Queensland coastal waters. Seasonal closures, however, not only potentially provide more valuable catches, but allow fishers to undertake repairs and refits, and to take holidays (fortuitously during or close to the Christmas period in the best closures modelled here). Additionally, fishing costs, which have been estimated as approximately one half of total costs (Sean Pascoe, Australian Bureau of Agricultural and Resource Economics, pers. com.), are reduced during closures.

It is difficult to anticipate the behaviour of fishers in response to given closure scenarios. We equated estimates of pre-closure (1983) effort to that in the event of no closure, and allowed no increase in annual effort during a closure year compared to a non-closure year. These are important assumptions, because "perceptions about the disposition of fishing effort that would be expended without a closure can produce greatly different results" (Watson and Restrepo in press). If simulations were run with significantly different patterns of fishing effort to those used in this study, the outcomes would be significantly different. A study of the responses of fishers to management measures is clearly needed, as this would enable more informed predictions about effort, and hence closures, to be made.

8.4.2 Cairns

Near Cairns, where no seasonal closure was implemented, the range of positive closure options was far more limited, and predicted gains (and losses) were much less, than for Princess Charlotte Bay. The best simulation for near Cairns was a four-month closure beginning in October, for which a gain of less than 1% was predicted (Figure 8.3). Simulations of the same scenario as the closures implemented in Princess Charlotte Bay (Figures 8.1 and 8.2) predicted a loss of about 1% near Cairns (Figure 8.3).

Differences between Cairns and Princess Charlotte Bay were expected, as the major commercial species (Section 4.4.1) and the no-closure effort pattern (Fbase) differed between the two areas. The small predicted losses in value for the fishery near Cairns affirm that the current management strategy (i.e. not to apply the Princess Charlotte Bay closure regime to the fishery near Cairns) is appropriate.

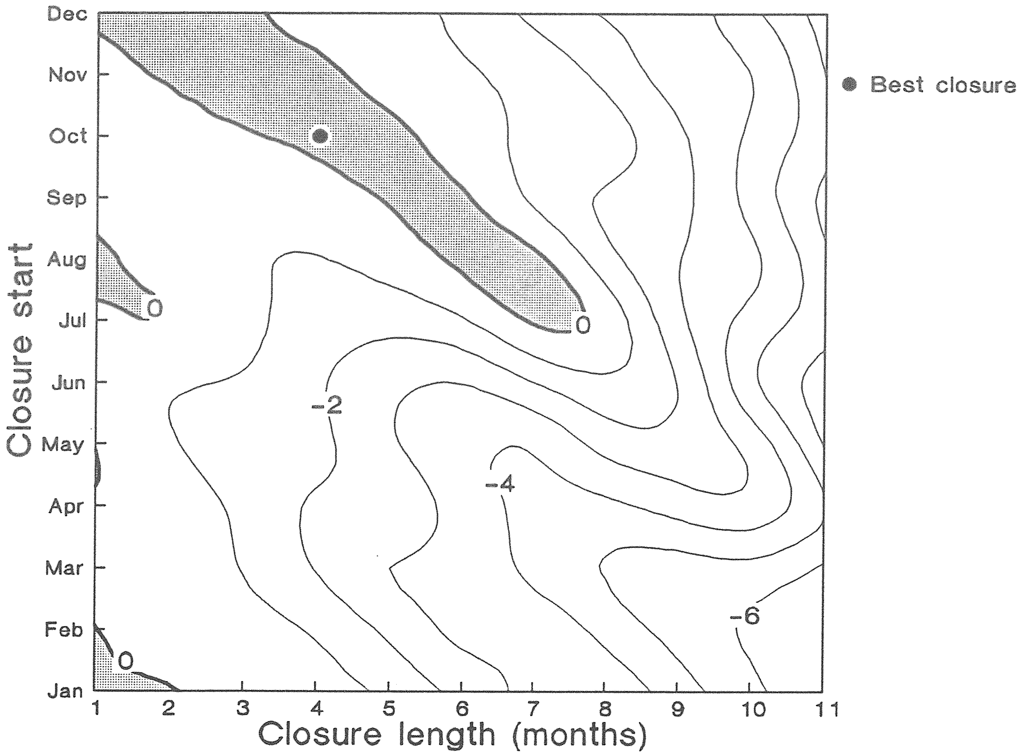

Figure 8.3 Predicted percentage change from simulations of Cairns closures, 1990.

9 CONCLUSIONS

We believe that seasonal closures are a useful management tool for prawn trawl fisheries, and more specifically, that the current seasonal closure regime is a suitable management measure for the north-east Australian prawn trawl fishery. The seasonal closures implemented in Princess Charlotte Bay in 1990 and 1991 were appropriate, and it was also appropriate that no seasonal closure was implemented near Cairns.

Seasonal closures are most effective in less complex fisheries (i.e. fisheries with few commercial species which have similar recruitment patterns). Thus seasonal closures would be particularly effective in prawn trawl fisheries which target few species, such as those in South Australia, New South Wales and Western Australia. We would welcome the opportunity to discuss our application of simulation modelling with colleagues working on penaeid prawn fisheries. It may be that our techniques can be applied in those fisheries.

Our ability to evaluate management measures would improve with a better appreciation of several factors. The success of management measures may be greatly influenced by the behaviour of fishers. Information on the response of fishers to management measures, along with relevant biological data, is needed for future evaluations of closure options. Knowledge of long-term inter-annual variation in recruitment patterns would increase the certainty of our evaluations, while more information on the relative importance of different nursery areas (e.g. deep-water versus reef-top seagrass) would enable more informed decisions about which areas are most important to protect to ensure the survival of the fishery.

10 TRANSFER OF RESULTS TO INDUSTRY

Fishers were initially advised of the project via "Queensland Fishermen" articles (Appendix E). The tagging program was publicised in local media (press and radio), and fishers were sent letters which contained information about the growth and movement of any tagged prawns which they returned (Appendix E). Progress reports were presented at Queensland Fish Management Authority (QFMA) meetings and at Queensland Commercial Fishermen's Organisation (QCFO) branch meetings. Results were also presented at the 1991 and 1992 Pre-season Prawn Workshops in Cairns, and at the 1991 Australian Society for Fish Biology Conference in Hobart. Three "Princess Charlotte Bay Prawn Newsletters" (Appendix E) were distributed during the course of project, and we hope to produce a final newsletter soon. Copies of this report will be forwarded to the QFMA and the QCFO, and will be available on request from the Northern Fisheries Centre in Cairns. Preparation of several scientific articles has begun, and FRDC will be advised of these when publication is imminent.

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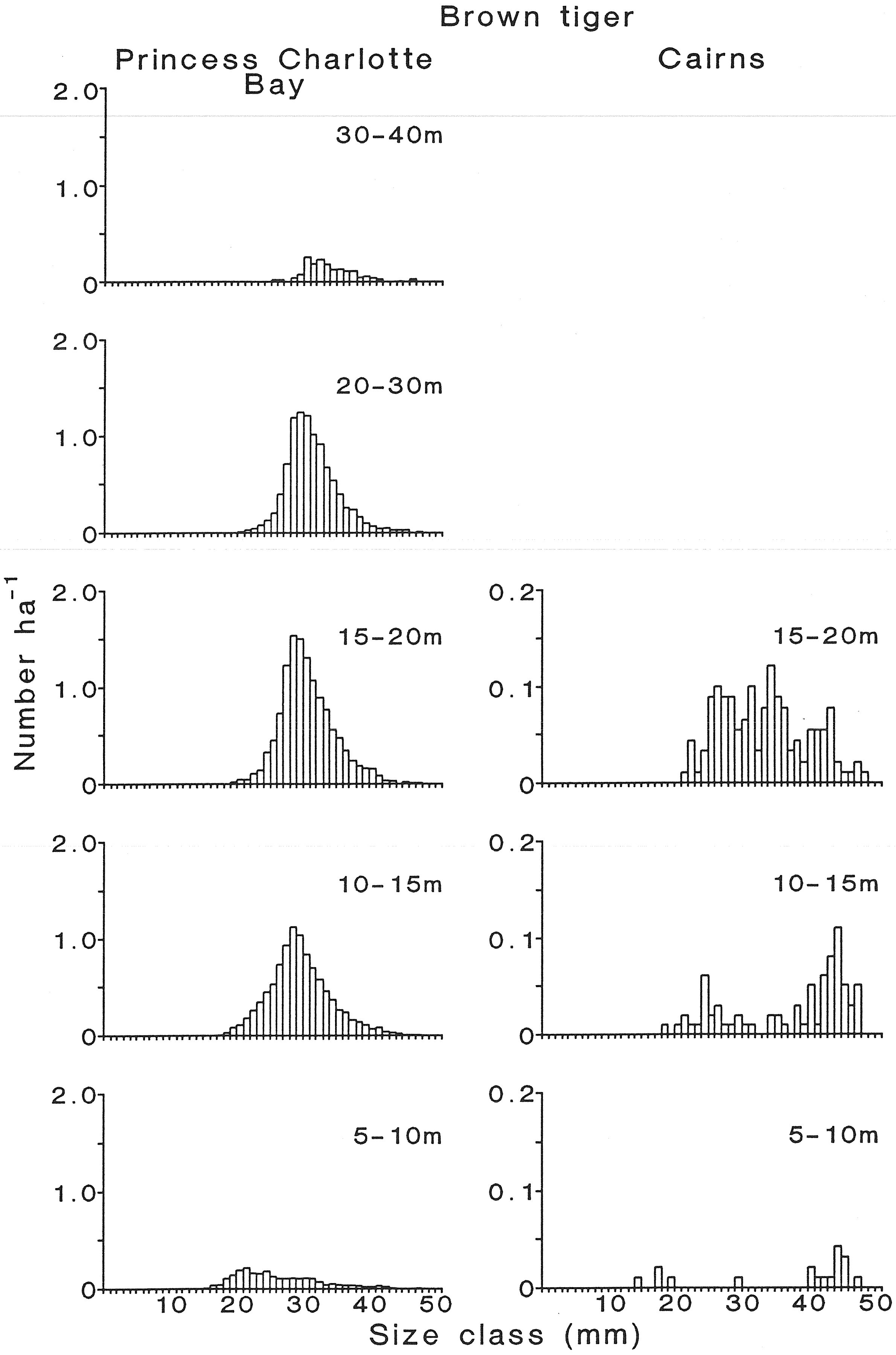
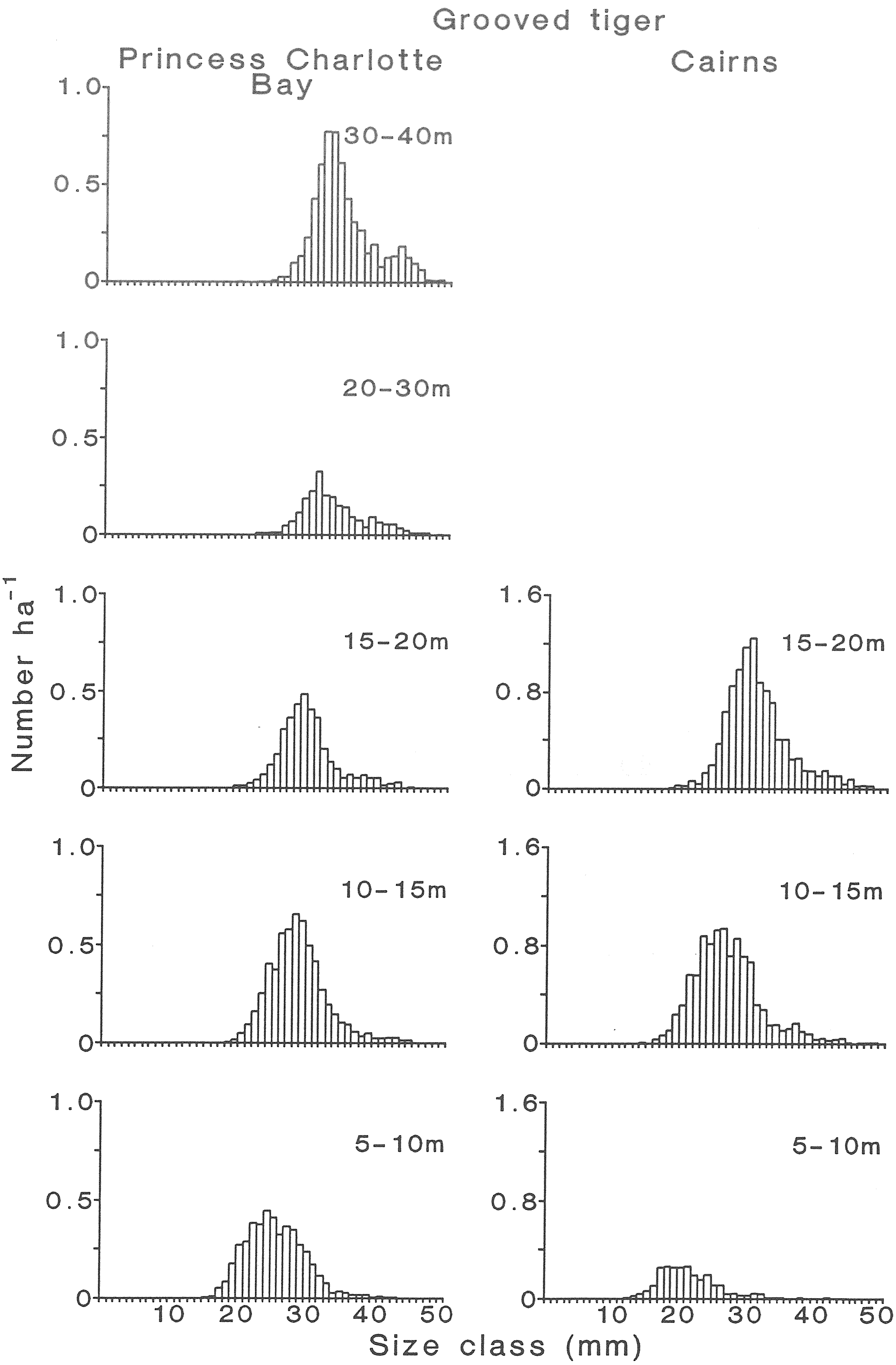
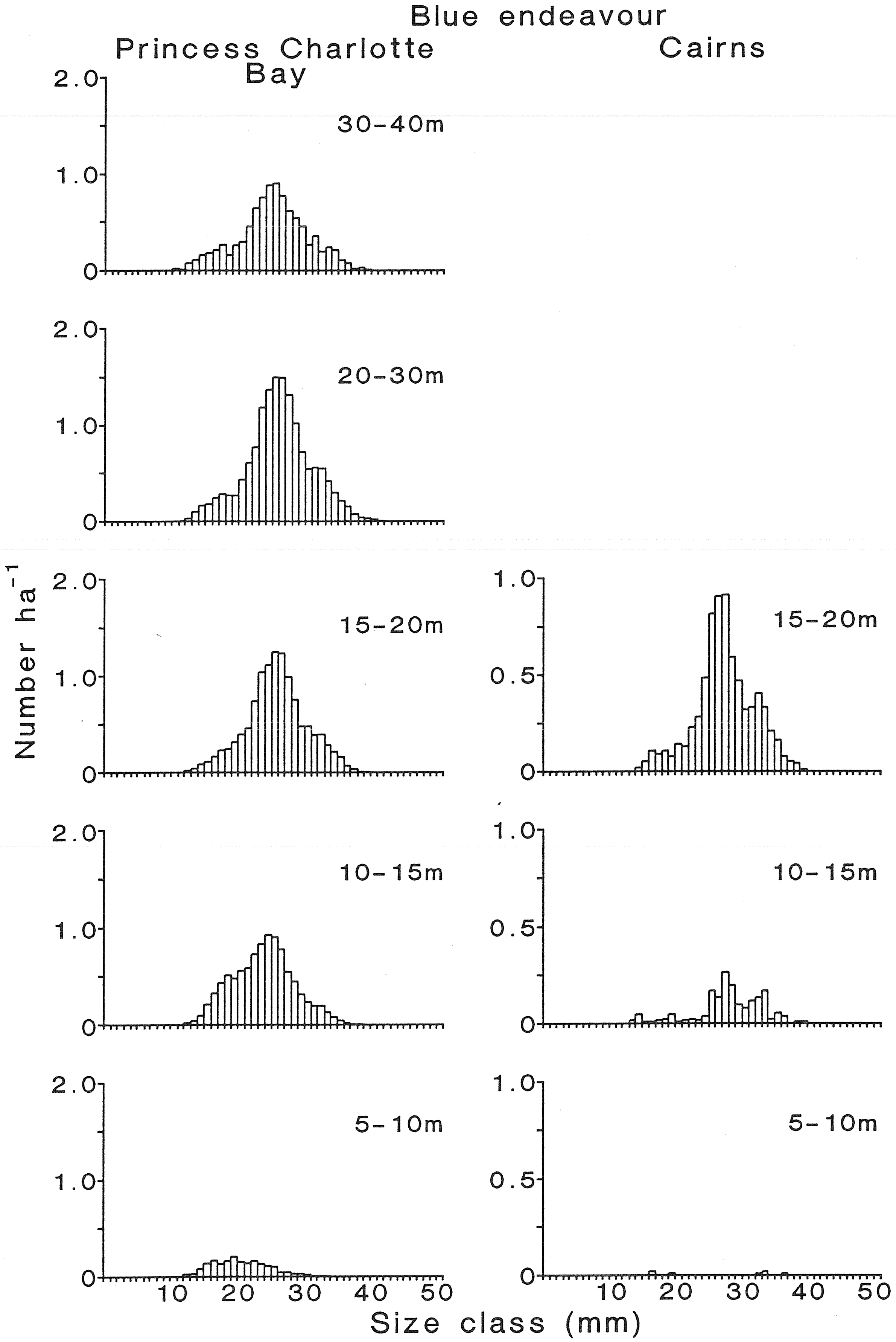
APPENDIX A Adult size frequencies for each species in each depth range in Princess Charlotte Bay and near Cairns.



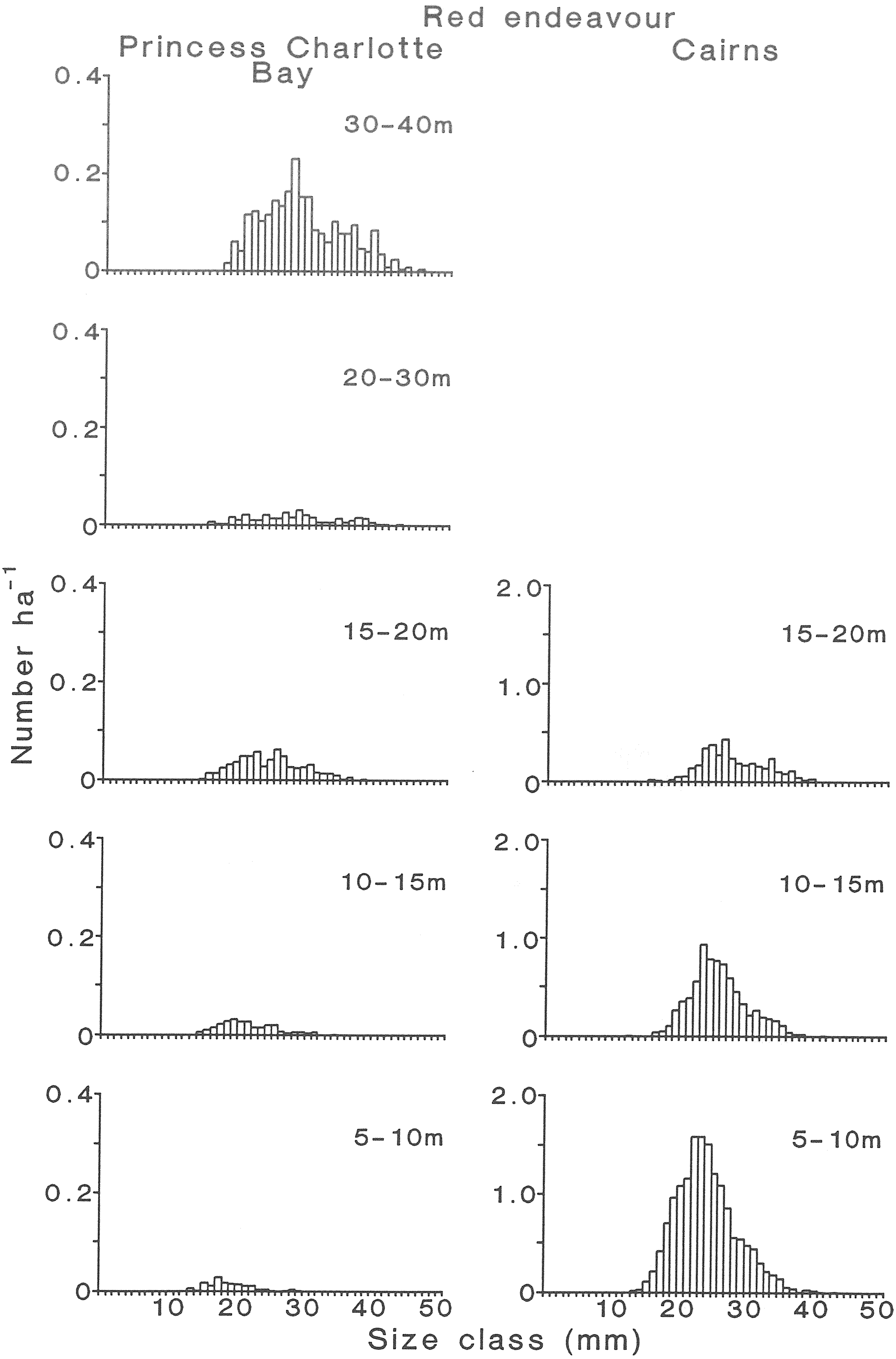
Brown tiger
Princess Charlotte Bay
Cairns
Number ha^{-1}
2.0
1.0
0
0.2
0.1
30-40m
20-30m
15-20m
10-15m
5-10m
10
20
30
40
50
Size class (mm)

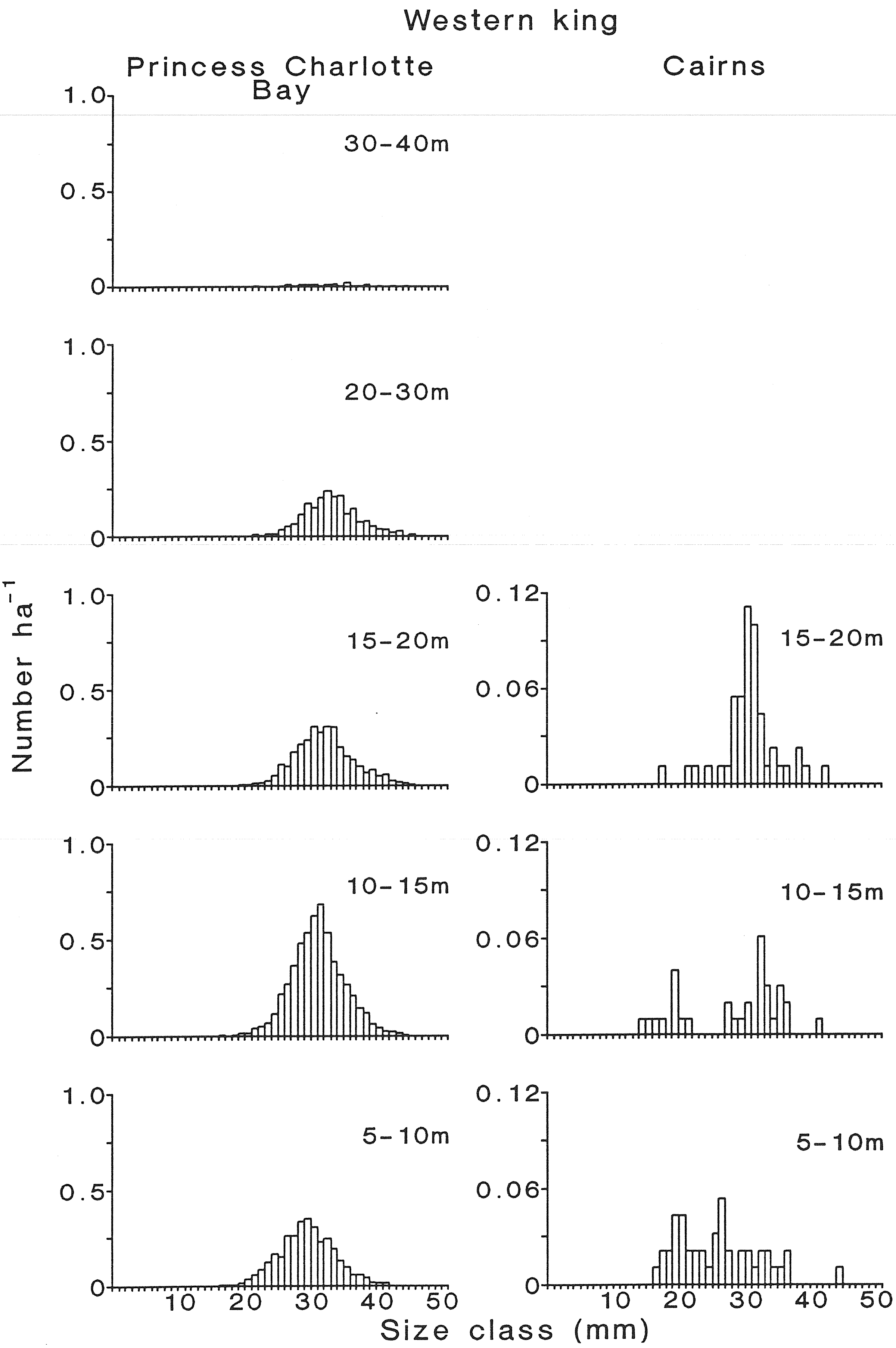


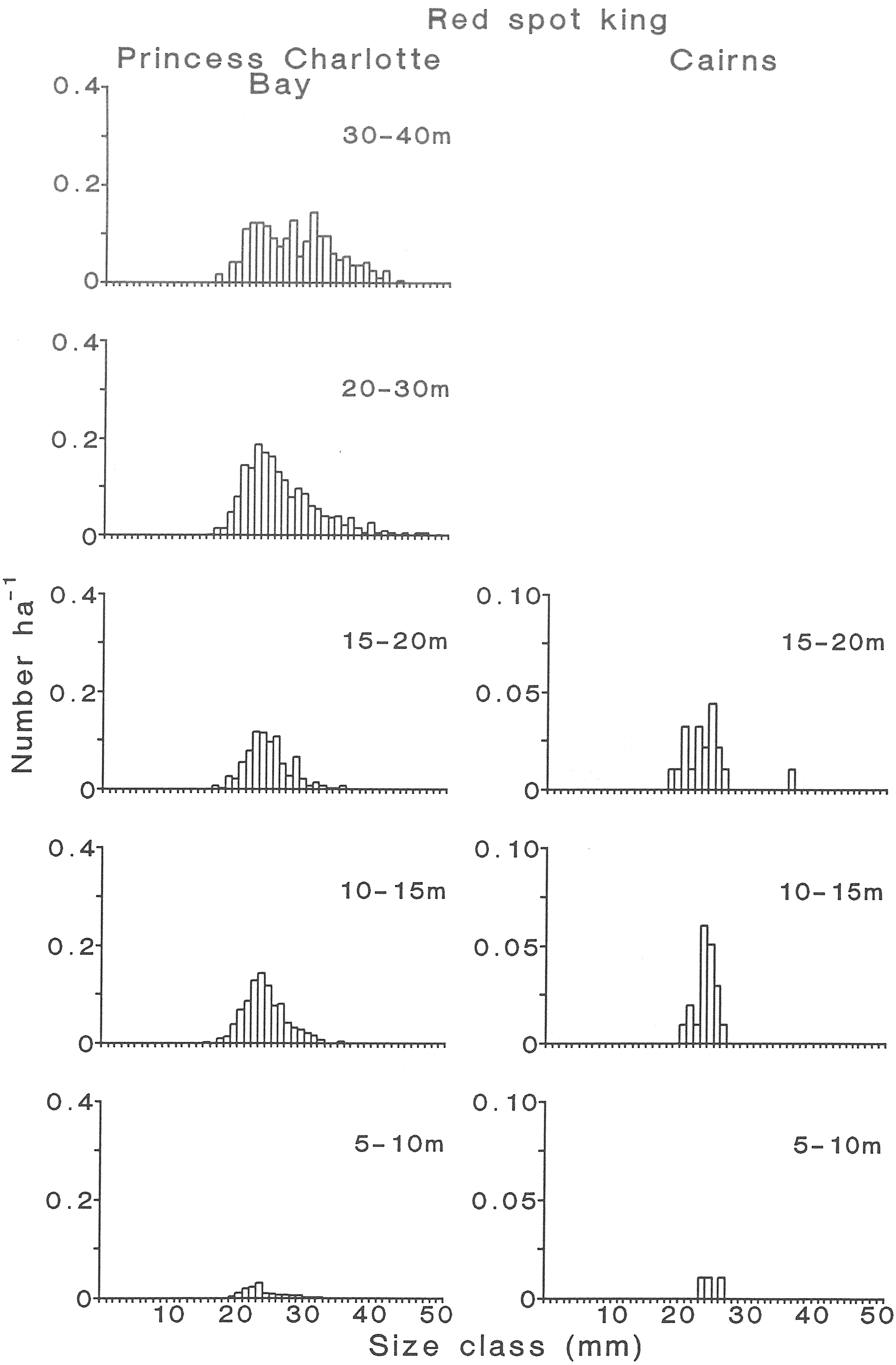
Grooved tiger
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
10-15m
5-10m
Number ha^{-1}
1.0
0.5
0
1.6
0.8
10
20
30
40
50
Size class (mm)

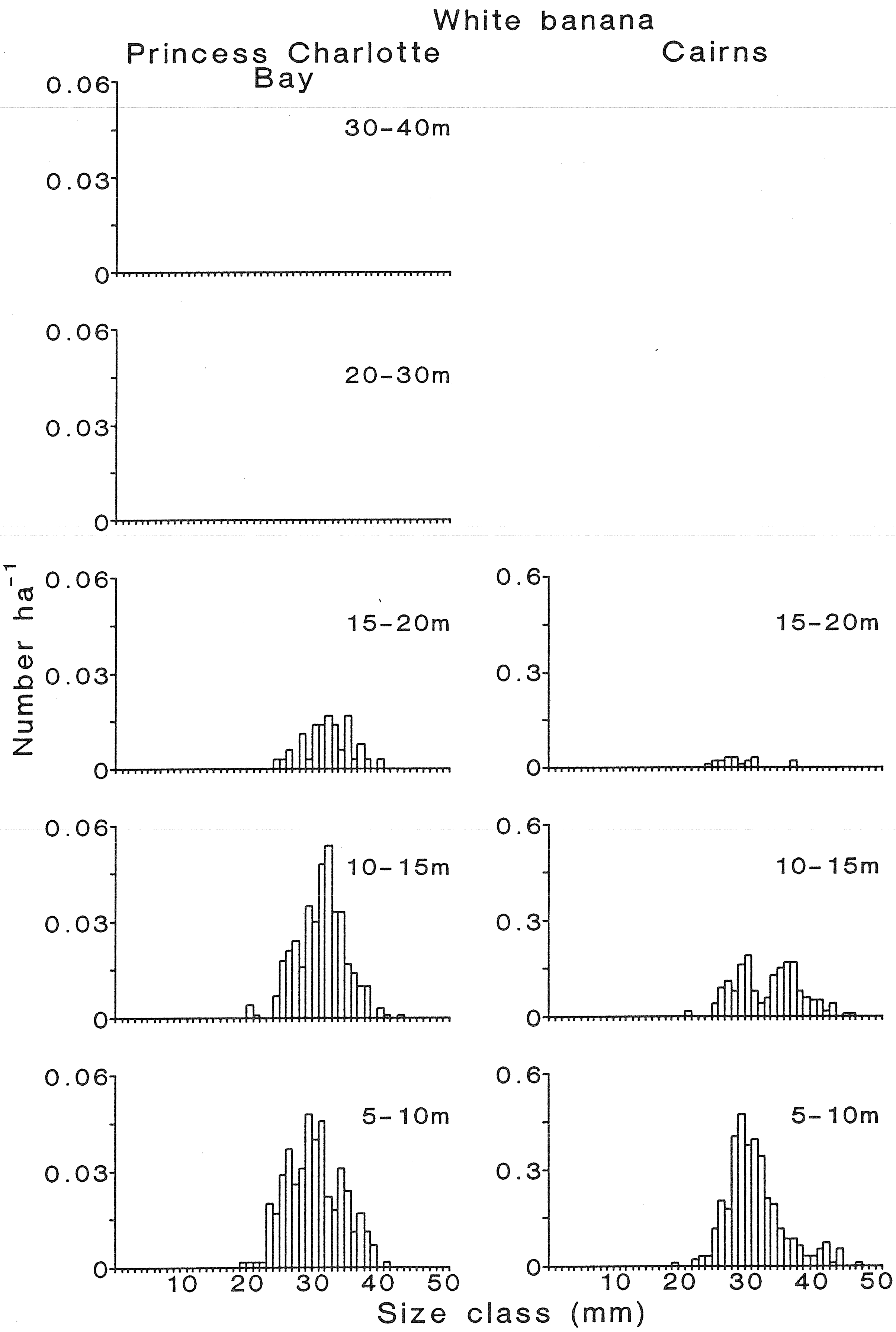


Blue endeavour
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
10-15m
5-10m
Number ha^{-1}
2.0
1.0
0
0.5
10
20
30
40
50
Size class (mm)

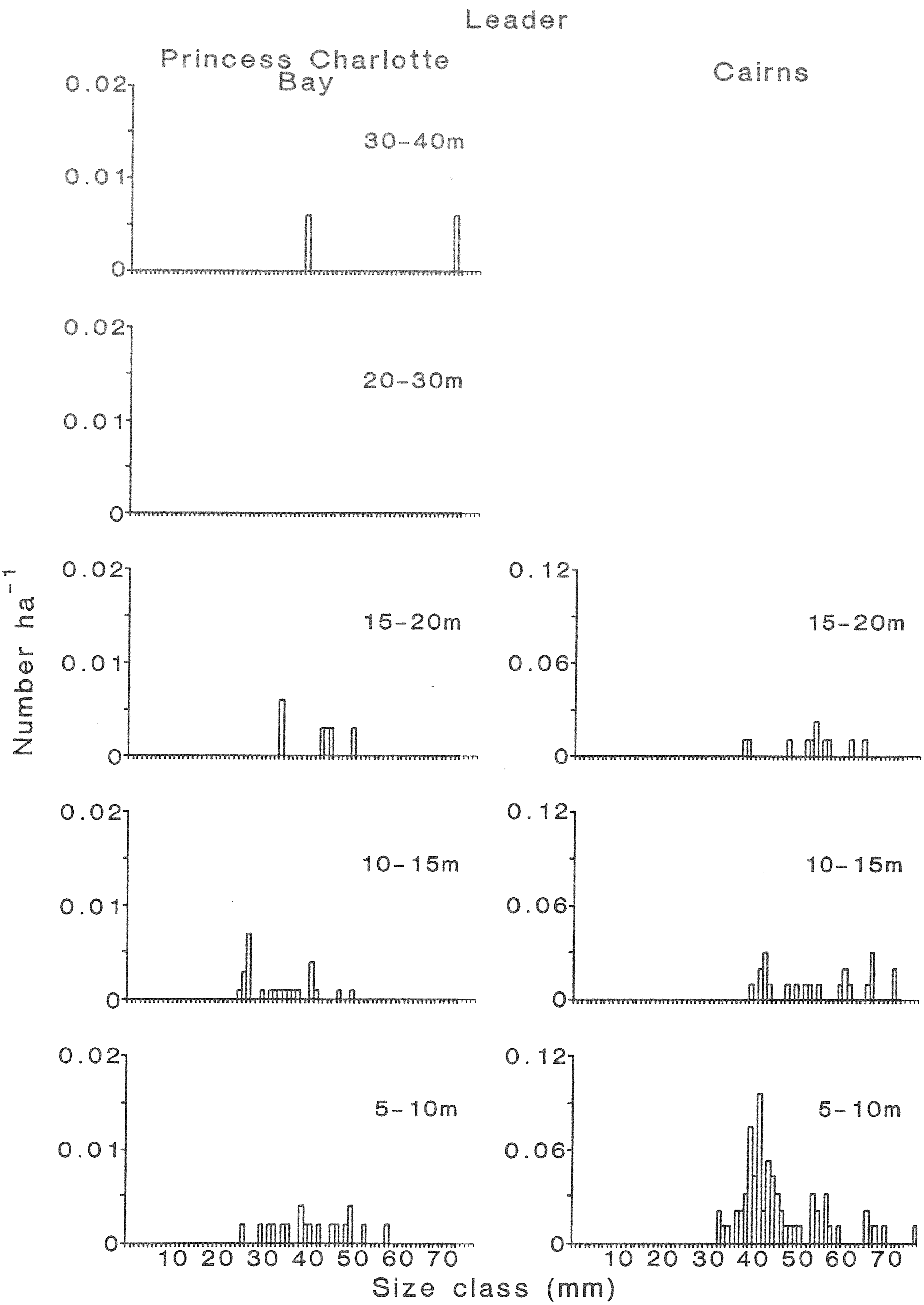

Red endeavour
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
15-20m
10-15m
10-15m
5-10m
5-10m
Number ha^{-1}
0.4
0.2
0
2.0
1.0
10
20
30
40
50
Size class (mm)


Western king
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
10-15m
5-10m
Number ha⁻¹
1.0
0.5
0
0.12
0.06
10 20 30 40 50
Size class (mm)

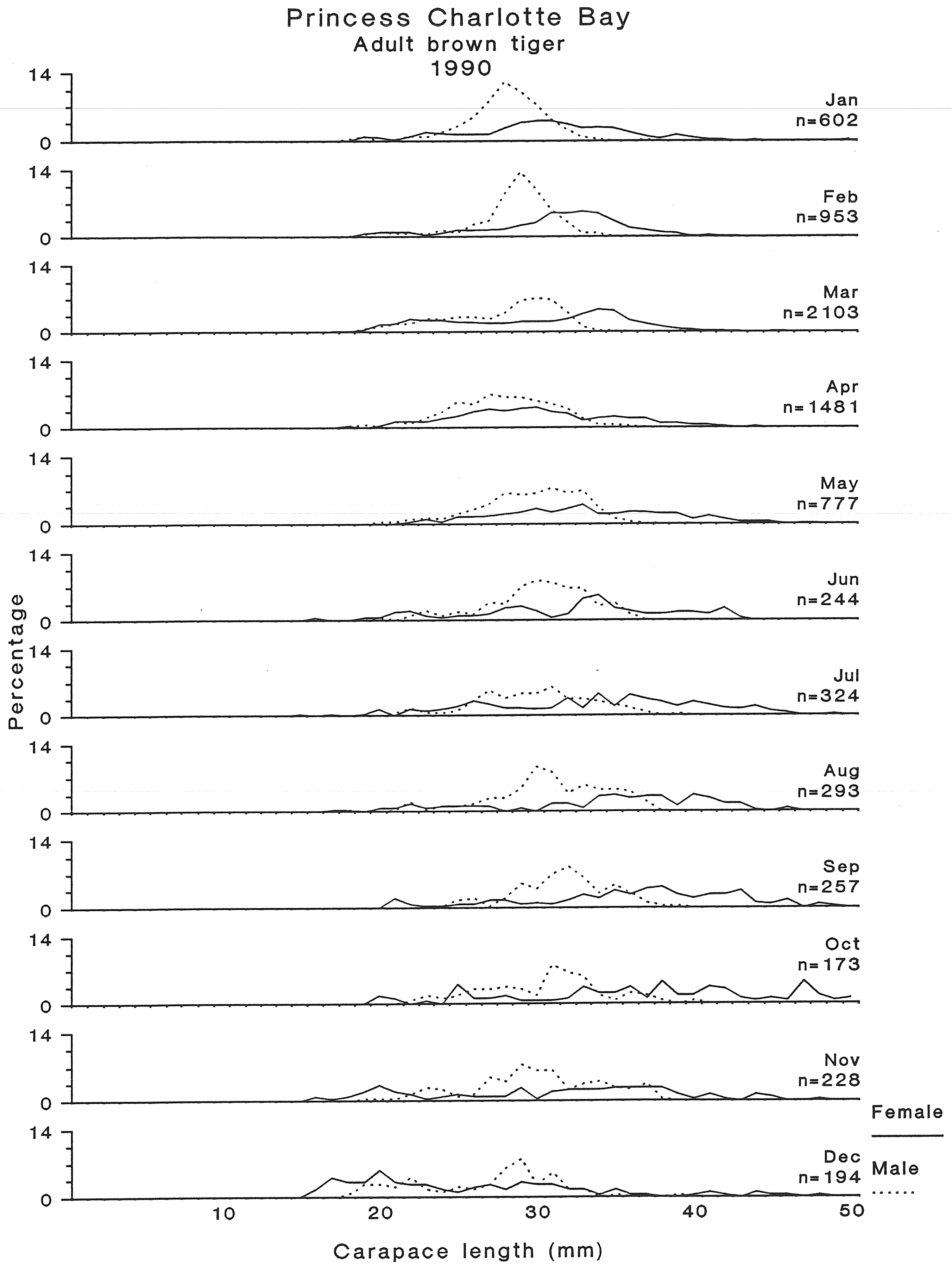

Red spot king
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
10-15m
5-10m
Number ha^{-1}
0.4
0.2
0
0.10
0.05
10 20 30 40 50
Size class (mm)



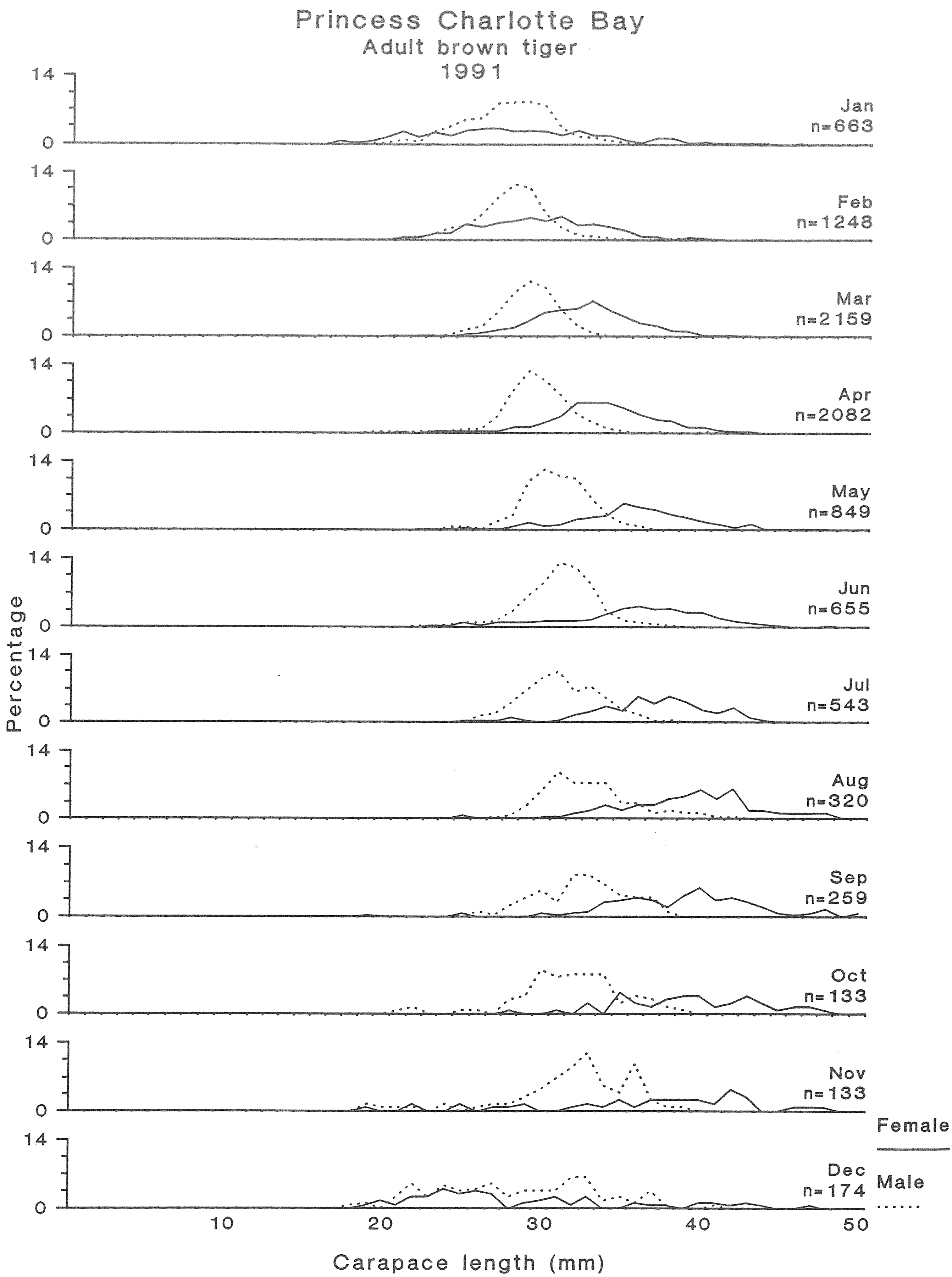
White banana
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
10-15m
5-10m
Number ha^{-1}
0.06
0.03
0
0.6
0.3
10
20
30
40
50
Size class (mm)

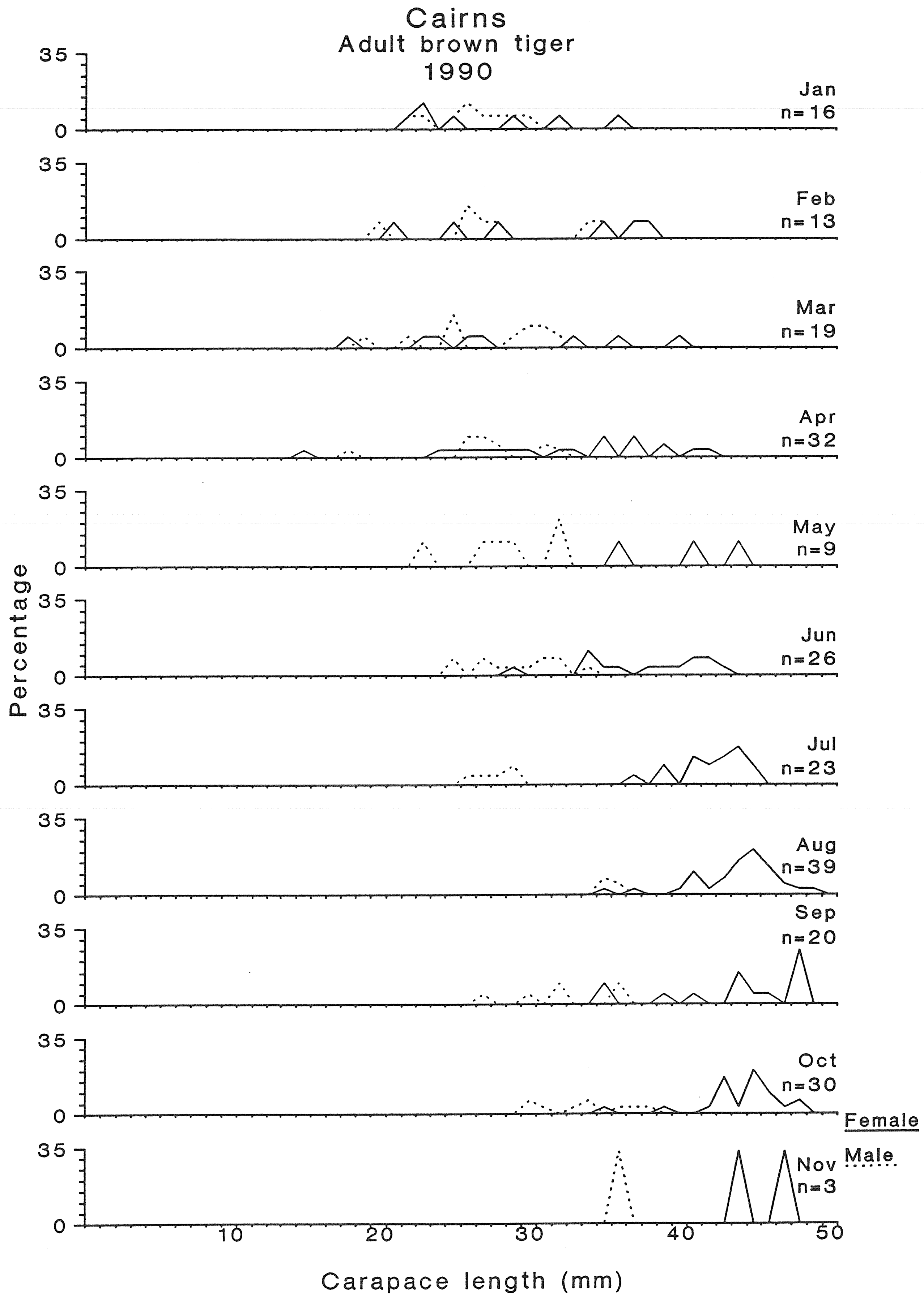

Leader
Princess Charlotte Bay
Cairns
30-40m
20-30m
15-20m
10-15m
5-10m
Number ha^{-1}
0.02
0.01
0
0.12
0.06
10 20 30 40 50 60 70
Size class (mm)

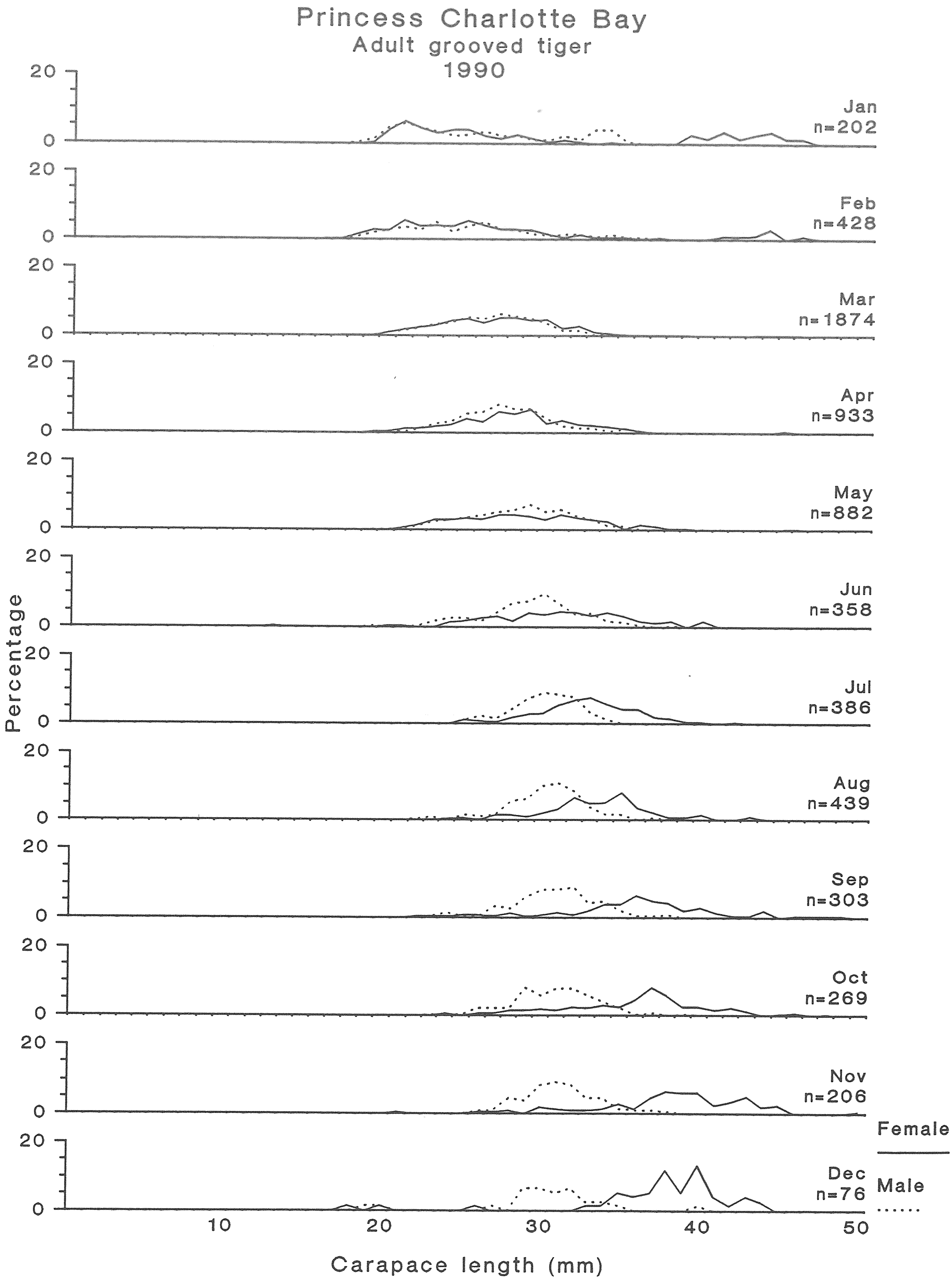
APPENDIX B Monthly adult size frequencies for each species in Princess Charlotte Bay and near Cairns.

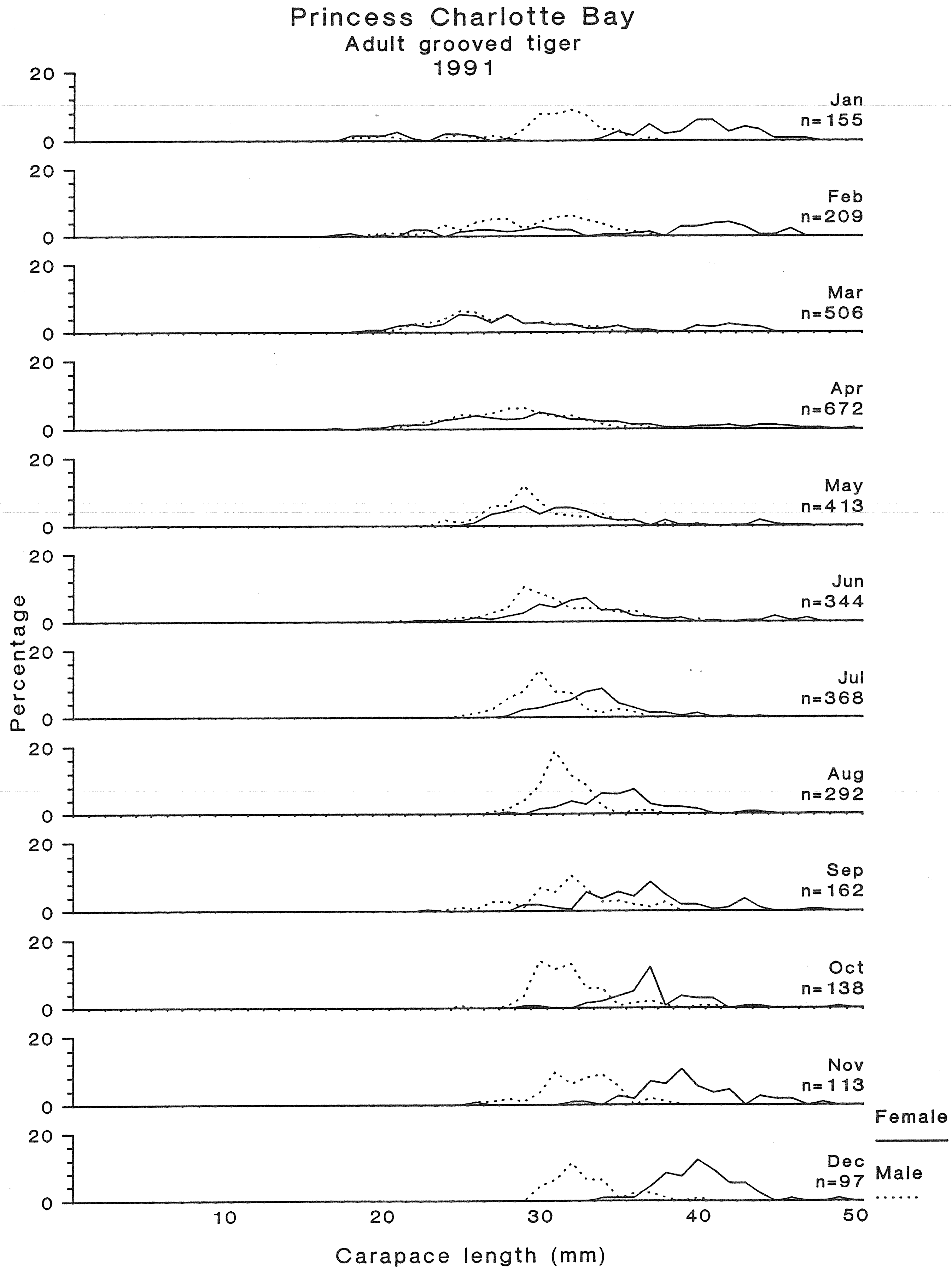


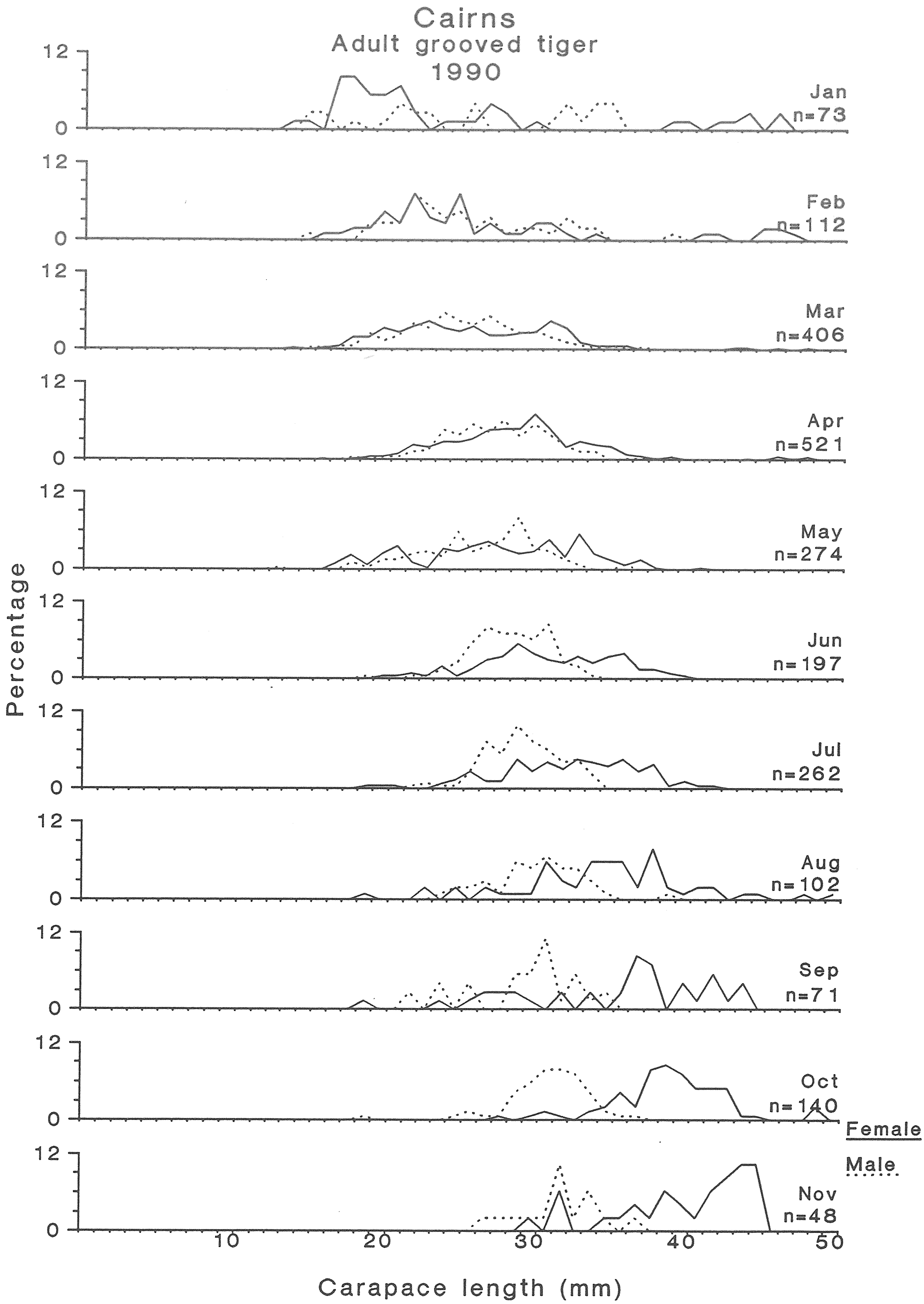
Princess Charlotte Bay
Adult brown tiger
1990
Jan n=602
Feb n=953
Mar n=2103
Apr n=1481
May n=777
Jun n=244
Jul n=324
Aug n=293
Sep n=257
Oct n=173
Nov n=228
Dec n=194
Percentage
0
14
10
20
30
40
50
Carapace length (mm)
Female
Male


Princess Charlotte Bay
Adult brown tiger
1991
14
0
Jan
n=663
Feb
n=1248
Mar
n=2159
Apr
n=2082
May
n=849
Jun
n=655
Jul
n=543
Aug
n=320
Sep
n=259
Oct
n=133
Nov
n=133
Dec
n=174
Percentage
10
20
30
40
50
Carapace length (mm)
Female
Male

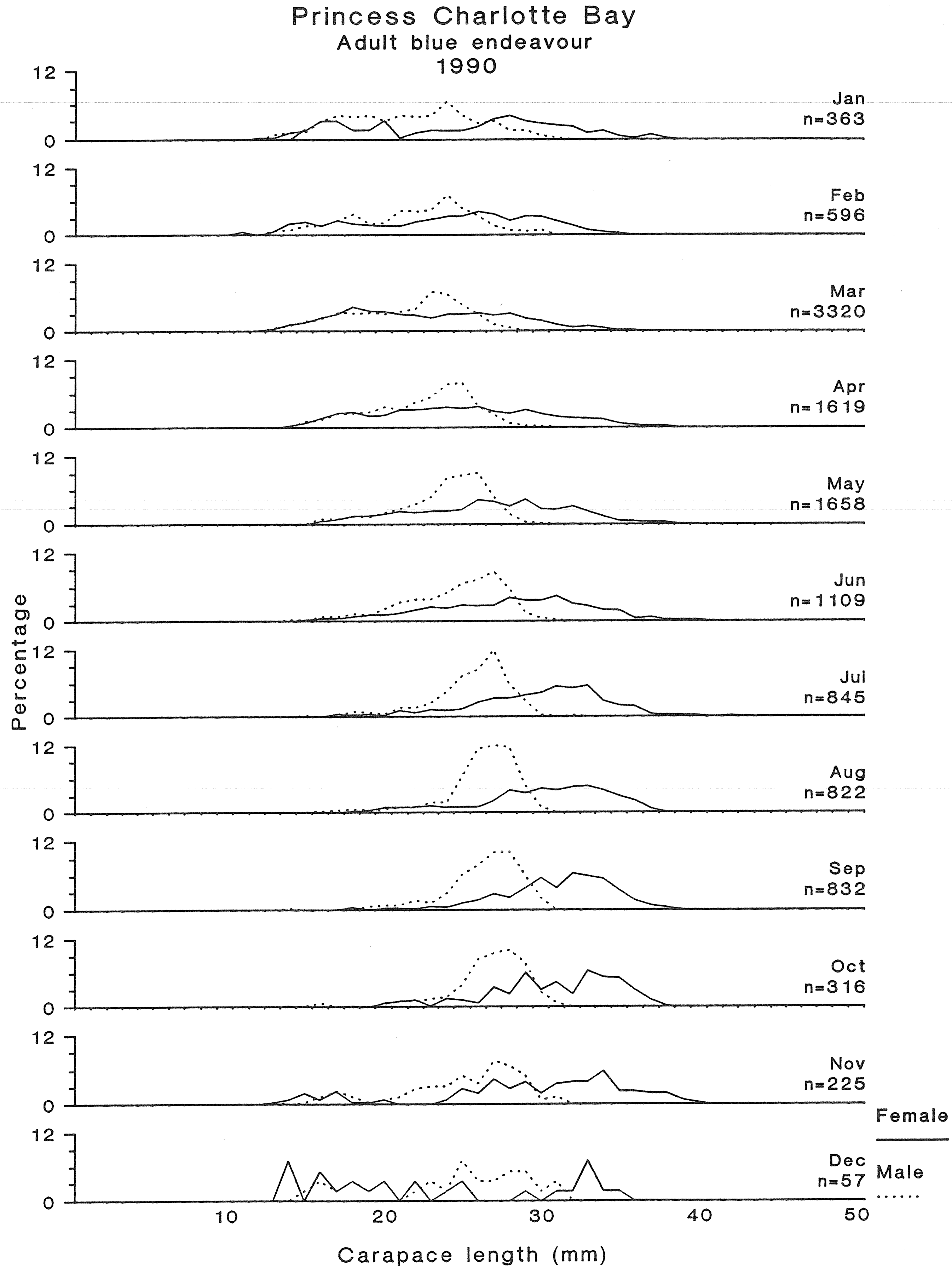

Cairns
Adult brown tiger
1990
Jan n=16
Feb n=13
Mar n=19
Apr n=32
May n=9
Jun n=26
Jul n=23
Aug n=39
Sep n=20
Oct n=30
Nov n=3
Female
Male
Percentage
Carapace length (mm)
0
35
10
20
30
40
50

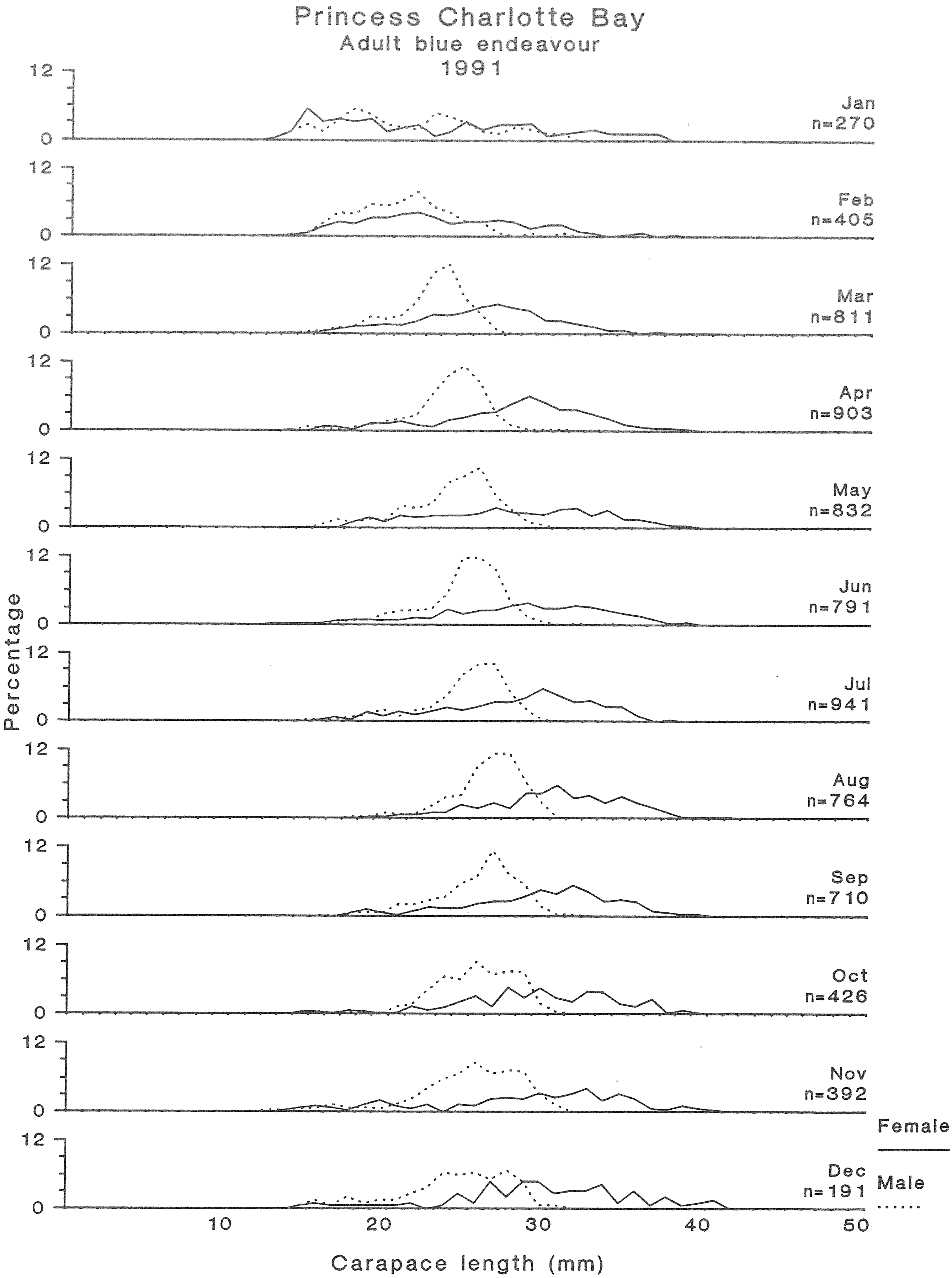

Princess Charlotte Bay
Adult grooved tiger
1990
Jan
n=202
Feb
n=428
Mar
n=1874
Apr
n=933
May
n=882
Jun
n=358
Jul
n=386
Aug
n=439
Sep
n=303
Oct
n=269
Nov
n=206
Dec
n=76
20
0
Percentage
10
20
30
40
50
Carapace length (mm)
Female
Male


Princess Charlotte Bay
Adult grooved tiger
1991
Percentage
Jan n=155
Feb n=209
Mar n=506
Apr n=672
May n=413
Jun n=344
Jul n=368
Aug n=292
Sep n=162
Oct n=138
Nov n=113
Dec n=97
Female
Male
20
0
10
20
30
40
50
Carapace length (mm)

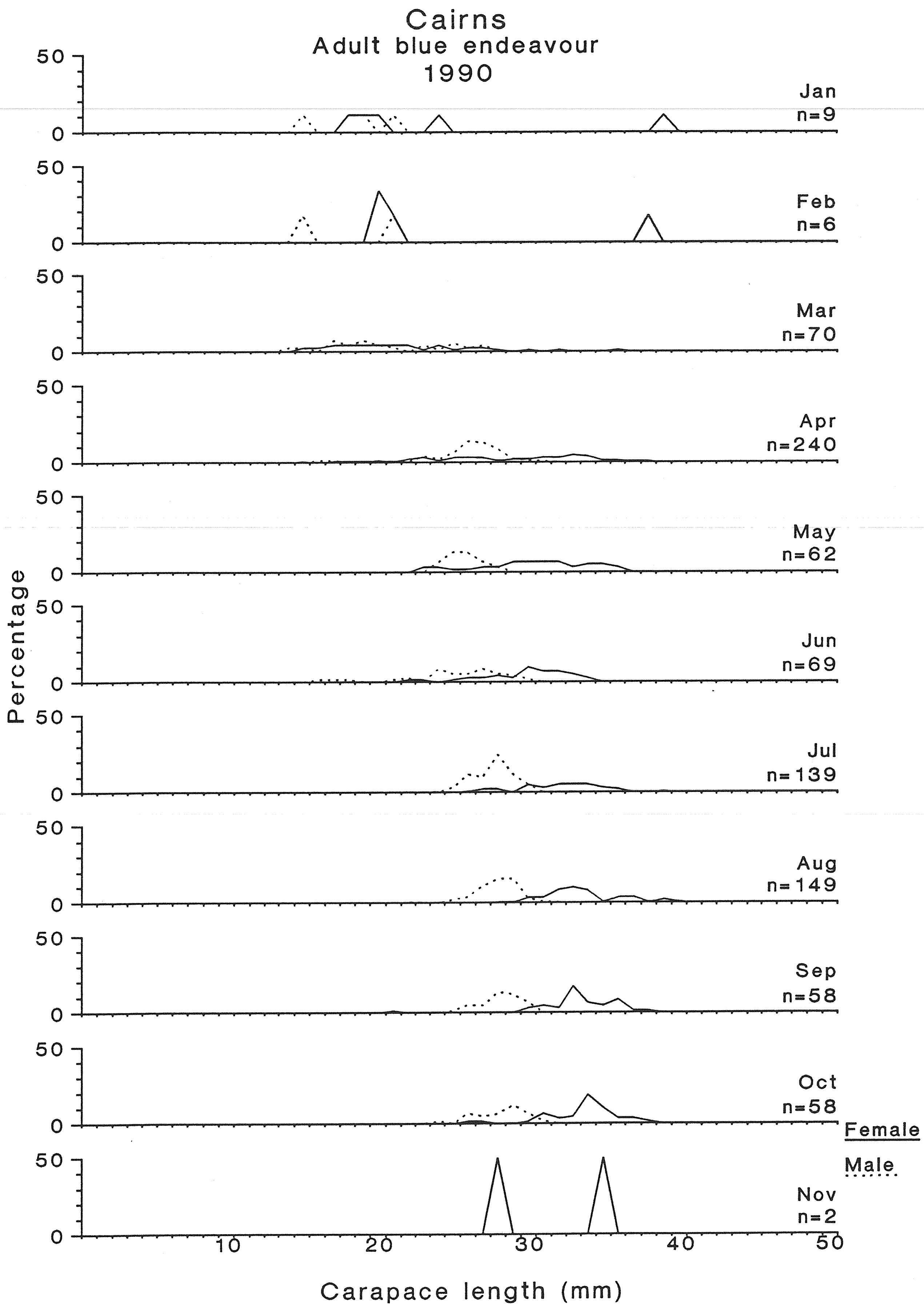

Cairns
Adult grooved tiger
1990
Percentage
12
0
Jan
n=73
Feb
n=112
Mar
n=406
Apr
n=521
May
n=274
Jun
n=197
Jul
n=262
Aug
n=102
Sep
n=71
Oct
n=140
Nov
n=48
Female
Male
10
20
30
40
50
Carapace length (mm)

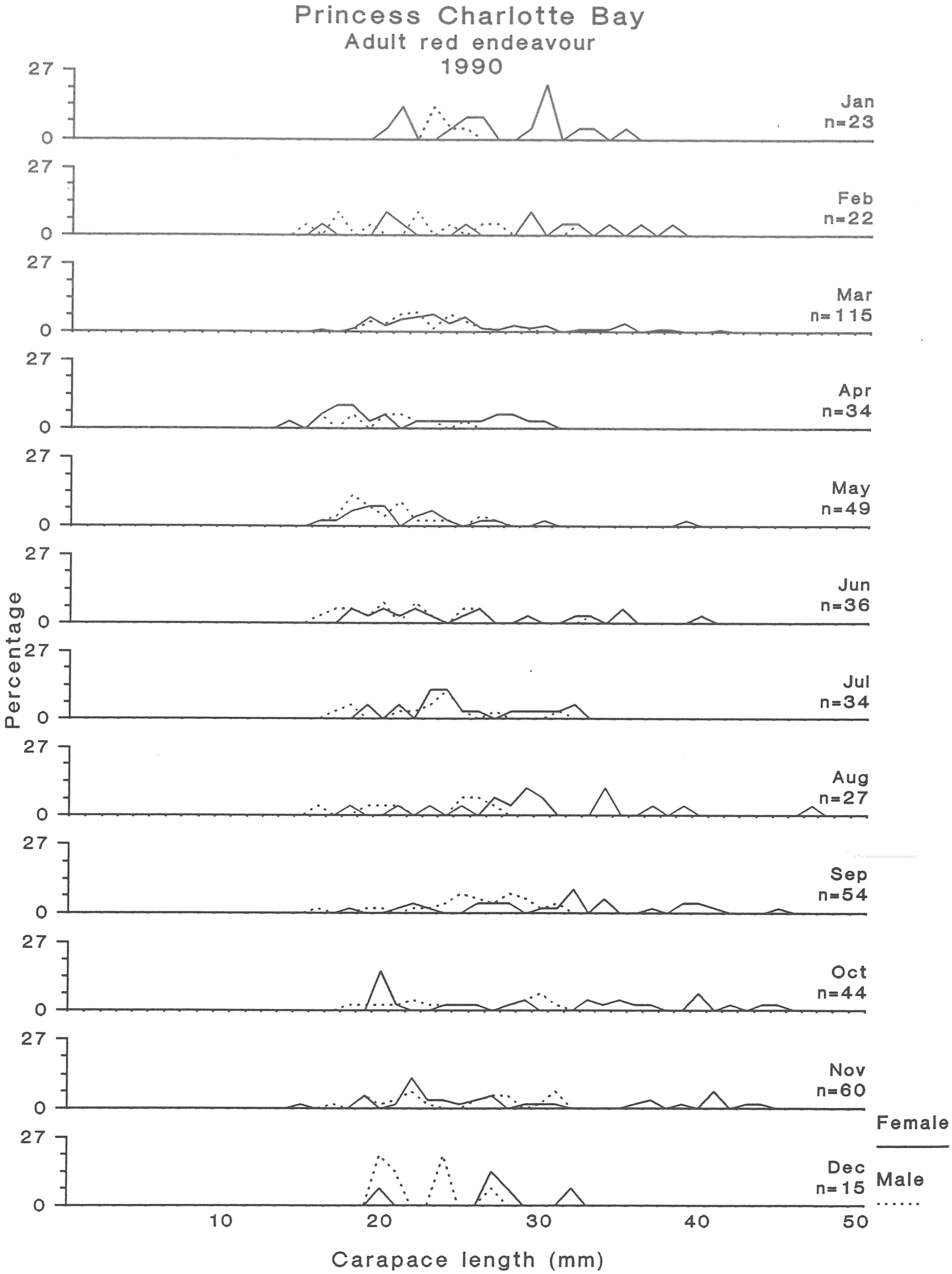
 0645-001.CNF


Princess Charlotte Bay
Adult blue endeavour
1990
Jan n=363
Feb n=596
Mar n=3320
Apr n=1619
May n=1658
Jun n=1109
Jul n=845
Aug n=822
Sep n=832
Oct n=316
Nov n=225
Dec n=57
Female
Male
Percentage
Carapace length (mm)
0
12
10
20
30
40
50

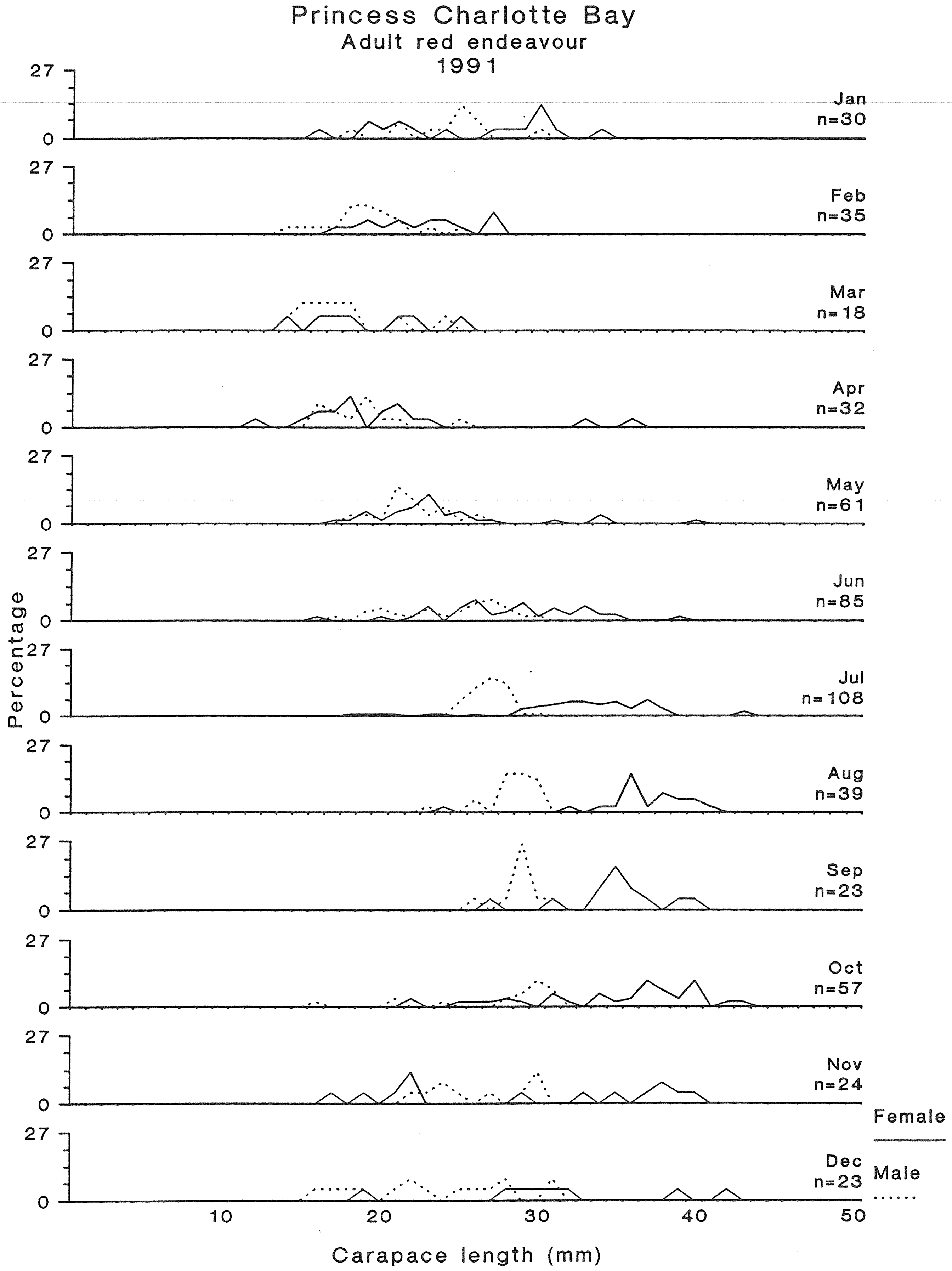


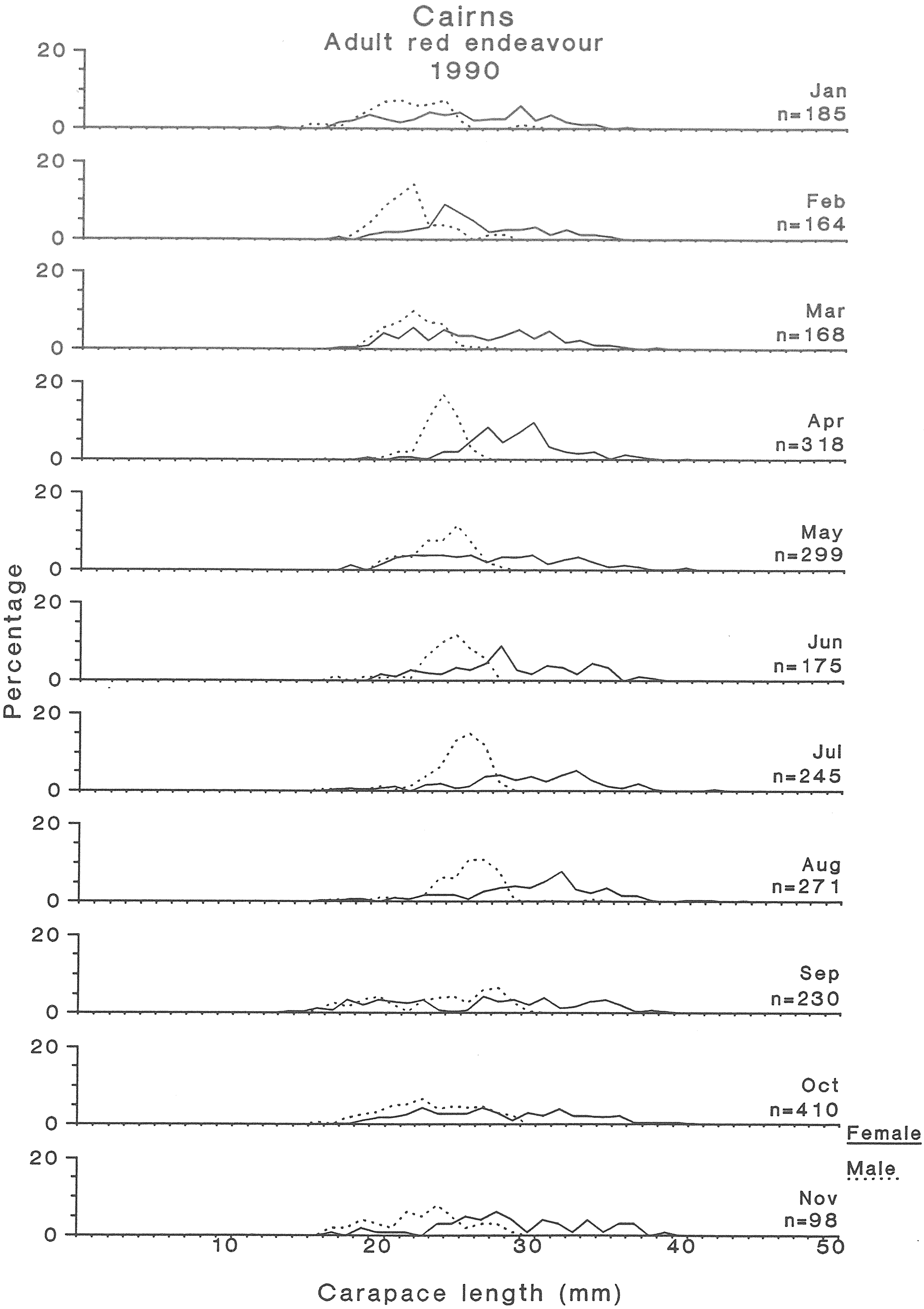
Princess Charlotte Bay
Adult blue endeavour
1991
Percentage
Jan n=270
Feb n=405
Mar n=811
Apr n=903
May n=832
Jun n=791
Jul n=941
Aug n=764
Sep n=710
Oct n=426
Nov n=392
Dec n=191
Female
Male
Carapace length (mm)

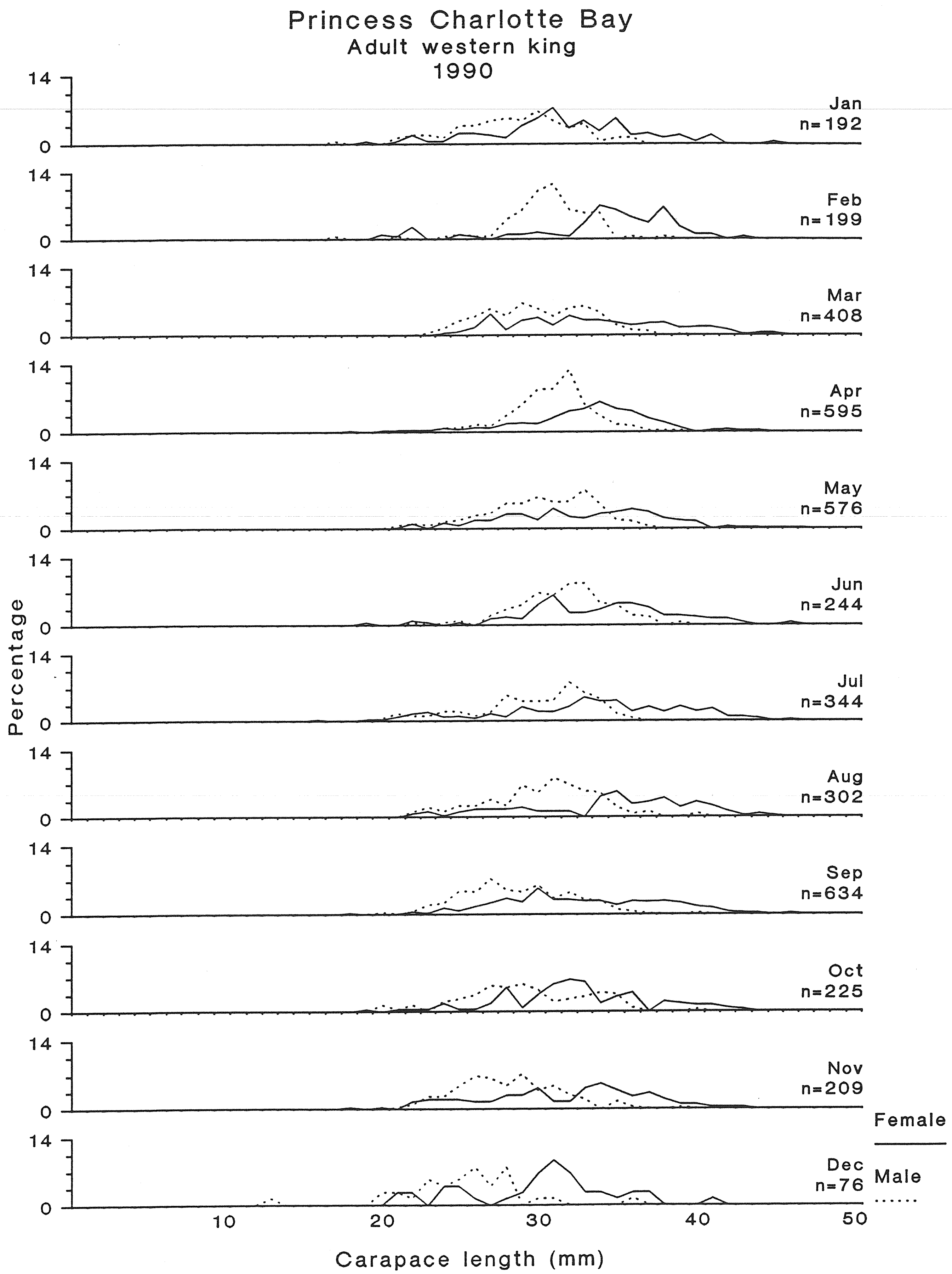

Cairns
Adult blue endeavour
1990
Percentage
Jan n=9
Feb n=6
Mar n=70
Apr n=240
May n=62
Jun n=69
Jul n=139
Aug n=149
Sep n=58
Oct n=58
Nov n=2
Female
Male
Carapace length (mm)



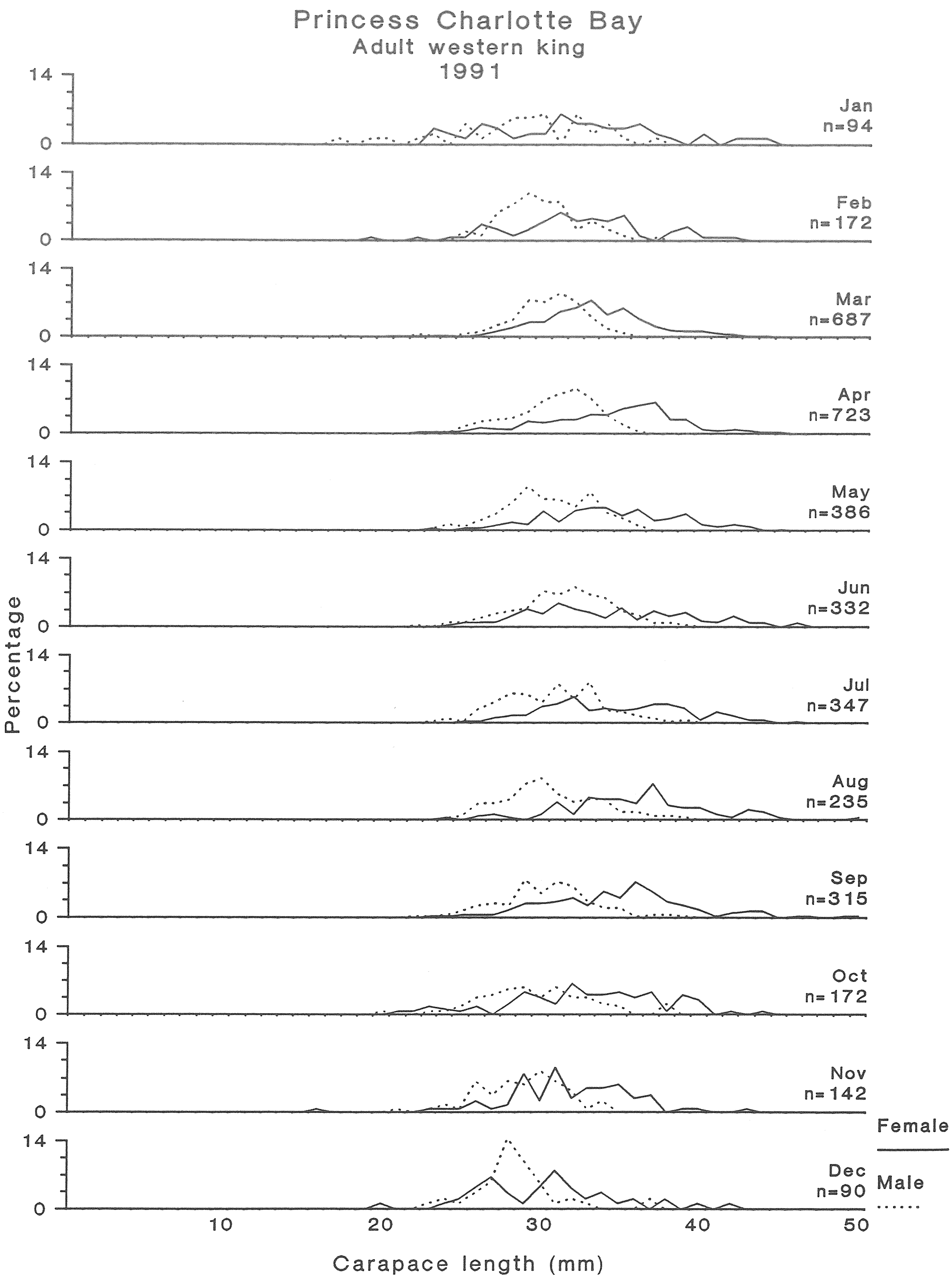
Princess Charlotte Bay
Adult red endeavour
1990
Percentage
27
0
Jan
n=23
Feb
n=22
Mar
n=115
Apr
n=34
May
n=49
Jun
n=36
Jul
n=34
Aug
n=27
Sep
n=54
Oct
n=44
Nov
n=60
Dec
n=15
Female
Male
10
20
30
40
50
Carapace length (mm)


Princess Charlotte Bay
Adult red endeavour
1991
Percentage
Jan n=30
Feb n=35
Mar n=18
Apr n=32
May n=61
Jun n=85
Jul n=108
Aug n=39
Sep n=23
Oct n=57
Nov n=24
Dec n=23
27
0
10
20
30
40
50
Carapace length (mm)
Female
Male

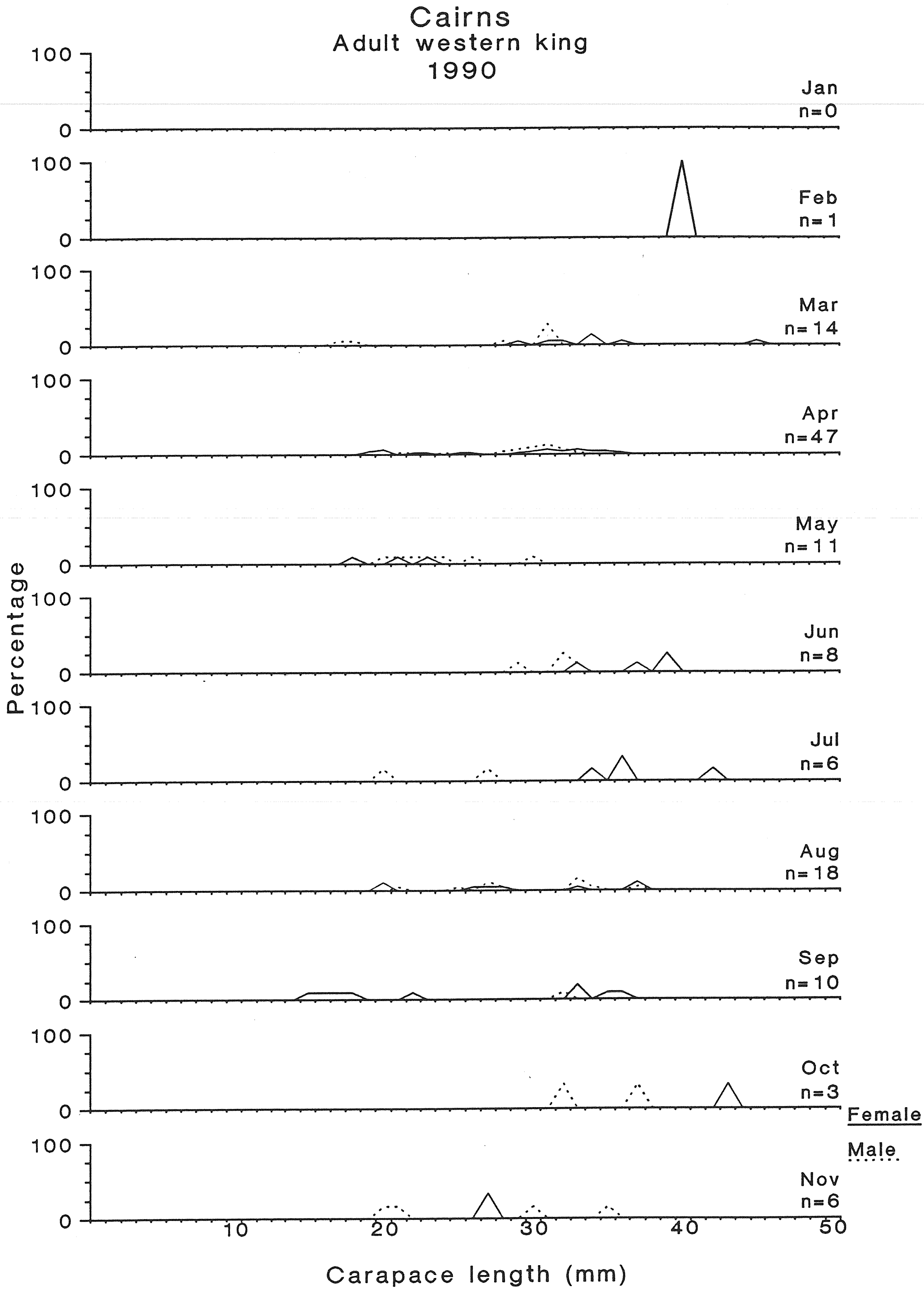

Cairns
Adult red endeavour
1990
Percentage
Carapace length (mm)
Jan
n=185
Feb
n=164
Mar
n=168
Apr
n=318
May
n=299
Jun
n=175
Jul
n=245
Aug
n=271
Sep
n=230
Oct
n=410
Nov
n=98
Female
Male
0
20
10
30
40
50

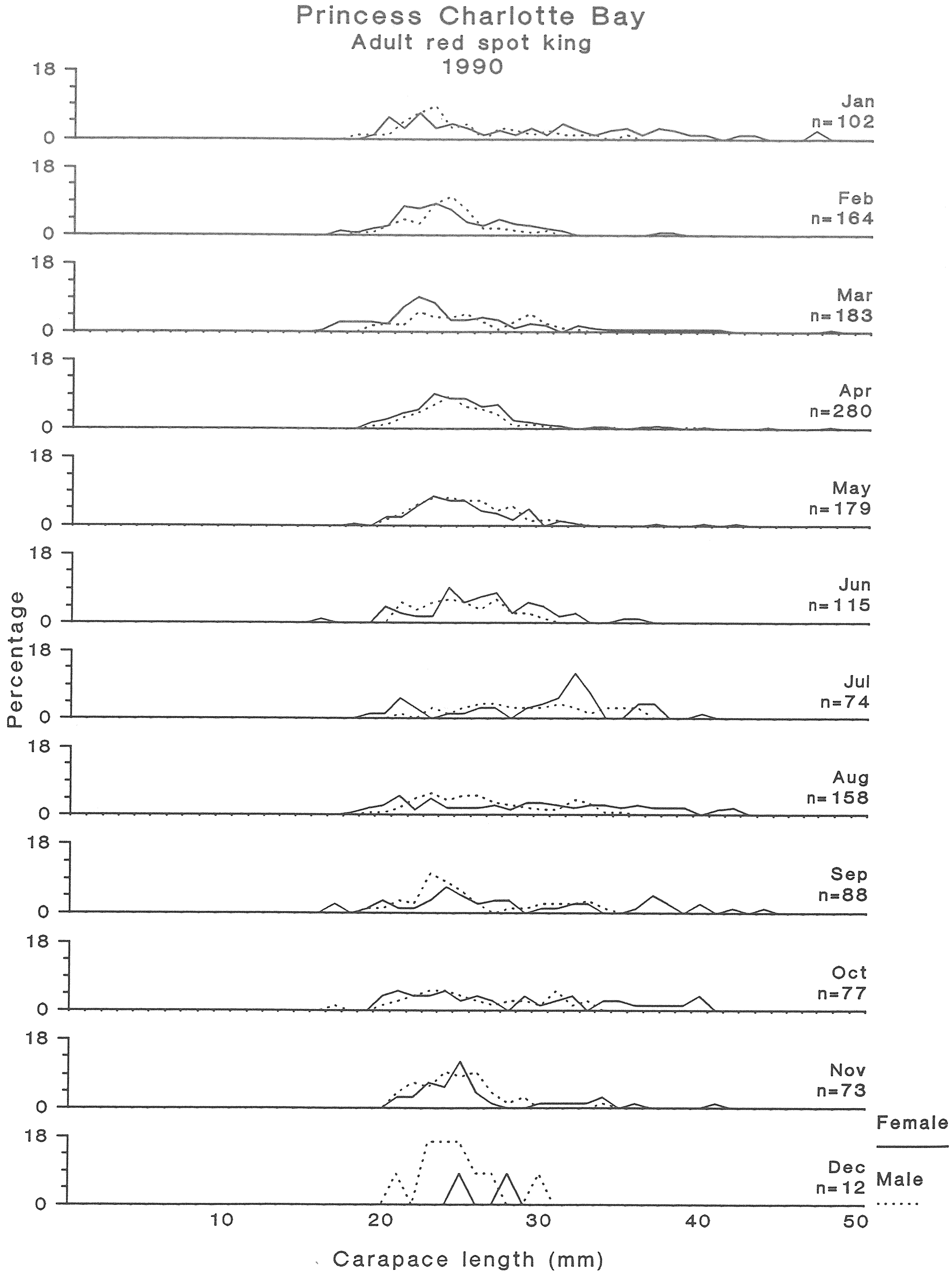


Princess Charlotte Bay
Adult western king
1990
14
0
Jan
n=192
Feb
n=199
Mar
n=408
Apr
n=595
May
n=576
Jun
n=244
Jul
n=344
Aug
n=302
Sep
n=634
Oct
n=225
Nov
n=209
Dec
n=76
Percentage
10
20
30
40
50
Carapace length (mm)
Female
Male

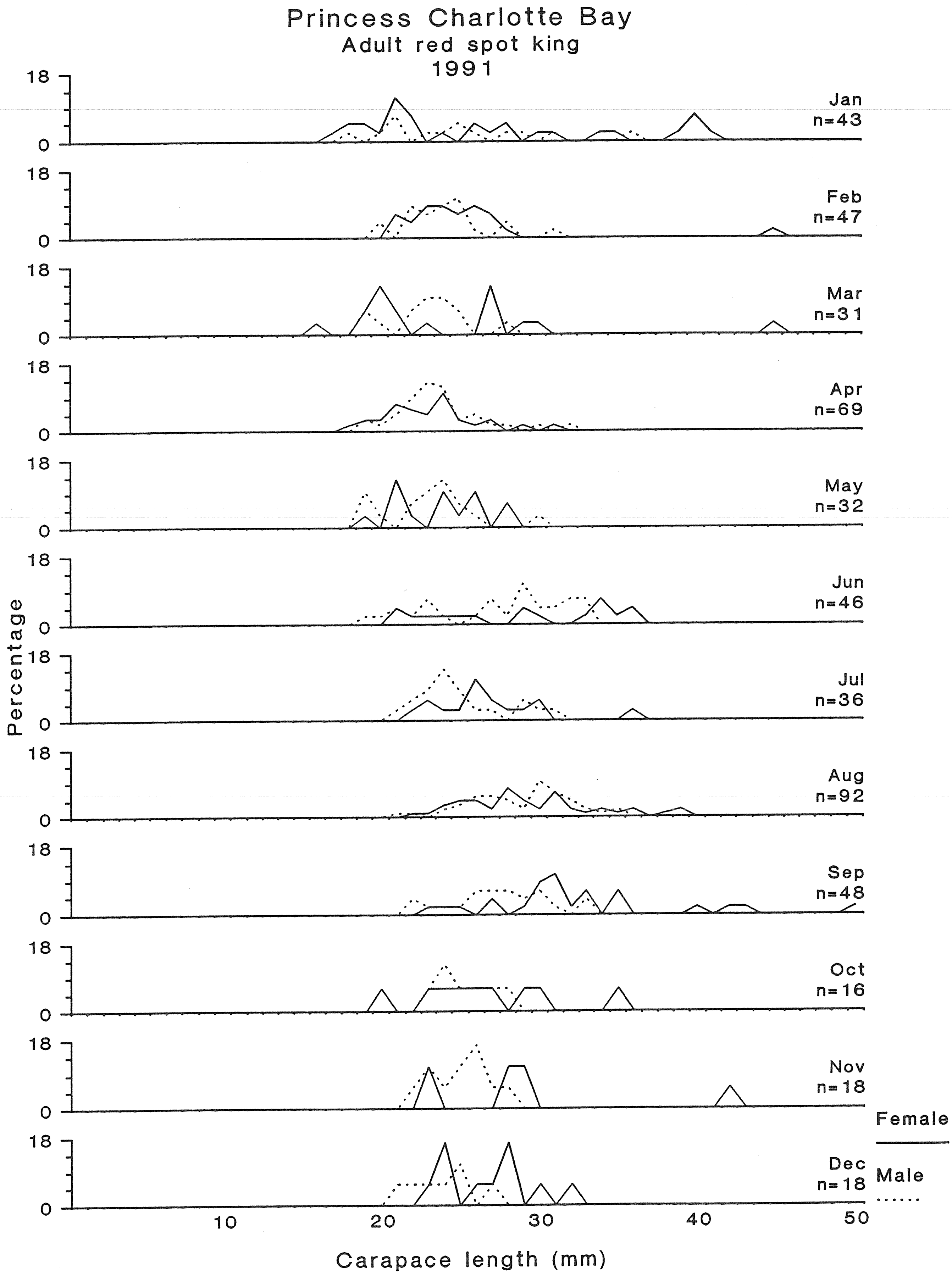


Princess Charlotte Bay
Adult western king
1991
Percentage
Jan n=94
Feb n=172
Mar n=687
Apr n=723
May n=386
Jun n=332
Jul n=347
Aug n=235
Sep n=315
Oct n=172
Nov n=142
Dec n=90
0
14
10
20
30
40
50
Carapace length (mm)
Female
Male

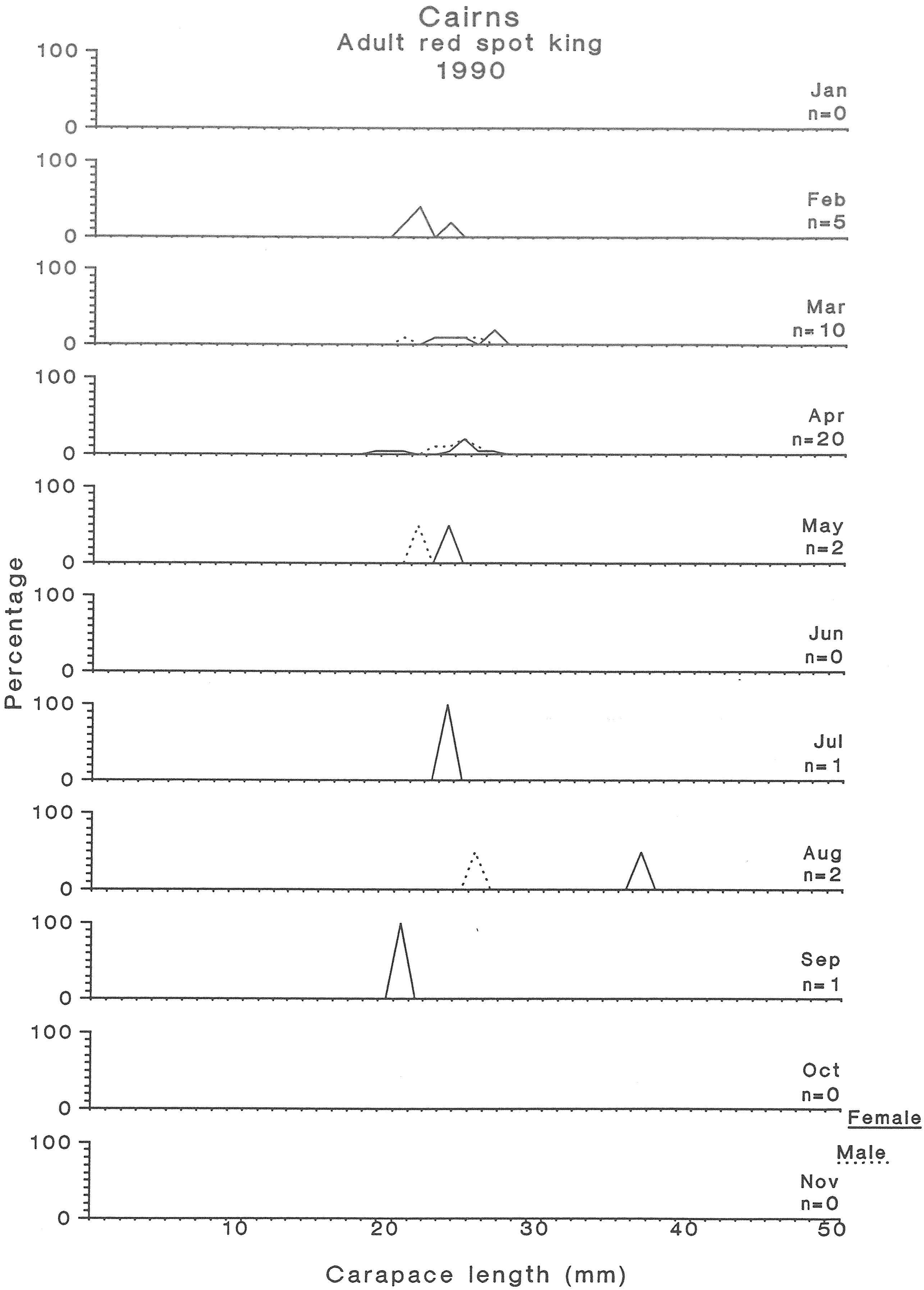

Cairns
Adult western king
1990
Percentage
Carapace length (mm)
Jan n=0
Feb n= 1
Mar n= 14
Apr n=47
May n= 11
Jun n=8
Jul n=6
Aug n= 18
Sep n= 10
Oct n=3
Nov n=6
Female
Male
100
0
10
20
30
40
50

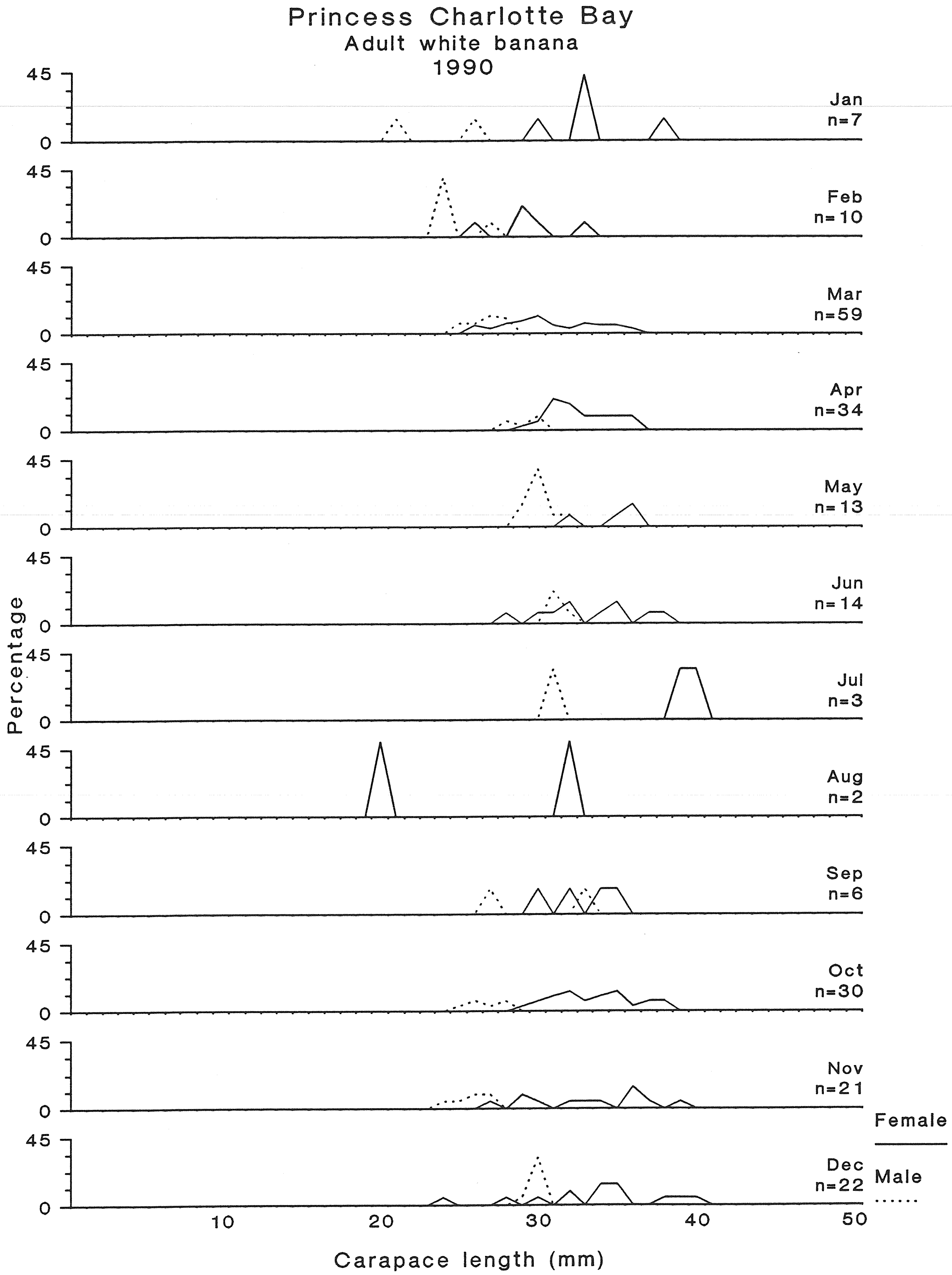


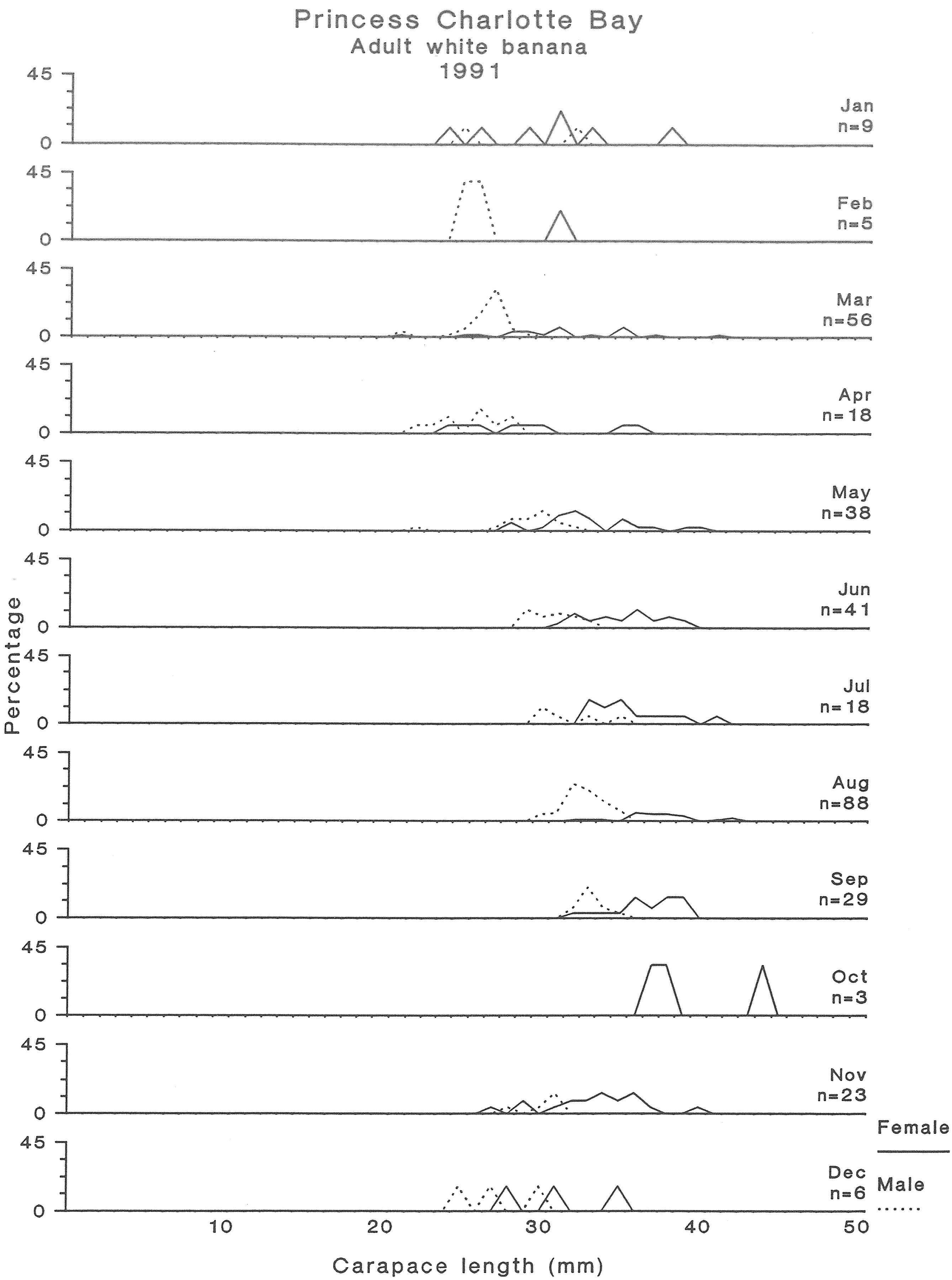
Princess Charlotte Bay
Adult red spot king
1990
Percentage
Jan n=102
Feb n=164
Mar n=183
Apr n=280
May n=179
Jun n=115
Jul n=74
Aug n=158
Sep n=88
Oct n=77
Nov n=73
Dec n=12
Female
Male
18
0
10
20
30
40
50
Carapace length (mm)

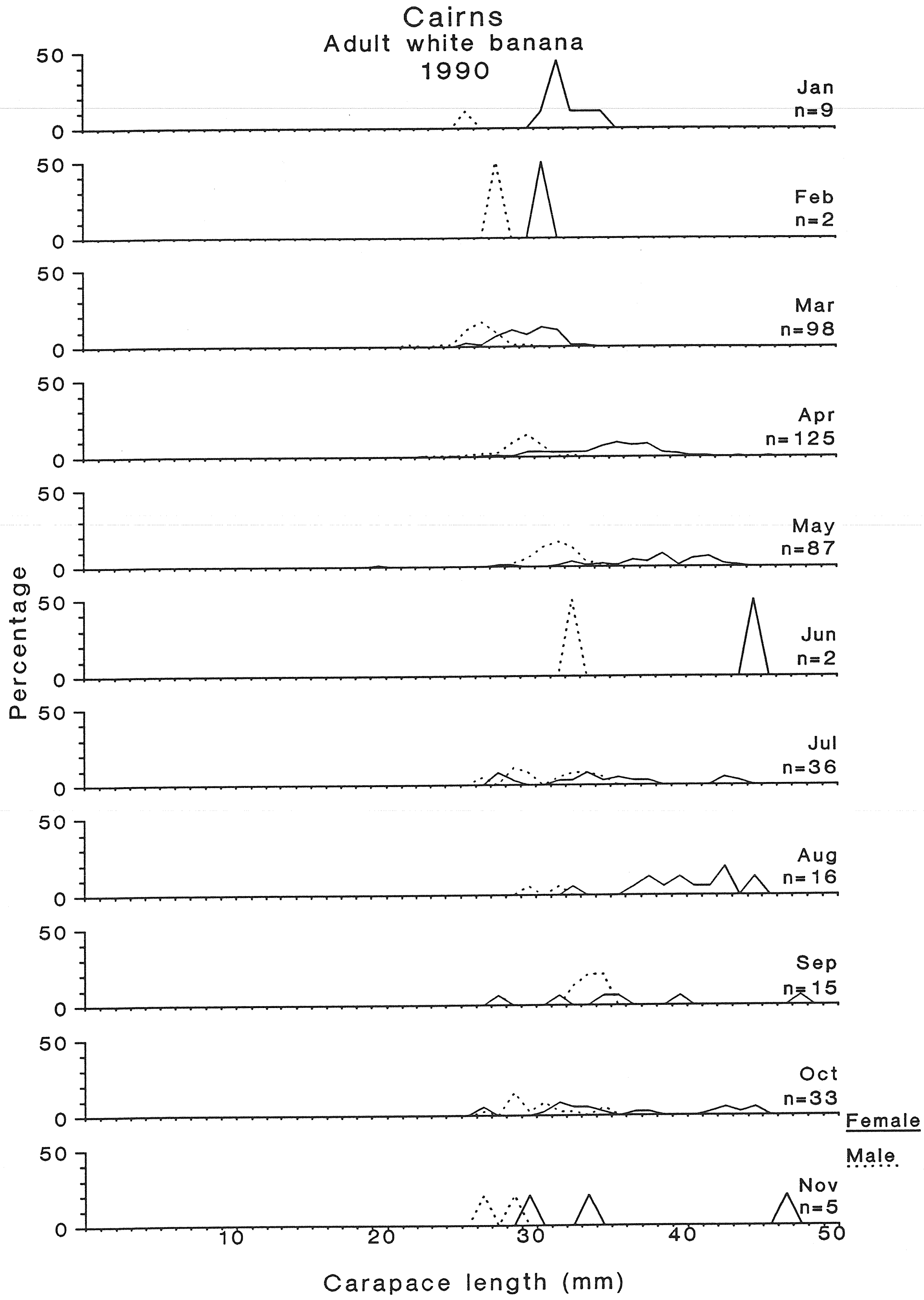


Princess Charlotte Bay
Adult red spot king
1991
Percentage
18
0
Jan
n=43
Feb
n=47
Mar
n=31
Apr
n=69
May
n=32
Jun
n=46
Jul
n=36
Aug
n=92
Sep
n=48
Oct
n=16
Nov
n=18
Dec
n=18
Female
Male
10
20
30
40
50
Carapace length (mm)

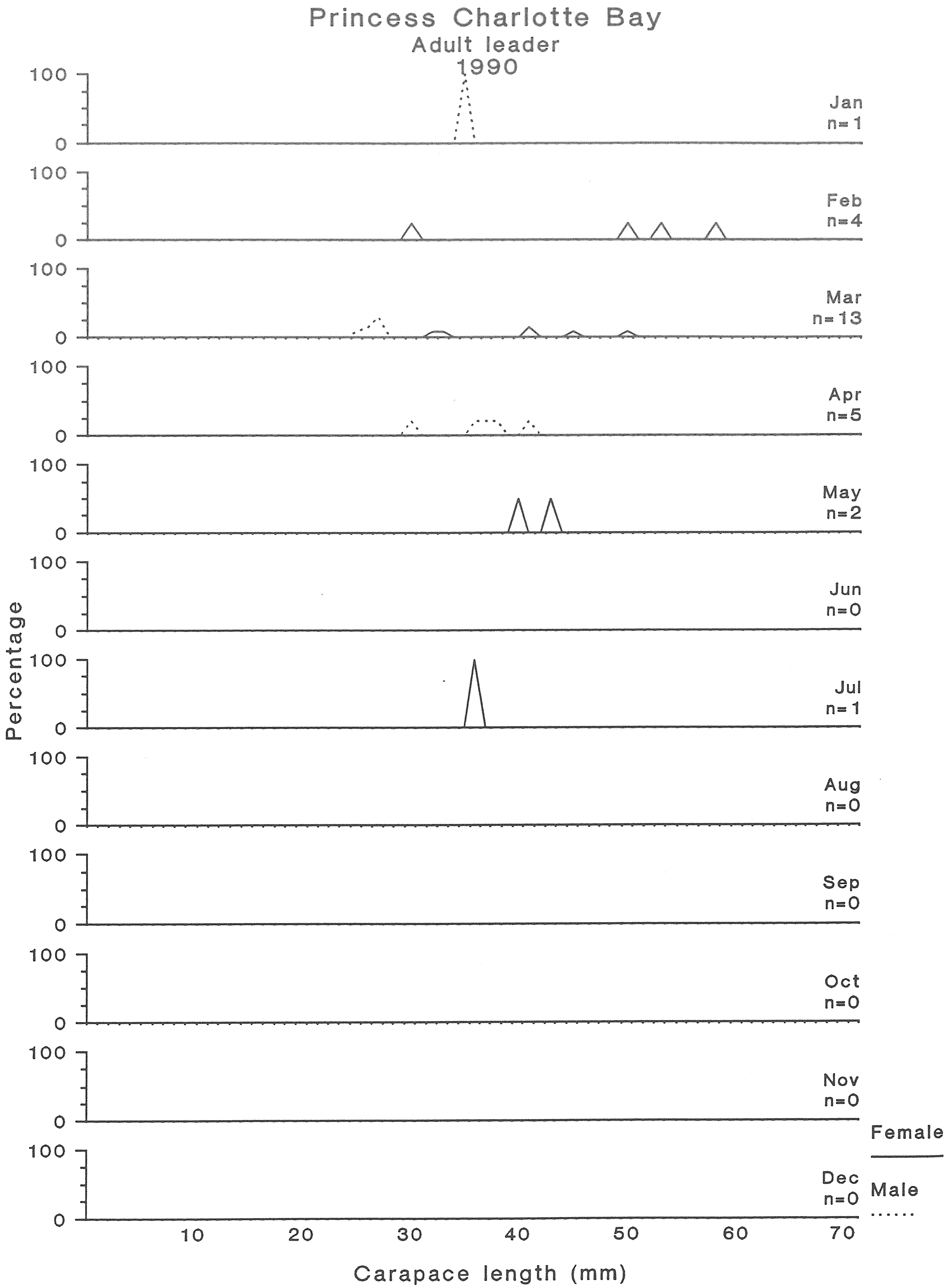

Cairns
Adult red spot king
1990
Percentage
100
0
Jan
n=0
Feb
n=5
Mar
n=10
Apr
n=20
May
n=2
Jun
n=0
Jul
n=1
Aug
n=2
Sep
n=1
Oct
n=0
Nov
n=0
Female
Male
10
20
30
40
50
Carapace length (mm)


Princess Charlotte Bay
Adult white banana
1990
45
0
Jan
n=7
Feb
n=10
Mar
n=59
Apr
n=34
May
n=13
Jun
n=14
Jul
n=3
Aug
n=2
Sep
n=6
Oct
n=30
Nov
n=21
Dec
n=22
Percentage
10
20
30
40
50
Carapace length (mm)
Female
Male

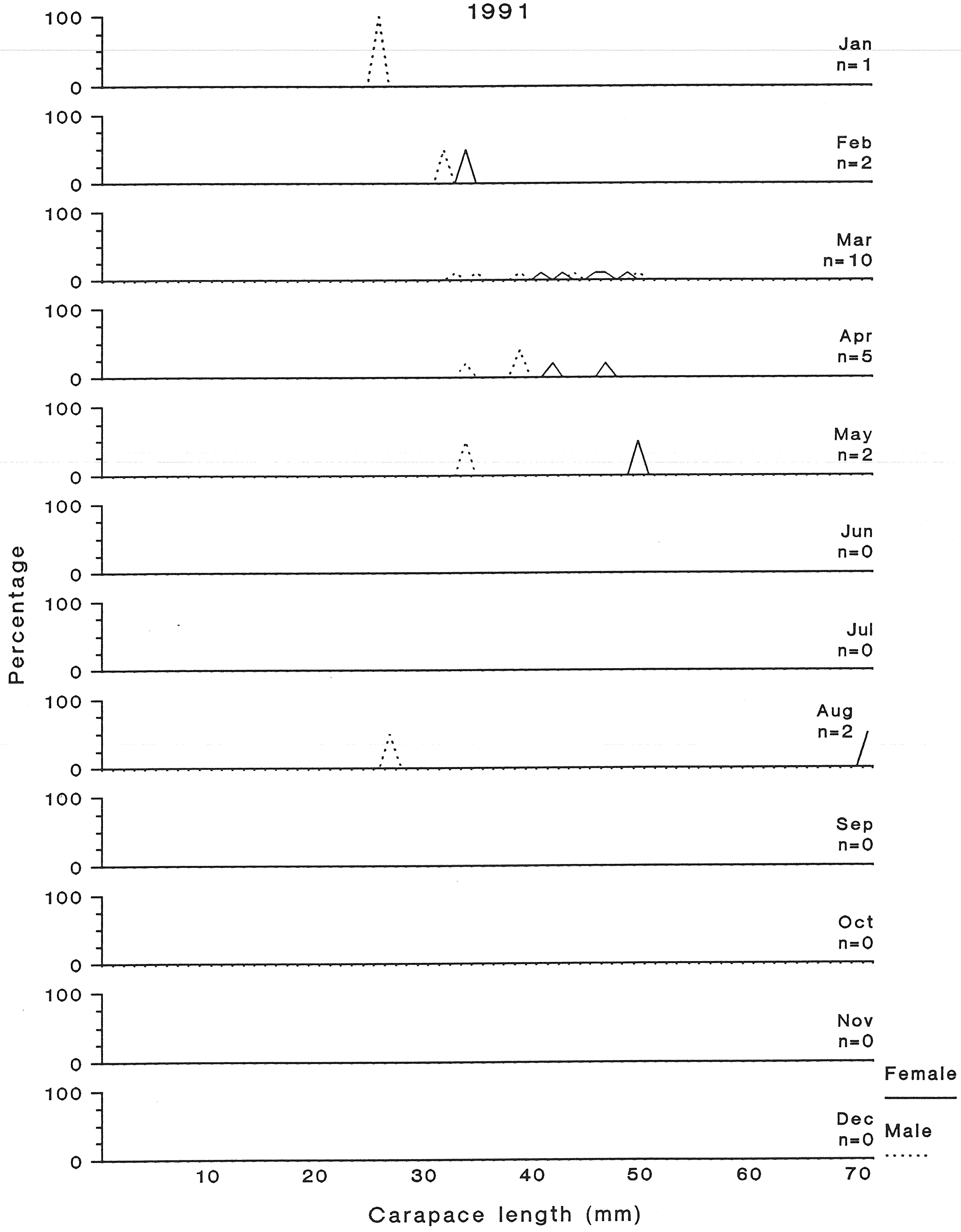

Princess Charlotte Bay
Adult white banana
1991
Percentage
45
0
Jan n=9
Feb n=5
Mar n=56
Apr n=18
May n=38
Jun n=41
Jul n=18
Aug n=88
Sep n=29
Oct n=3
Nov n=23
Dec n=6
Female
Male
10
20
30
40
50
Carapace length (mm)

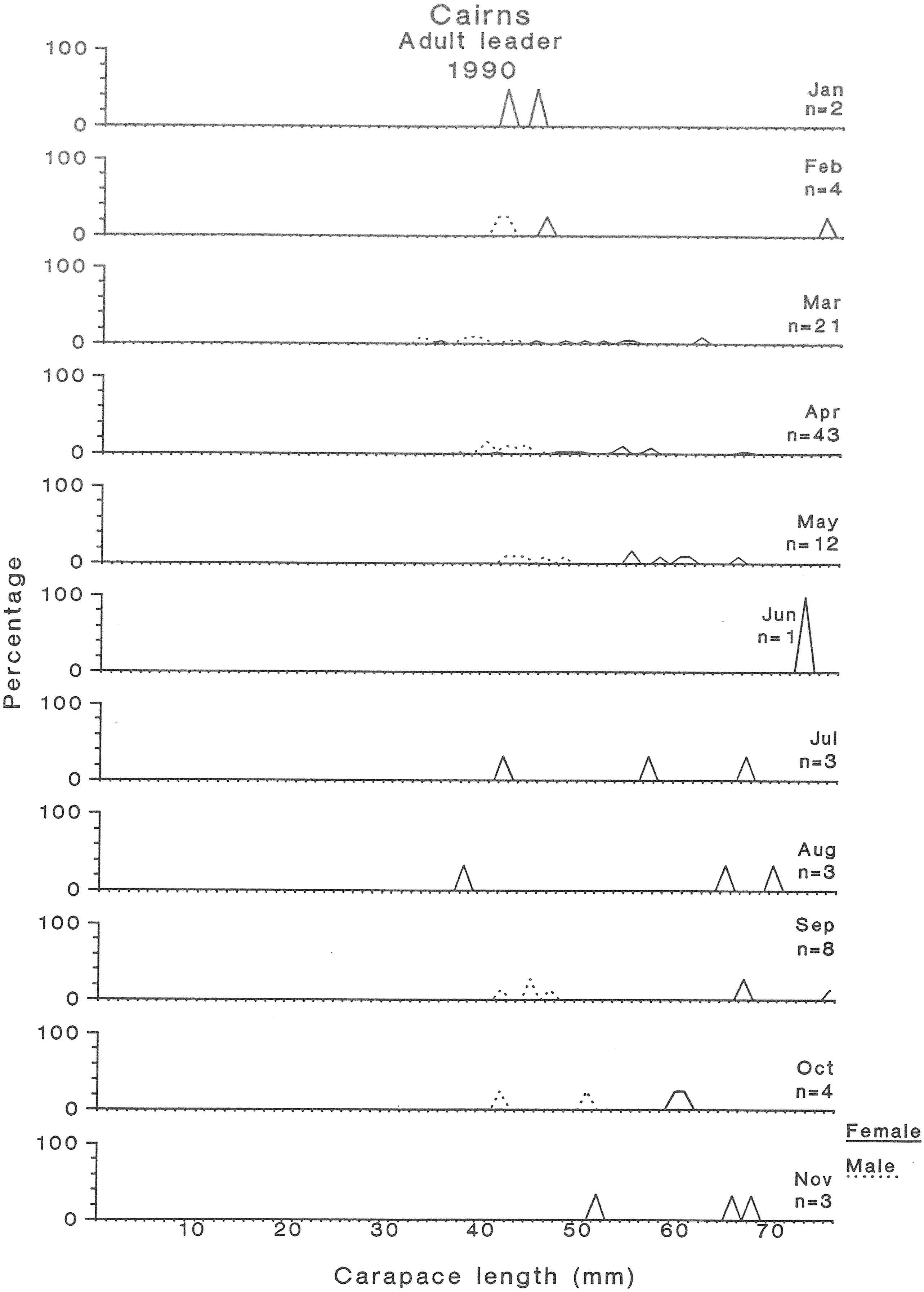


Cairns
Adult white banana
1990
Jan
n=9
Feb
n=2
Mar
n=98
Apr
n=125
May
n=87
Jun
n=2
Jul
n=36
Aug
n=16
Sep
n=15
Oct
n=33
Nov
n=5
Female
Male
Percentage
Carapace length (mm)


Princess Charlotte Bay
Adult leader
1990
Percentage
100
0
Jan n=1
Feb n=4
Mar n=13
Apr n=5
May n=2
Jun n=0
Jul n=1
Aug n=0
Sep n=0
Oct n=0
Nov n=0
Dec n=0
10
20
30
40
50
60
70
Carapace length (mm)
Female
Male

Princess Charlotte Bay
Adult leader
1991





Cairns
Adult leader
1990
Percentage
100
0
Jan
n=2
Feb
n=4
Mar
n=21
Apr
n=43
May
n=12
Jun
n=1
Jul
n=3
Aug
n=3
Sep
n=8
Oct
n=4
Nov
n=3
Female
Male
10
20
30
40
50
60
70
Carapace length (mm)

APPENDIX C Statistical analysis of the relationship between juvenile prawn abundance and habitat.

Table C.1 Simple correlations between juvenile prawn abundance and seagrass/sediment factors in Princess Charlotte Bay. Critical $r_{(6)}$ = 0.621, n=8.

	Seagrass cover	Mud fraction	Coarse fraction	Blue endeavour	Red endeavour	Brown tiger	Western king	Red spot king	White banana	Leader
Seagrass cover	1.0000									
Mud fraction	-0.6481	1.0000								
Coarse fraction	0.4116	**-0.8725**	1.0000							
Blue endeavour	**0.7735**	-0.2281	-0.0297	1.0000						
Red endeavour	-0.5867	0.4507	-0.1432	-0.4471	1.0000					
Brown tiger	-0.3830	0.1582	0.0593	-0.0992	0.1336	1.0000				
Western king	-0.1327	-0.1965	0.5170	-0.4052	0.2009	0.4844	1.0000			
Red spot king	0.2734	**-0.6689**	**0.7866**	-0.0870	0.3050	-0.0864	0.5192	1.0000		
White banana	-0.3505	0.1642	0.0269	-0.2041	**0.7633**	0.4026	0.4793	0.5172	1.0000	
Leader	0.1826	0.0514	-0.2029	**0.6276**	-0.3418	0.0965	-0.4066	-0.3088	-0.2037	1.0000
Grooved tiger	-0.2283	-0.0850	-0.0287	-0.0368	-0.1314	0.3616	-0.4086	-0.2844	-0.1937	0.0660

Red spot king prawns correlated significantly with coarse sediments (r=0.7866) and muddy sediments (r=-0.6689) (Table C.1). Because coarse and muddy sediments were also correlated, a principle components analysis was used to generate new variables which were orthogonal. The first principle component only explained 93.6% of the variance (Table C.2), therefore both new variables were used in an all subsets regression. The only model which was significant included the first principle component (F=7.814, df=6, p=0.03) and explained 49% of the variation in total abundance of red spot king prawns (Table C.3). The coefficient for the independent variable (187.06) indicated that the principle component positively influences mean abundance of red spot king prawns. Examination of the magnitude and loading of the vectors associated with this principle component indicate the total abundance of red spot king prawns was equally influenced negatively by muddy sediments and positively by coarse sediments.

Table C.2 Eigenvalues and eigenvectors based on correlation matrix.

	Principle component	
	1	2
Eigenvalue	1.873	0.128
Cumulative percent of variance	93.6	100
Coarse	0.7071	0.7071
Mud	-0.7071	0.7071

Table C.3 All possible subset regression models between red spot king prawn abundance and unforced independent habitat (seagrass/sediment) variables: A = Principle component 1; B = Principle component 2.

Model variables	Mallows CP	Adjusted R^2	R^2	Residual SS	DF	p
Intercept only	7.2	0.00	0.0000	810,900	-	-
A	1.7	0.4933	0.5657	352,200	6	0.03
AB	3.0	0.4680	0.6200	308,100	5	0.08
B	8.4	-0.1033	0.0544	766,800	6	0.59

Table C.4 Simple correlations between temporal abundance of juvenile prawns and seagrass cover in Princess Charlotte Bay. Critical $r_{(62)} = 0.207$, n = 64.

	Seagrass cover	Blue endeavour	Red endeavour	Brown tiger	Western king	Red spot king	White banana	Leader
Seagrass cover	1.0000							
Blue endeavour	**0.2464**	1.0000						
Red endeavour	-0.1040	-0.0110	1.0000					
Brown tiger	0.0445	**0.2219**	**0.3685**	1.0000				
Western king	0.0583	-0.1438	-0.0504	-0.0189	1.0000			
Red spot king	**0.2457**	0.0666	**0.5893**	0.1747	0.0245	1.0000		
White banana	-0.0744	0.0109	**0.9370**	**0.4196**	-0.0467	**0.6043**	1.0000	
Leader	-0.0396	**0.4638**	-0.0326	**0.2499**	-0.0603	-0.0604	-0.0214	1.0000
Grooved tiger	-0.0669	**0.2656**	0.0606	**0.2649**	-0.1779	-0.1657	-0.0605	**0.2092**

Blue endeavour and red spot king prawn abundances correlated significantly with seagrass cover through time (Table C.4). The dependent variable used in the regression was the residuals obtained from a one way ANOVA, (with sites as the treatment variable) in order to reduce the noise caused by spatial variation between sites. The regression relationship with seagrass was not significant for either species through time (Blue endeavour prawn F=0.3691, df=62, p=0.55; Red spot king prawn F=0.036, df=62, p=0.85).

APPENDIX D Statistical analyses of size at release.

Table D.1 Kolmogorov-Smirnov statistics (D) and associated p-values for comparison of the size distribution of prawns tagged in different months.

	1990				1991			
	Male		Female		Male		Female	
	D	p	D	p	D	p	D	p
Jan vs Feb	0.22	0.00	0.14	0.00	**0.04**	**0.13**	0.07	0.00
Feb vs Mar	0.22	0.00	0.21	0.00	0.23	0.00	0.21	0.00
Mar vs Jan	0.13	0.00	0.15	0.00	0.19	0.00	0.26	0.00

Table D.2 Kolmogorov-Smirnov statistics (D) and associated p-values for comparison of the size distribution of releases and the size distribution at release of those that were returned.

	1990				1991			
	Male		Female		Male		Female	
	D	p	D	p	D	p	D	p
January	0.04	1.000	0.04	1.000	0.12	0.095	0.10	0.210
February	0.03	1.000	0.07	0.555	**0.13**	**0.019**	0.09	0.211
March	**0.15**	**0.045**	0.06	1.000	0.06	0.979	0.05	1.000
All months	0.07	0.131	0.06	0.446	0.05	0.317	0.03	0.972

APPENDIX E Project publicity.

PRINCESS CHARLOTTE BAY PRAWN NEWSLETTER #1, December 1990.

INTRODUCTION

The Queensland Department of Primary Industries, Fisheries Branch project "Stock Assessment In The North East Australian Prawn Trawl Fishery" began in August of 1989. The research is centred in Princess Charlotte Bay and is funded by the Fishing Industry Research and Development Council until June 1992. Our aim is to collect information about the commercial prawns and use this to assess closure management schemes by means of computer models.

TAGGING

During the 1990 closure, over 10,000 tagged prawns were released at three sites in Princess Charlotte Bay and Bathurst Bay. Most were brown tiger prawns and most were released just west of the Flinders Group. Tagging provides valuable information about prawn movement and their rates of growth and death, and the success of any tagging programme depends on industry co-operation, which has been very good to date.

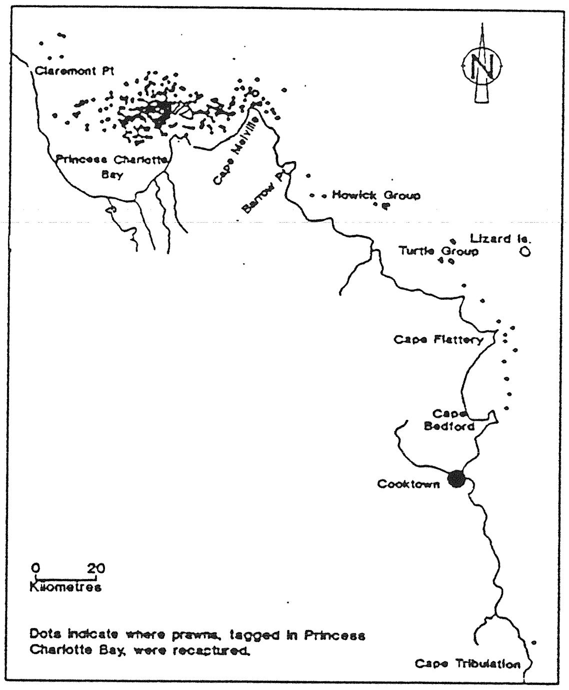


Figure 1.

Around 9% of the brown tiger prawns were recaptured and returned. Most did not move far, but some did move considerable distances to the south (see Figure 1). The maximum time at liberty was 207 days. Male brown tiger prawns grew an average of 0.3mm (head or carapace length) per week, while females grew an average of 0.5mm per week. Our estimate of the rate of natural mortality (i.e. death due to natural causes) was about 10% per week.

SAMPLING THE FISHERY

Following preliminary cruises in September and November 1989, we began regular sampling of adult prawns in Princess Charlotte Bay in December 1989. Each month a chartered commercial fishing vessel makes three 20 minute shots in each grid (see Figure 2).

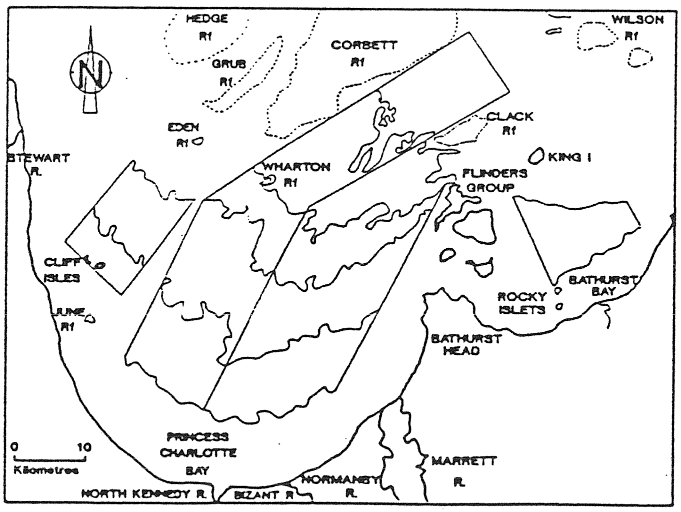


Figure 2. Sampling grids in the Princess Charlotte Bay area.

We have found several trends in species and size composition during 1990. The relative proportion of different species changes through the year, with the grooved tiger making up more of the catch than the brown tiger later in the season (see Figure 3). Similar surveys were conducted off Cairns during 1990.

SAMPLING JUVENILE PRAWNS

Preliminary sampling of juvenile prawns began in Princess Charlotte Bay in October 1990. We have selected several nursery areas (seagrass beds) in the region which we sample with a dinghy-towed small mesh beam trawl. This work will enable us to determine the timing of settlement onto the beds and movement off the beds and into the fishery. Initial results suggest that different species may settle as juveniles in different areas.

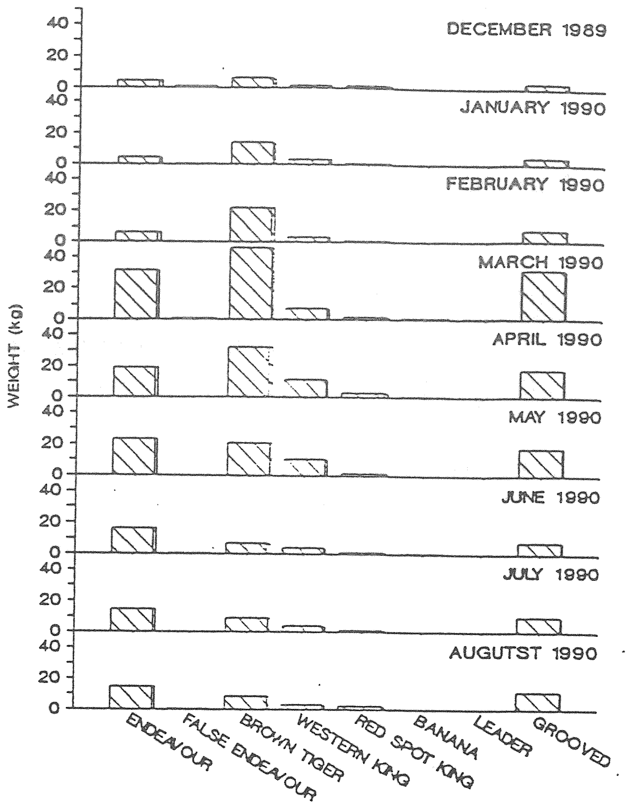


Figure 3. Prawn species composition in Princess Charlotte Bay.

THE FUTURE

A tagging programme similar to 1990 will be conducted during the 1991 closure. The main aim of this work is to make a second, and better, estimate of natural mortality, and we will again gather valuable information on movement and growth. IT IS IMPORTANT THAT ANY RECAPTURED TAGGED PRAWNS BE RETURNED INTACT WITH PRECISE INFORMATION ABOUT DATE AND PLACE OF RECAPTURE. Without your help, tagging will not be successful.

Adult sampling will continue each month in Princess Charlotte Bay during 1991 and juvenile sampling will continue until at least June 1991. Analysis will increase during 1991 and we will begin using specially developed computer models soon.

We would like to thank the fleet for the assistance rendered so far and, as we have a busy year ahead of us, ask for your continued co-operation in 1991.

FOR FURTHER INFORMATION CONTACT:

Kurt Derbyshire or Sue Helmke
Northern Fisheries Centre
cnr Tingira and Aumuller Streets
Portsmith, Cairns.
ph. (070) 351 580

Queensland
Department
of Primary
Industries

NORTHERN FISHERIES CENTRE
PO Box 5396, Cairns Qld 4870
Telephone: (070) 35 1580 QNET: 23899
Facsimile: (070) 35 1401

PRINCESS CHARLOTTE BAY PRAWN NEWSLETTER

Number 2 April 1991

TAGGING

Following our successful tagging programme of last year, more than 9,000 tagged brown tiger prawns were released in Princess Charlotte Bay at site 'A' during the 1991 closure (see Figure 1). An additional 1,000 brown tigers were released near Cape Flattery at sites 'D' and 'E'.

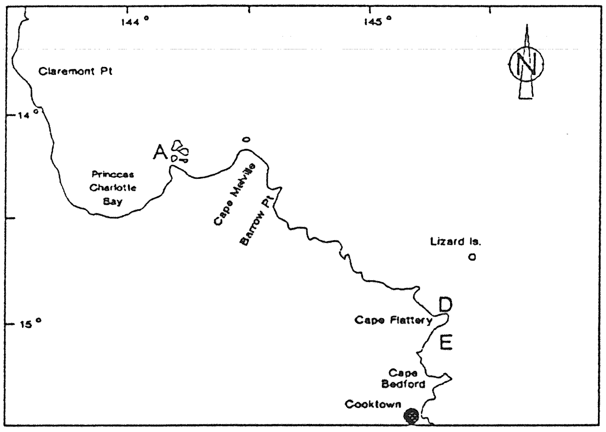


Figure 1. 1991 tagged prawn release positions.

We hope that the 1991 tagging programme will add to the information that we gained last year about movement patterns and growth rates, and improve our estimate of the rate of natural mortality of brown tiger prawns.

Many fishermen have already been issued with tagged prawn return kits. Additional kits are available from motherships, fuel barges and at the address above.

IT IS IMPORTANT THAT ANY RECAPTURED TAGGED PRAWNS BE RETURNED INTACT WITH PRECISE INFORMATION ABOUT THE DATE AND PLACE OF RECAPTURE.

Once again this year we will issue a lottery ticket for each tagged prawn which is returned. The lottery prizes are:

1. $1500 gold bullion
2. Video player
3. Portable stereo

The prize draw will be held in December 1991.

More than 100 recaptured tagged prawns were returned to us during the first week of the season. With the co-operation of the fleet, the 1991 tagging programme will be even more successful than last year's.

SAMPLING THE FISHERY

Monthly sampling in Princess Charlotte Bay continued through the 1991 closure. Numbers of small (below export size) and large (above export size) prawns for the four major commercial species are presented in Figure 2. Note that this data is from 15/8" mesh nets and that some sites were missed in December 1991 due to Cyclone 'Joy'.

The number of brown tiger prawns caught during the 1990 and 1991 closures was similar, but there were more large brown tigers during the 1991 closure.

The proportion of small grooved tiger prawns was similar during both closures, but the total number of grooved tigers was lower during the 1991 closure.

The total number of endeavour prawns was much lower during the 1991 closure than for the corresponding period in 1990, but the proportion of small endeavours in the catch was similar for both closures.

There were more large western king prawns at the end of the 1991 closure than during the same period in 1990, while the number of small western kings was about the same for both closures.

Differences between the two closures in the number and size of prawns may be due to differences in the timing and extent of the wet season in 1990 and 1991.

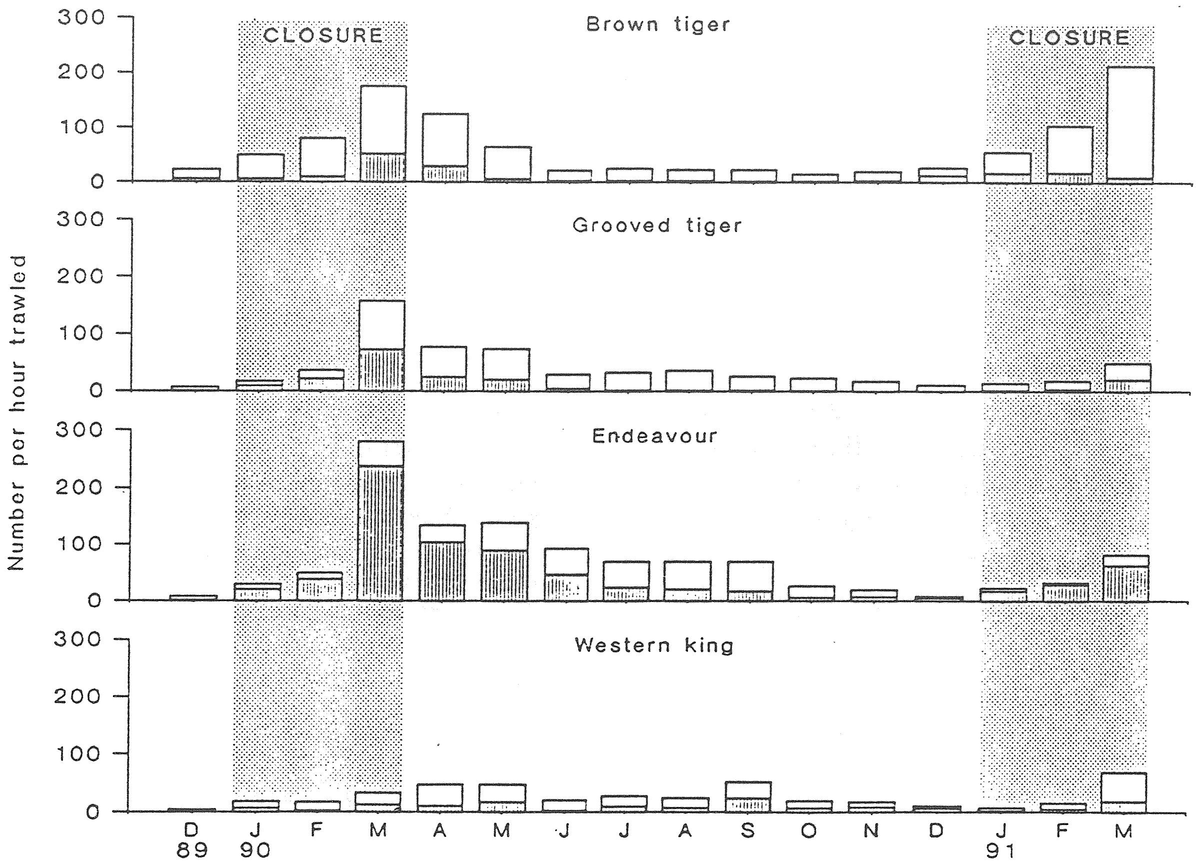


Figure 2. Number of prawns above (☐) and below (☐) export size in Princess Charlotte Bay between December 1989 and March 1991.

THE FUTURE

Sampling in Princess Charlotte Bay will continue until December 1991. Our analysis of the 1990 tagging programme is continuing and we will begin analysing the 1991 tag return data later in the year. Use of computer modelling techniques will increase during 1991.

For further information about our work in Princess Charlotte Bay, contact Kurt Derbyshire or Sue Helmke at the Northern Fisheries Centre.

Queensland
Department
of Primary
Industries

NORTHERN FISHERIES CENTRE
PO Box 5396, Cairns Qld 4870
Telephone: (070) 35 1580. QNET: 23899
Facsimile: (070) 35 1401

PRINCESS CHARLOTTE BAY PRAWN NEWSLETTER

Number 3 July 1991

TAGGING

The 1991 tagging programme is providing us with valuable information about brown tiger prawns in Princess Charlotte Bay. A total of 710 tagged prawns were returned to us by the end of June (see Table 1). Over 75% of these returns had moved less than 6 nautical miles, which, given the length of a trawl shot, is equivalent to no movement at all. The southward movement which occurred in 1990 (see Newsletter #1) has not been repeated to date this year (see Figure 1).

While we do not expect large numbers of returns between now and year's end, we do encourage the fleet to return any tagged prawns which may still be on board or are captured in the future. We rely on a very high rate of reporting of recaptured tagged prawns to provide you with accurate results.

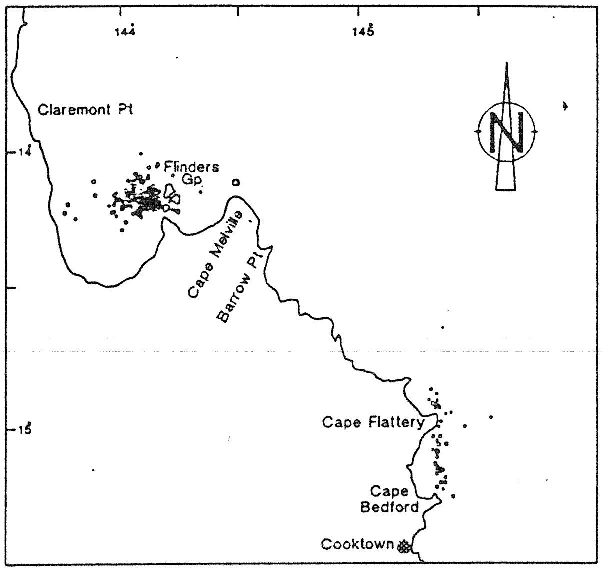


Figure 1. 1991 tag return positions. Circles represent recaptures of prawns released east of the Flinders group. Filled squares represent recaptures of prawns released north of Cape Flattery and open squares represent recaptures of prawns released south of Cape Flattery.

Table 1. Return information for tagged prawns released during the 1991 closure.

SITE	MONTH	NUMBER RELEASED	NUMBER RETURNED	AVERAGE DISTANCE MOVED (n miles)	AVERAGE GROWTH* (mm/week)
East of Flinders Island	January, February and March	9406	632	4	M=0.3 F=0.4
North of Cape Flattery	February	600	31	7	M=0.7 F=0.8
South of Cape Flattery	March	500	42	3	M=0.4 F=0.6
Unknown**	N/A	0	5	N/A	N/A
TOTAL		10506	710	4	M=0.3 F=0.5

* increase in head length.
** release information not available for these prawns due to damage or non-return of tags.

JUVENILES

Juvenile prawns were sampled each month between October 1990 and June 1991 with a dinghy-towed, small-mesh beam trawl at sites which ranged from coastal to reef-top habitats (see Figure 2).

Endeavour prawns were found at all sites (see Figure 3) and in particular at the island sites. Endeavours were the most numerous juvenile prawns that we found. Red spot king prawns were only found on the reef flat at Pipon Island and at Cliff Isles. Small numbers of western king prawns were found at Pipon Island, Cliff Isles and Claremont Point. Grooved tigers were found only at Bathurst Bay and Flinders Island, while brown tigers occurred at Bathurst Bay, Claremont Point, Flinders Island and Cliff Isles. Very small tiger prawns (too small to tell whether they were brown or grooved) were found at Bathurst Bay, Cliff Isles and Pipon Island.

Sites such as those at Bathurst Bay and Cliff Isles appear to be important nursery areas that support juveniles of several commercial prawn species. Differences between sites in species composition and the number of juvenile prawns may be due to factors such as sediment composition and the nature of the bottom vegetation. We are currently collating information about the sediment and seagrass composition of our beam trawl sites.

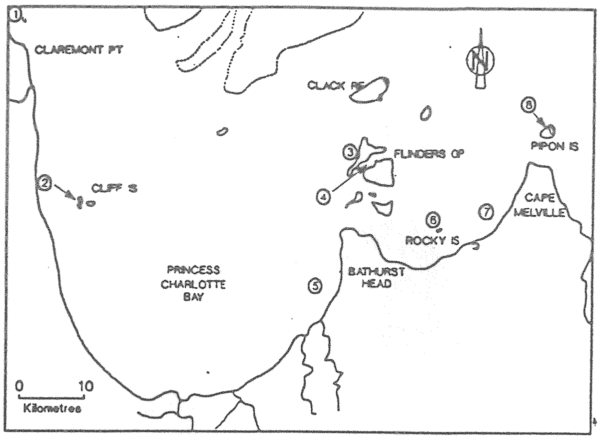


Figure 2. Juvenile prawn sites around Princess Charlotte Bay.

THE FUTURE

Monthly sampling of adult prawns in Princess Charlotte Bay will continue until December 1991. Our work will gradually focus more on analysis and write-up through the second half of this year and into 1992.

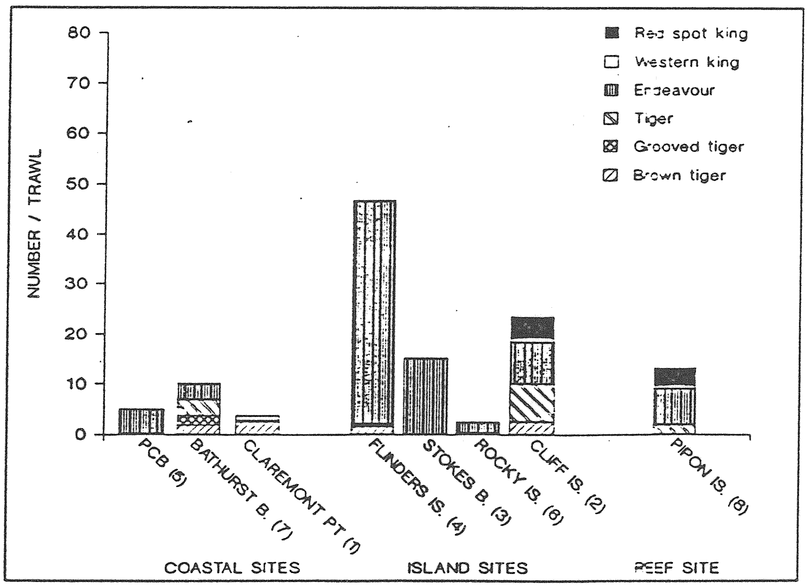


Figure 3. Average number of prawns per shot (100m), at each juvenile site, from October 1990 to April 1991.

FURTHER INFORMATION

Contact Kurt Derbyshire or Sue Helmke at the Northern Fisheries Centre.

Officiating at the recent tag lottery draw were (left to right): Chris Lupton (OIC Fisheries Station, Burnett Heads, QDPI); Reg. Watson (Senior Biologist, Northern Fisheries Centre, QDPI); Bill Izard (QCFO Cairns Branch Chairman); and Steve Bredhauer (MLA for Cook, which includes Cape York and Torres Straits.)

From previous page

A word from our sponsors (Trinity Petroleum, Mobil and Carpentaria Marine Pty Ltd).

Wednesday 20

Over view of the northern fin-fish management plan (AFS).

Who is NORMAC? Summary of 1990 activities (NORMAC Chairman).

Biological view of restructuring (CSIRO).

Restructuring report (AFS Task Force).

Private discussions where required (AFS).

A few other items are also being considered and I am sure that with this diversity of topical subjects and with the speakers I have arranged, this workshop will again be most interesting and informative. Please be sure to show this notice to someone else who may wish to attend.

I am looking forward to hearing from fishermen shortly.

I can be contacted at CSIRO Division of Fisheries, PO Box 120, Cleveland, QLD 4163, fax (07) 286 2582, phone (07) 286 8226.

Brian Taylor
Liaison Officer

Tag lottery winners

WINNERS have been announced of the QDPI northern tagged prawn lottery.

Primary Industries Department researchers have been tagging prawns along the coast and putting the names of fishermen returning tags into the draw for a lottery for a variety of prizes.

First prize in each case was a windsurfer, second prize a compact disc player and third a colour television.

The winners are:

Bowen-Mackay Lottery
First: D. R. and A. J. Vickers, Bowen.
Second: D. Steer, Bowen.
Third: A. Dewar, Bundaberg.

Princess Charlotte Bay Lottery
First: A. Carr, Cairns.
Second: F. Wren, Cannonvale.
Third: J. Burns, Bundaberg.

Torres Straits Lottery
First: G. Lowe, Cairns.
Second: P. Eastauchffe, Brisbane.
Third: P. Schultz, Brisbane.

COMINGS & GOINGS

Herb Bonney retires

HERB Bonney, former Acting Director-General of the Department Environment & Heritage (DEH), has retired.

Mr Bonney, who was well known to many fishermen, retired in late November and was farewelled at separate functions at DEH and the Primary Industries Department, where he served for much of his 30 years in the State Public Service.

The new DEH Director-General is (Dr) Craig Emerson.

Bank appointment

A BANKER with 16 years' experience has returned to Townsville for the third time to take up duty as Regional Marketing Manager with the Commonwealth Development Bank.

Mark Llewellyn, previously at the Commonwealth Bank in Mackay, has been appointed to this new position. Mr Llewellyn has spent most of his

Cairns Post 10/3/90

DPI tag 12,000 prawns in crucial fishing area

MEMBERS of the Northern Fisheries Unit of the Department of Primary Industries have started to monitor one of the most important commercial fishing areas of the North Queensland coast.

Last month a team from the fisheries unit in Cairns tagged about 12,000 prawns in Princess Charlotte Bay and according to the project leader, Mr Kurt Derbyshire, another 4000 will be tagged in the next few weeks.

He said it was the first time they had tagged prawns in Princess Charlotte Bay, even though it was considered an important area to monitor.

"It is a multi-species area that has several species of prawn which are commercially viable," Mr Derbyshire said.

He said the tagging program involved pushing a plastic tag through the body of the prawn and was conducted during the off-season when trawlers were not fishing the area.

"They seem to survive this quite well and grow normally," Mr Derbyshire said.

He said the prawn season did not start until April 15 which allowed time for the prawns to grow and move around. When the prawns were eventually caught and returned to the DPI, information gained would be put into a computer program.

"We want to discover their movements, growth rate and natural mortality rate," Mr Derbyshire said.

He said prawn trawlers could get tag return kits from the Northern Fisheries Unit and their co-operation was essential for the success of the project.

Mr Derbyshire said although the danger of over-fishing always existed in areas like Princess Charlotte Bay, monitoring programs helped keep tabs on the situation.

He said the program involved tagging important commercial species including brown tiger prawns, red spot king prawns, blue legged king prawns and endeavor prawns.

The Cairns Post, Friday, April 20, 1990

Computer helps with prawn catch

CATCHING small, unprofitable prawns early in the prawn season could be a thing of the past with the development of a sophisticated computer model to pinpoint life cycles.

The Queensland Department of Primary Industry's Northern Fisheries Unit based in Cairns in conjunction with centres at Burnett Heads and Brisbane is working on the model, known as the Yield per Recruit Model.

The Queensland DPI Northern Fisheries Unit fisheries biologist, Mr Kurt Derbyshire, said a version of the model was being used in Bowen and it should be perfected by the end of the year.

"The computer will help us predict how the prawns are growing. If they are below a certain size then they are no value for the export market," he said.

"Life cycles vary from year to year hence variations on season closures but what is good for the prawns is good for the fishermen and we are caught between the devil and the deep blue sea at the moment.

"One big thing about the closures is that it is there to protect juvenille prawns," he said.

More than 700 trawlers dropped their nets on Sunday for the beginning of the season.

Early reports indicate there were a lot of catches of small prawns, Mr Derbyshire said.

Fishermen also have reported soft shells in catches.

Mr Derbyshire said this could be caused by prawns malting (they do this regularly to grow), due to moom phases, rain and so on.

He said variations in life cycles and therefore the timing of the prawn season could be weather driven.

"For example the banana prawns in the Gulf are very dependent on rainfall and although they are not as important on the east coast, it could be a similar reason for the catches they are pulling in now," he said.

"But it is not common for them to be all doing it at once and we won't know for ourselves until we get there and take samples," he said.

A fisheries representative will spend a week on a commercial vessel at Princess Charlotte Bay on Monday to collect samples for analysis.

Tagged prawns

FISHERMEN have returned 250 of the 11,000 tagged prawns released at Princess Charlotte Bay earlier this year. Northern Fisheries Unit of the DPI biologist, Mr Kurt Derbyshire, said he was happy about the current return rate and they expected 10 per cent of the prawns returned by the end of the season. He said fisherman should return any tagged prawn with accurate details of when and where it was caught. Mr Derbyshire said such details gave them an idea of how the prawns move, their growth rate and natural mortality rate.

Cairns Post 30/5/90

Cairns Post 8/6/90

Prawn tag project in need of aid

A MAJOR prawn research project looking at the effectiveness of prawn closures along the Queensland coast needs the help of the State's fisherman.

Queensland Department of Primary Industries fish researchers have released almost 40,000 tagged prawns in northern Queensland waters.

"It is absolutely essential to our research that fishermen who catch any tagged prawns return them to us through any one of a number of sources along the coast," the officer-in-charge of the Burnett Heads Research Station, Mr Mike Dredge said.

"It should be done as soon as possible after the catch." "Tagged prawns should be put into a plastic bag - leaving the tag in the prawn - and frozen.

"Recapture information including when and where the catch was made and the fisherman's name and postal address should be included."

"Lottery tickets will be issued in return for the tagged prawns."

Mr Dredge said the tagging between January and April had been concentrated in three areas:

- Torres Strait (20,300 released) where studies had been underway since the early 1980's.
- Princess Charlotte Bay (7900) where research was in the first of a three year project.
- Bowen-Mackay (8200) where two years' work had been undertaken.

"Already substantial numbers of prawns have been returned but it is important that the returns keep coming in as we need better information on the older prawns."

Mr Dredge said the Bowen-Mackay report should be ready in about 12 months; the Princess Charlotte Bay report about 12 months later. In the meantime, seasonal information was being communicated to commercial fishermen

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Prawn lottery draw

• Queensland Commercial Fishermen's Organisation Cairns branch chairman Bill Izard looks on as Member for Cook, Steve Bredhauer draws the winners of the tagged prawn lottery at the Northern Fisheries Stations, Cairns.

TWO Cairns men Andrew Carr and Geoff Lowe took out the top prizes in a lottery with a difference last week — their tickets were prawns.

Tickets for the lottery were given only to fishermen who returned tagged prawns to the Queensland Department of Industries.

The prawn tagging program is the key to research into prawn migration patterns, growth rates and natural mortality estimates — with some 44,000 prawns released this year.

This information will assist in the planning and evaluation of prawn closures.

The tagged prawn lottery was conducted for three regions — Bowen Mackay, Princess Charlotte Bay and Torres Straits — with prizes of a wind surfer, a compact disc player and a portable color television set for each region.

Andrew Carr won first prize in the Princess Charlotte Bay lottery while Geoff Lowe won the Torres Straits draw.

The Member for Cook, Mr Steve Bredhauer and Queensland Commercial Fishermen's organisation representative, Mr Bill Izard drew the winners for the three regions.

Second and third in the Princess Charlotte Bay lottery were F. Wren, Cannonvale. John Burns, Bundaberg.

In the Torres Straits lottery P. Eastauchffe, Brisbane, was second and P. Schultz, Brisbane, third.

Results in the Bowen/Mackay region were 1 Dudley and Anthony Vickers, Bowen; 2 David Steer, Bowen; Andrew Dewar, Bundaberg.