Report

to

The Great Barrier Reef Marine Park Authority

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THE DISTRIBUTION AND ABUNDANCE OF CETACEANS IN THE GREAT BARRIER REEF REGION WITH NOTES ON SIGHTINGS OF WHALE SHARKS.

H Marsh

Zoology Department, James Cook University of North Queensland,

Townsville, Qld 4811

EXECUTIVE SUMMARY

Between 1984 and 1987 inclusive, cetaceans were counted from the air at an overall sampling intensity of 9.6% over a total area of 70471km² within the Great Barrier Reef region during surveys designed primarily to census dugongs. The surveys concentrated on the region between the coast and 20km offshore, but extended to the outer barrier between Dunk Island (17°59'S., 146°14'E.) and Hunter Point (11°30'S., 142°50'E.). All surveys were conducted between September and December inclusive, except for one in April 1985. The resultant information is thus seasonally biased. Only 56% of the 457 groups of dolphins sighted were even tentatively identified to genus or species: *Tursiops truncatus* (176 groups), *Sousa chinensis* (62 groups), *Orcaella brevirostris* (12 groups) and *Stenella* species (5 groups). Twenty-six small whales (*Pseudorca crassidens* or *Globicephala macrorhynchus*) were sighted; 25 of these were between Townsville and Dunk Island. Only seven large whales were sighted: six presumed minkes, *Balaenoptera acutorostrata*, (four confirmed) near mid shelf reefs opposite Cape Grenville (11° 58'S) in November 1985; and a humpback (*Megaptera novaeangliae*) in the Whitsunday area in October 1987. Nine whale sharks, *Rhincodon typus* were seen, all but one on the mid to outer shelf around latitude 12°S. Dolphin sightings were corrected for perception bias (the proportion of animals visible in the transect which are missed by observers), but not for availability bias (the proportion of animals that are invisible due to water turbidity) with survey-specific correction factors. The resultant minimum population estimate for dolphins for the whole region surveyed in October-November was 13350 ± S.E.860 at an overall density of 0.19 ± S.E.0.012km^{-2}, a precision of 6.4%. This a major underestimate

of the numbers actually present. Dolphins occurred all along the coast and throughout the Great Barrier Reef lagoon. The largest area of high dolphin density (>0.5km^{-2}) was in the mid-shelf region between latitudes of 13° and 11°30′in November 1985.

CONCLUSION AND RECOMMENDATION

The Great Barrier Reef Marine Park supports a substantial population of cetaceans, mostly coastal species. Their distribution and abundance should continue to be monitored in the course of the dedicated surveys for dugongs. There is no justification for conducting dedicated cetacean surveys at this time.

INTRODUCTION

Despite public enthusiasm for live cetaceans, the limited scientific knowledge of the whales and dolphins of the Great Barrier Reef region is largely derived from the examination of putrid carcasses of animals washed up on beaches. Heinsohn (1978) lists 27 species of cetaceans that are likely to occur along the northern Great Barrier Reef section of the Queensland coast. However, the occurrence of several of these species has not been verified.

The cetaceans of the Great Barrier Reef region fall into two taxonomic groups: (1) large baleen whales, most of which spend relatively short periods in Great Barrier Reef waters in the course of their migrations; (2) toothed whales which range in size from the giant sperm whale to small dolphins. The small whales and dolphins also form two groups on the basis of their broad ecological affinities: (1) coastal dolphins such as the bottlenose dolphin, *Tursiops truncatus*, the Indopacific humpback dolphin, *Sousa chinensis*, and the Irrawaddy dolphin, *Orcaella brevirostris*, which feed and are mostly seen in inshore waters; and (2) oceanic species such as pilot whales *Globicephala*, false killer whales, *Pseudorca crassidens*, and spinner dolphins *Stenella longirostris* which are usually observed some distance from land.

The only information on the abundance of cetaceans in Barrier Reef waters is for humpback whales, *Megaptera novaeangliae*, which are censused in southern Queensland en route to their winter breeding grounds in the Great Barrier Reef region (Paterson and Paterson, 1989; Bryden *et al* 1990; see also Simmons and Marsh, 1986). In this report, I present data on the distribution and relative abundance of cetaceans sighted during dedicated aerial surveys for dugongs which were conducted in the Great Barrier Reef region between 1984 and 1987 inclusive.

These surveys were designed primarily to census dugongs, and were consequently suboptimal as cetacean surveys. It is much easier to control the sampling fraction if the survey aircraft does not routinely deviate from the transect to circle groups of animals. Hence, circling is not usually permitted during a dugong survey. This is satisfactory as dugongs are relatively easy for a trained observer to identify, and are usually sighted in small groups. In contrast, it is often necessary to circle groups of dolphins to identify them to species and to obtain accurate counts. As this was not done in these surveys, I was often unable to obtain specific identifications. Thus many of the identifications should be regarded as tentative only. Further, it is likely that group sizes were often underestimated. The surveys were conducted between September and December inclusive, except for one in April 1985,. The resultant information is thus seasonally biased. This is particularly serious for species such as humpback whales, most of which are winter visitors to the Great Barrier Reef region. Finally, the surveys were limited to the inshore waters in the Central and Southern Section of the Park, and so provide no information on the distribution and abundance of cetaceans in the mid and outer shelf waters south of Dunk Island.

Admitting these limitations, this report aims to provide a baseline for monitoring future trends by (1) generating distribution maps for cetaceans in parts of the Great Barrier Reef Marine Park (GBRMP), and (2) calculating a minimum estimate for dolphins in the area. These baseline data will then be compared with the results obtained during the surveys for dugongs which the Great Barrier Reef Marine Park Authority (GBRMPA) has agreed to conduct every five years.

Whale sharks, <u>Rhincodon typus</u>, are the largest fish known and approximate in size to some species of large whale. They were also sighted occasionally during these surveys and these sightings are included in this report.

METHODS

The surveys were conducted over the inshore waters of the region to at least 20km offshore between the southern boundary of the Great Barrier Reef Marine Park and Hunter Point (11°30'S., 142°50'E.). The surveys were extended to the outer barrier reef between Dunk Island (17°59'S., 146°14'E.) and Hunter Point. Details of the survey design are in Marsh and Saalfeld (1989a and b and 1990). The transect lines (Figures 1 to 14) were aligned east west, and after the initial survey (Figure 8), were spaced at intervals of 2.5' latitude except in areas of particular interest to the GBRMPA (see Figures 1,2,4,5,6,9,13,14). The overall sampling intensity over the total survey area of 70471km² was 9.6%.

For estimation of regional densities, the area was divided into 36 blocks (Figures 1-14). The intensity at which each block was surveyed is summarised in Table 1.

The timing of the various surveys is summarised in Tables 1 and 2, and Figures 1-14; more details are given in Marsh (1989), Marsh and Saalfeld (1989a and 1990). The surveys were carried out only when the weather was good. The weather conditions are summarised in Table 2, and detailed in Marsh (1989). All surveys were held during periods of neap tides to minimise water turbidity. Daily schedules were arranged to avoid severe glare associated with low or mid-day sun.

Survey methodology, data handling, and analytical techniques were similar to those used in other surveys as outlined by Marsh and Saalfeld

(1989b) and Marsh and Sinclair (1989a and b).

A combined population estimate for all dolphins was calculated for each block for each survey because of the problem of identifying dolphin species. The sightings of whales and whales sharks were too few for statistical treatment.

Correction factors for perception bias (groups of dolphins visible on the transect line that were missed by observers) and their associated coefficients of variation were calculated for each survey (Table 3) as outlined in Marsh and Sinclair (1989a). I did not calculate separate correction factors for groups of different sizes (see Graham and Bell, 1989). The numbers of large groups was very small (Figure 15) so that the probability of a group's being seen by one or both members of each observing team was independent of group size for each survey (Chi-square tests, 4 d.f., $p>0.05$). It was not possible to correct for availability bias (dolphins that were unavailable to observers because of water turbidity) because of the lack of data from an aerial survey of dolphins in clear water (when all animals are potentially visible) to use as a standard.

The significance of the differences in density between surveys for the areas which were surveyed twice were tested using paired t tests with transect as the basis for pairing. Input data were corrected densities per square kilometre based on mean group sizes and the estimates of the correction factor for perception bias, each transect contributing one density per survey based on the combined corrected counts of the teams of observers on each side of the aircraft.

RESULTS

Species sighted

Only 56% of the 457 groups of dolphins sighted in the transects were even tentatively identified to genus or species: Tursiops truncatus (176 groups), Sousa chinensis (62 groups), Orcaella brevirostris (12 groups) and Stenella species (5 groups). The relative abundance of identified groups should not be regarded as a reliable index of relative abundance per se; some observers were more confident of identifying some species than others.

Sightings of larger cetaceans and whales sharks were comparatively rare and I have included incidental records obtained in the course of the surveys. Twenty-six small whales were sighted in 11 groups. I was unable to confirm whether they were false killer whales, Pseudorca crassidens, or pilot whales, Globicephala, however, I believe that those seen in the Central Section (Figures 5 and 6) were probably false killer whales. Nine whale sharks and seven large whales were sighted: six presumed minkes, Balaenoptera acutorostrata, (four confirmed), and a humpback, M. novaeangliae.

Group size and composition

Figure 15 summarises the group sizes for dolphins identified as T. truncatus, S. chinensis and Stenella species, and for unidentified dolphins. The median group sizes were as follows: T. truncatus (1), S. chinensis (1.5), Stenella species (2), O. brevirostris (2) and small whales (1). The largest group of small whales sighted was six. The six minke whales sighted in the Far Northern Section in November 1985 (Figure 14) were loosely scattered in the same general area. All sightings of whale sharks were of single individuals. These small group sizes may partly be an artefact of the relatively narrow transect width

(200m on either side of the aircraft).

Population and density estimates for dolphins

Dolphins are distributed all along the coast of the Great Barrier Reef region (Figures 1-14). The resultant minimum population estimate for the whole region surveyed in October-November was 13350 ± S.E.860 at an overall density of 0.19 ± S.E.0.012km^{-2}, a precision of 6.4%. This is a major underestimate of the numbers actually present as densities were not corrected for animals which were invisible below the surface. The highest densities of dolphins were seen in inshore waters near both the northern and southern boundaries of the Southern Section in November 1986 (Figures 1 and 3); off the Whitsundays (Figure 4) and the Palm Islands (Figure 6) in October 1987; and in the mid-shelf region between latitudes 13° and 11° 30'S in November (but not in April) 1985 (Figure 12 and 14). It was in this last region that the highest density estimate for a block was recorded (0.542 dolphins per km^2 for Block 36 in November 1985) (Figure 14 and Table 1).

There were significant differences between repeat surveys of some areas. Between Campbell Point and Hunter Point in the Far Northern Section (Figures 11-14), the density of dolphins was significantly higher on the offshore blocks (30, 32, 36) in November 1985 than in the previous April 2 (paired t test, $t=6.1$, d.f.=48; $p < 0.0000$). However, there was no detectable change in dolphin density in the inshore blocks (29, 31, 33, 34 35) in this region between the same surveys (paired t test, $t=1.82$, d.f.=58; $p < 0.07$). These results suggest that the higher density observed in the offshore blocks in November as opposed to April was real rather than an artefact of sighting conditions.

The density of dolphins between Cape Cleveland and Dunk Island (Blocks 16-19) was significantly greater in October 1987 than in

September 1986 (paired t test, t=2.68, d.f.=62; $p < 0.009$). Again, the difference is probably real; the weather conditions were slightly better in 1986 than in 1987 (Table 2).

Sightings of whales and whale sharks

Twenty-five of the 26 small (probably false killers) whales sighted were seen in the coastal waters between Townsville and Dunk Island (Figures 5 and 6). Fifteen individuals were seen September 1986, 10 in October 1987. The only other small whale sighted was on the northernmost transect of the entire surveys in November 1985 (Figure 14).

Six presumed minke whales (four confirmed) were sighted in November 1985 in the same general region as all but one of the whale sharks (Figures 12 and 14). The only other large whale sighted was a humpback the Whitsundays in October 1987 (Figure 4). A whale shark was also sighted in this region on the same survey.

DISCUSSION

Comparison with other areas

It is difficult to place the densities obtained in this study in perspective. The only aerial surveys for dolphins reported in the literature were of localised inshore areas and were carried out using a slightly different survey technique. Standard errors for the density estimates were not usually listed (e.g. Leatherwood, 1979). The results listed for the USA in Table 4 are probably more appropriately compared with the densities given for various blocks in Table 1. Give the differences in the technique, the density values are of similar magnitude.

The most relevant comparison is with the data obtained from western Australia using the technique developed for the Great Barrier Reef surveys. Again the density values are similar. The density of dolphins in the Great Barrier Reef region is apparently unremarkable and similar to other coastal regions.

The differences in density observed between surveys are not surprising. Seasonal differences in dolphin density have been reported from other areas e.g. there is considerable evidence of seasonal movements of T. truncatus both between coastal and offshore areas and between higher and lower latitudes (see Kenney, 1990). The marked differences in density observed between the April and November 1985 surveys in the Far Northern Section of the GBRMP presumably represent similar movements.

Important areas for cetaceans identified by the surveys

The central shelf area in the Far Northern Section of the GBRMP between about 11° 30′ and 13° S is clearly of particular interest in view of the high density of dolphins and the sightings of whales and whale sharks in November 1985. The dolphins generally occurred in relatively small groups and those identified were mainly T. truncatus (Figure 15). Williams (1983) observed that the fish on these reefs were more similar to the inshore communities elsewhere in the Great Barrier Reef Region than to other mid-shelf communities which is consistent with the lack of observations of oceanic dolphins.

The presence of minke whales and whale sharks in this area in November 1985 suggests that it is rich in plankton. Wolanski et al., (1988) demonstrated a mechanism whereby localised upwellings on the upper continental slope of the northern Great Barrier Reef can enrich the depleted surface waters of nutrients, particularly nitrate and phosphate. The presence of banks of Halimeda in the inter-reefal seabed at the latitudes where the whales and whale sharks were sighted (Drew and Abel, 1988) is consistent with upwellings occurring in this area.

I also saw baleen whales and whale sharks (Simmons and Marsh, 1986) in a similar situation in the Murray Island area near the northern tip of the Great Barrier Reef in November 1983.

The sighting of small whales in the inshore area between Townsville and Dunk Island is interesting, and consistent of anecdotal reports of sightings of small whales in this area at that time of year.

Future surveys

Despite the limitations of these surveys, I do not recommend that GBRMPA fund dedicated surveys for cetaceans at present. Cetaceans do not present an urgent management problem in this region even though some drown accidentally in gill nets such as shark nets set for bather protection (Paterson, 1979).

The chief weakness of my surveys is that they were seasonally limited, providing virtually no information on seasonal visitors to the reef waters such as humpback whales. Humpbacks could become a management problem in the GBRMP as their numbers recover to pre-whaling levels especially with the burgeoning interest in commercial whale watching in Australia. There may be pressure to search for winter breeding concentrations of humpbacks to provide a focus for whale watching activities. However, as Simmons and Marsh (1986) point out such concentration may not exist in the Great Barrier Reef region (at least at present), because of the vastness of the area and the low whale numbers.

In view of the huge areas involved and the increasing level of surveillance resulting from the management presence, I consider that it would be premature to mount dedicated aerial surveys for humpbacks in the GBRMP. The success of such surveys would be strongly weather dependent. Bryden (1985) suggests that sighting is much reduced when skies are overcast and winds greater than Beaufort 5. Unfortunately, the occurrence of humpbacks in reef waters coincides with the season of south-east trade winds which means that the seas are often rough (Pickhard et al., 1977). As Osmond et al., (1989) have shown, the incidental observations of observers on surveillance aircraft offer a cost-effective method of acquiring data on the distribution (but probably not the relative abundance) of conspicuous species such as humpback whales in the GBRMP.

In the apparent absence of serious management problems associated with other cetaceans in the GBRMP, I suggest that their distribution and abundance should continue to be monitored in the course of the dedicated surveys for dugongs. There is no justification for conducting dedicated cetacean surveys at this time.

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ABLE 1: Total area (km²), sampling intensity (%), estimated densities (± S.E.) and number of dolphins (± S.E.) for the surveys of the Great Barrier Reef Marine Park. Sigtings of all species of dolphins have been combined for these estimates.

lock	Area (km²)	Sampling fraction	Density per km²	Numbers
ishore Southern Section, November 1986.				
	1391	9.0	0.502 ± 0.118	699 ± 164
	895	9.1	0.097 ± 0.049	87 ± 45
	1022	16.2	0.127 ± 0.037	130 ± 38
	3274	8.5	0.075 ± 0.023	245 ± 75
	1105	17.9	0.013 ± 0.008	15 ± 9
	6016	9.0	0.034 ± 0.017	205 ± 101
	1612	8.8	0.112 ± 0.050	180 ± 81
	775	9.3	0.365 ± 0.096	283 ± 74
otal				1844 ± 241
ecision				13.1%
ishore Central Section, September - October 1987.				
	297	20.0	0.381 ± 0.191	113 ± 57
	644	9.6	0.214 ± 0.077	250 ± 91
	1901	13.1	0.135 ± 0.054	229 ± 91
	448	17.8	0.106 ± 0.049	48 ± 22
	2230	7.9	0.223 ± 0.079	498 ± 178
	218	18.1	0	0
	560	18.2	0.280 ± 0.314	16 ± 18
	612	17.2	0.189 ± 0.104	115 ± 64
	3846	8.5	0.270 ± 0.062	1037 ± 239
	310	20.1	0	0
	714	18.5	0.303 ± 0.117	217 ± 84
tal				2523 ± 347
ecision				13.8%

E 1 (CONTINUED).

	Area (km²)	Sampling fraction	Density per km²	Numbers
ns Section: southern boundary to Cape Bedford, October 1987.				
	3800	8.6	0.174 ± 0.052	662 ± 197
	2013	8.3	0.460 ± 0.092	927 ± 186
	4785	8.6	0.151 ± 0.042	722 ± 201
	715	8.7	0.091 ± 0.055	65 ± 39
al				2376 ± 348
ision				14.6%
Bedford to Hunter Point, Cairns and Far Northern Sections, November				
	1004	8.3	0.050 ± (0.034)	50 ± 34
	665	16.3	0.019 ± (0.016)	13 ± 11
	1050	7.8	0.035 ± (0.034)	37 ± 36
	5233	8.9	0.026 ± (0.014)	135 ± 73
	7839	8.5	0.048 ± (0.016)	379 ± 127
	451	8.1	0	0
	1561	7.9	0.023 ± (0.021)	36 ± 33
	1194	7.9	0.183 ± (0.085)	219 ± 102
	4600	8.2	0.412 ± (0.086)	1896 ± 396
	259	9.5	0.286 ± (0.179)	74 ± 47
	396	25.9	0.173 ± (0.077)	69 ± 31
	452	8.2	0.287 ± (0.186)	130 ± 84
	6584	9.1	0.542 ± (0.075)	3571 ± 492
al				6609 ± 667
cision				10.1%

TABLE 1 (CONTINUED)

Block	Area (km²)	Sampling fraction	Density per km²	Numbers
Campbell Point to Hunter Point, Far Northern Section, April 1985.				
29	451	8.1	0.075 ± 0.068	34 ± 31
30	1561	7.9	0.022 ± 0.019	34 ± 31
31	1194	7.9	0.156 ± 0.065	187 ± 77
32	4600	8.2	0.033 ± 0.019	152 ± 88
33	259	9.6	0.180 ± 0.202	47 ± 53
34	396	25.9	0	0
35	452	8.2	0.146 ± 0.117	66 ± 53
36	6584	9.1	0.098 ± 0.028	642 ± 186
Total				1162 ± 236
Precision				20.3%
Cape Cleveland to Dunk Island, inshore Northern Central Section, September 1986.				
16	612	16.7	0	0
17	3845	8.4	0.123 ± 0.041	472 ± 159
18	310	18.3	0	0
19	714	16.1	0.147 ± 0.045	105 ± 32
Total				577 ± 162
Precision				28.1%

TABLE 2: Weather conditions encountered on each survey.

Date	Blocks	Wind speed (km h⁻¹)	Cloud cover (oktas)	Minimum Cloud height (m)	Beaufort sea state mode (range)	Glare mode (range)	Visibility (km)
Nov. 1984	24-27	≤ 20	0-2	650-1000	1 (0-3)	1 (0-2)	>10
Apr. 1985	29-36	≤ 30	2-7	200-2500	2 (1-3.5)	2 (0-3)	8->10
Nov. 1985	24-30	≤28	0.5-5	460-1525	2.5 (0-4)	1 (0-2.5)	8->10
Nov. 1985	31-36	≤19	0-4	305-610	1 (0-3)	1 (0-2.5)	>20->50
Sep. 1986	16-19	≤20	0-2	300	1.0 (0.0-3.0)	1.0-2.0 (0.0-3.0)	10-20
Nov. 1986	1-8	0-20	0-4	600	1.0 (0.0-3.0)	0.0-1.0 (0.0-2.0)	>20
Oct. 1987	9-19	0-<10	0-2	450	1.0 (0.0-3.0)	1.0-2.0 (0.0-3.0)	>20
Oct. 1987	20-23	5-15	0-4	450	1.0 (0.0-3.0)	0.0-1.0 (0.0-2.0)	<20

[a] worse side of aircraft

[b] scale: 0=none;1=25% of field of view affected by glare:2=25≤50%:3=>50%.

TABLE 3: Details of group size and correction factors used in the population estimates.

Date	Blocks: lines	Group size mean (C.V.)	Number of observers		Perception Correction Factor estimate (C.V.)	
			Port	Starboard	Port	Starboard
Apr. 1985	29-36	2.2121 (0.1345)	1[a]	2	2.0000 (0.0090)	1.2593 (0.0090)
Nov. 1985	24-27; 28:9-23; 29 & 30; 31-32: 10-12	1.4400 (0.1450)	2	2	2.0000 (0.4167)	1.4545 (0.2347)
Nov. 1985	28: 1-8	1.4400 (0.1450)	2	1[b]	2.0000 (0.4167)	2.0000 (0.2347)
Nov. 1985	31 & 32: 13-32; 33; 34: 39-42; 35: 43-48; 36: 33-48	3.4362 (0.0906)	2	2	1.0086 (0.0022)	1.0419 (0.0095)
Nov. 1985	34:50-57; 35&36:49;	3.4362 (0.0906)	1[c]	2	1.1020 (0.0022)	1.0419 (0.0095)
Sep. 1986	16; 17:111-14,117-30 18:151-58,161,164.	2.3810 (0.2433)	2	2	1.1250 (0.0833)	1.0286 (0.0189)
Sep. 1986	16; 17:131-38; 18:138; 19.	2.3810 (0.2433)	1[c]	2	1.5000 (0.0833)	1.0286 (0.0189)
Nov. 1986	1; 2; 3; 4; 5: 50-63, 75, 138-144; 6: 76, 81-88 & 90-106; 7; 8	2.5455 (0.1206)	2	2	1.0324 (0.0110)	1.0332 (0.0106)
Nov. 1986	5: 64-74; 6: 89	2.5455 (0.1206)	2	1[b]	1.0324 (0.0110)	1.1852 (0.0106)
Oct. 1987	9-23: all lines	2.7368 (0.1087)	2	2	1.0302 (0.0067)	1.0400 (0.0098)

[a] Port correction factor based on that of starboard mid-seat observer.

[b] Training transects for starboard mid-seat observer. Starboard correction factor based on correction factor starboard rear-seat observer for the remainder of this survey.

[c] Training transects for port mid-seat observer. Port correction factor based on correction factor of the port rear-seat observer for the remainder of this survey.

TABLE 4: Comparison of the dolphin densities observed in the Great Barrier Reef Marine Park with those obtained from other areas using aerial survey. The results from North America are not strictly comparable due to differences in survey technique.

Location	Dolphins km^{-2}
<u>Great Barrier Reef Region</u>	
Inshore Southern Section	0.11 ± 0.01
Inshore Central Section	0.21 ± 0.03
Cairns Section south of Cape Bedford	0.21 ± 0.03
Cairns-Far North Sections north of Cape Bedford	0.21 ± 0.02
<u>Western Australia</u>[1]	
Shark Bay	0.19 ± 0.02
Ningaloo-Exmouth Gulf	0.16 ± 0.04
<u>Southern USA</u>[2]	
Mississippi gulf coast	0.23
Louisiana gulf coast	0.44
Florida west coast	0.23
Texas gulf coast	0.65
Florida Indian River	0.68

[1] Marsh and Saalfeld unpublished; same technique as this study.

[2] Data from Leatherwood (1979); not strictly comparable with this study.

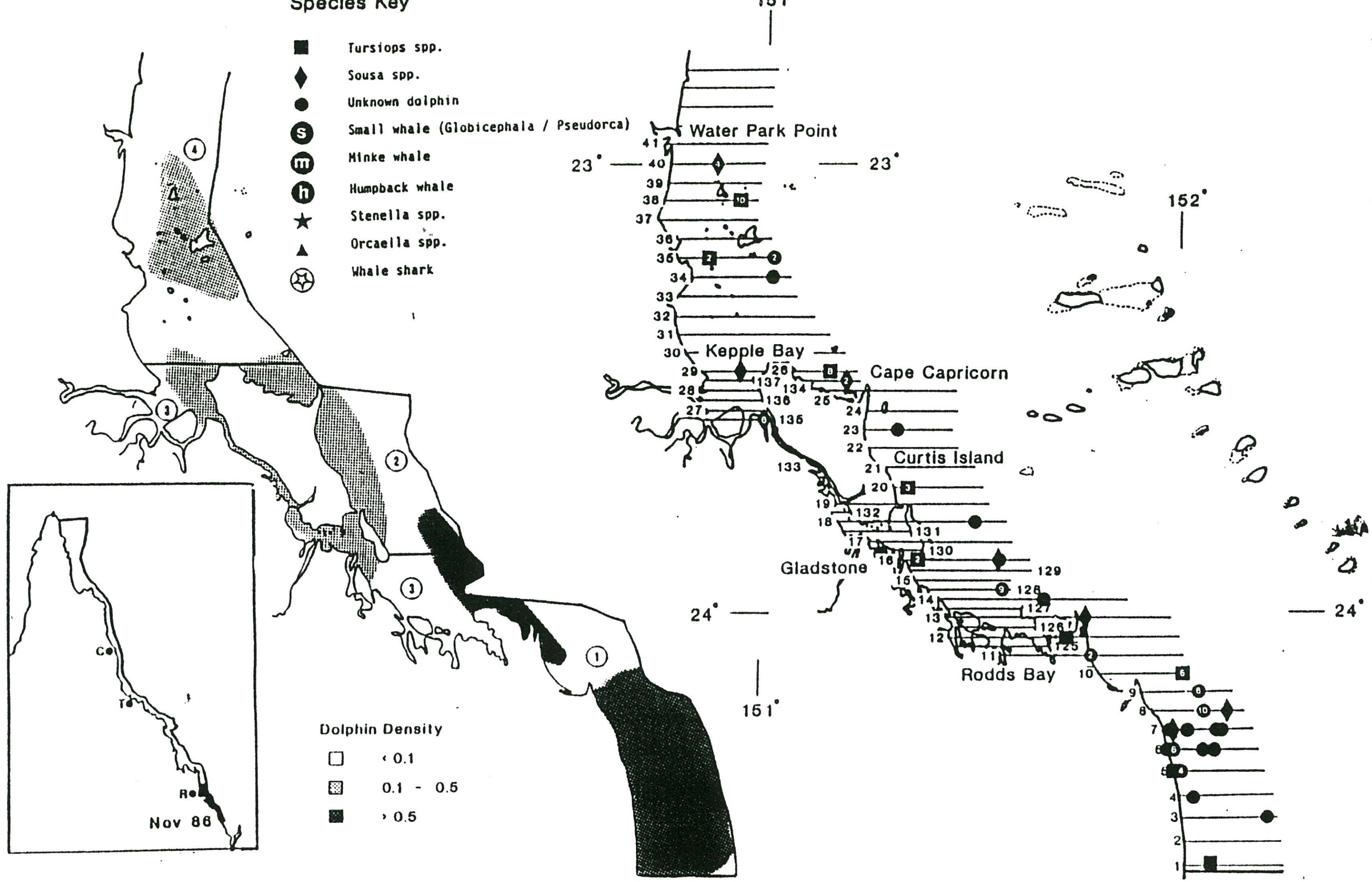

Figure 1 The survey area from the southern boundary of the Great Barrier Reef Marine Park to Water Park Point showing the survey blocks and the density distribution of dolphins in November 1986 (left) and the transect lines and sightings of individual cetaceans (right).

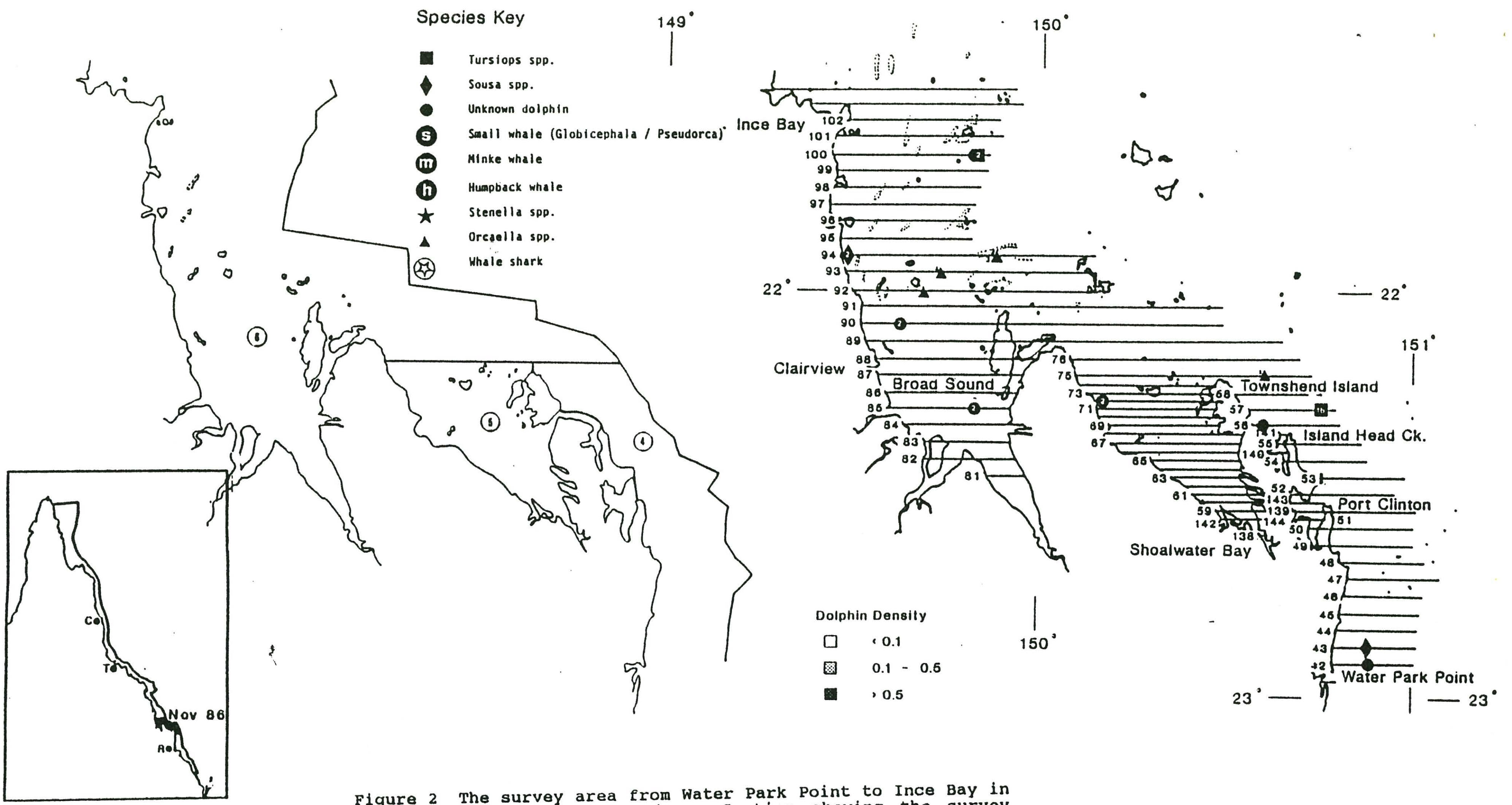

Figure 2 The survey area from Water Park Point to Ince Bay in the Mackay / Capricorn Section showing the survey blocks and the density distribution of dolphins in November 1986 (left) and the transect lines and sightings of individual cetaceans (right).

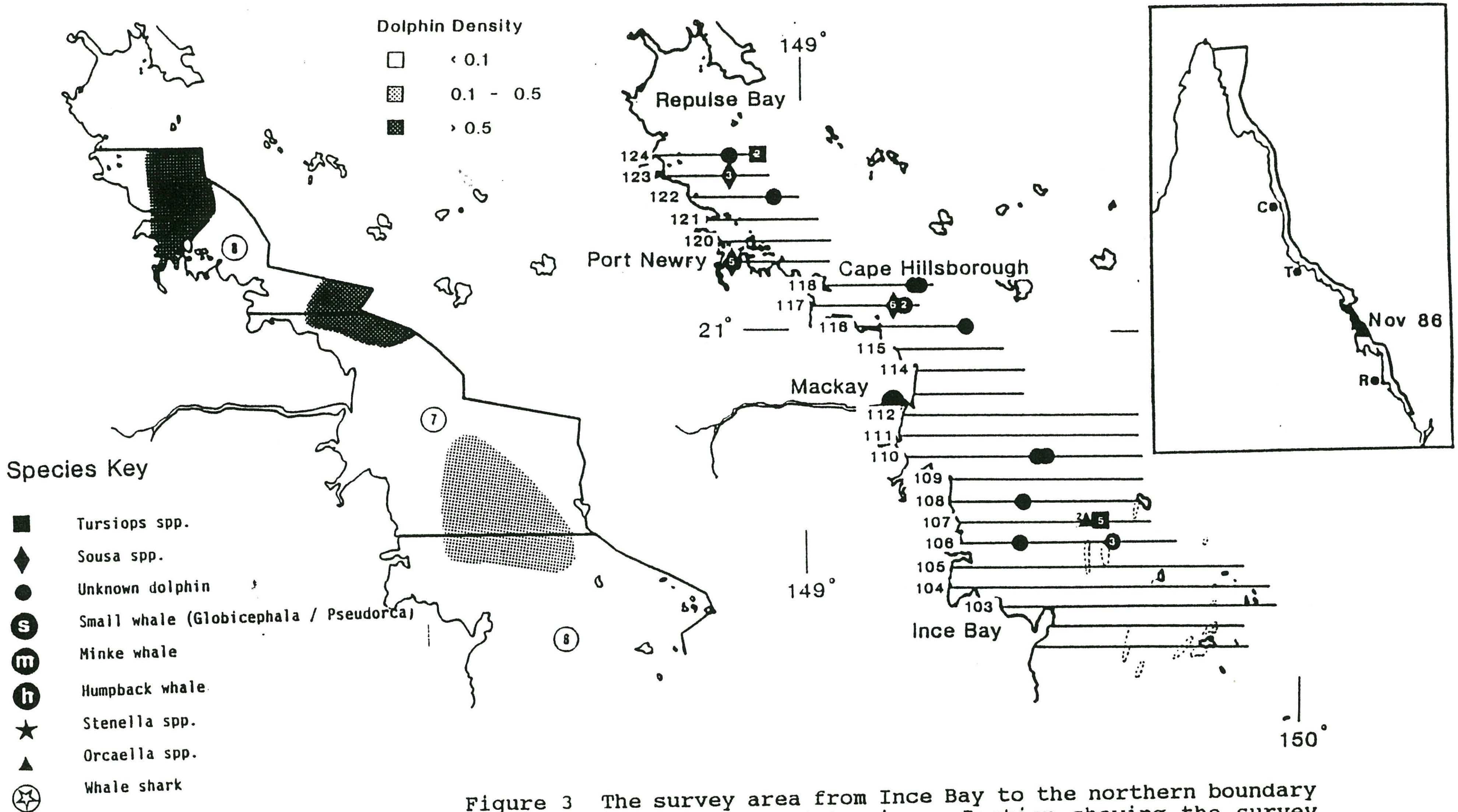

Figure 3 The survey area from Ince Bay to the northern boundary of the Mackay / Capricorn Section showing the survey blocks and the density distribution of dolphins in November 1986 (left) and the transect lines and sightings of individual cetaceans (right).

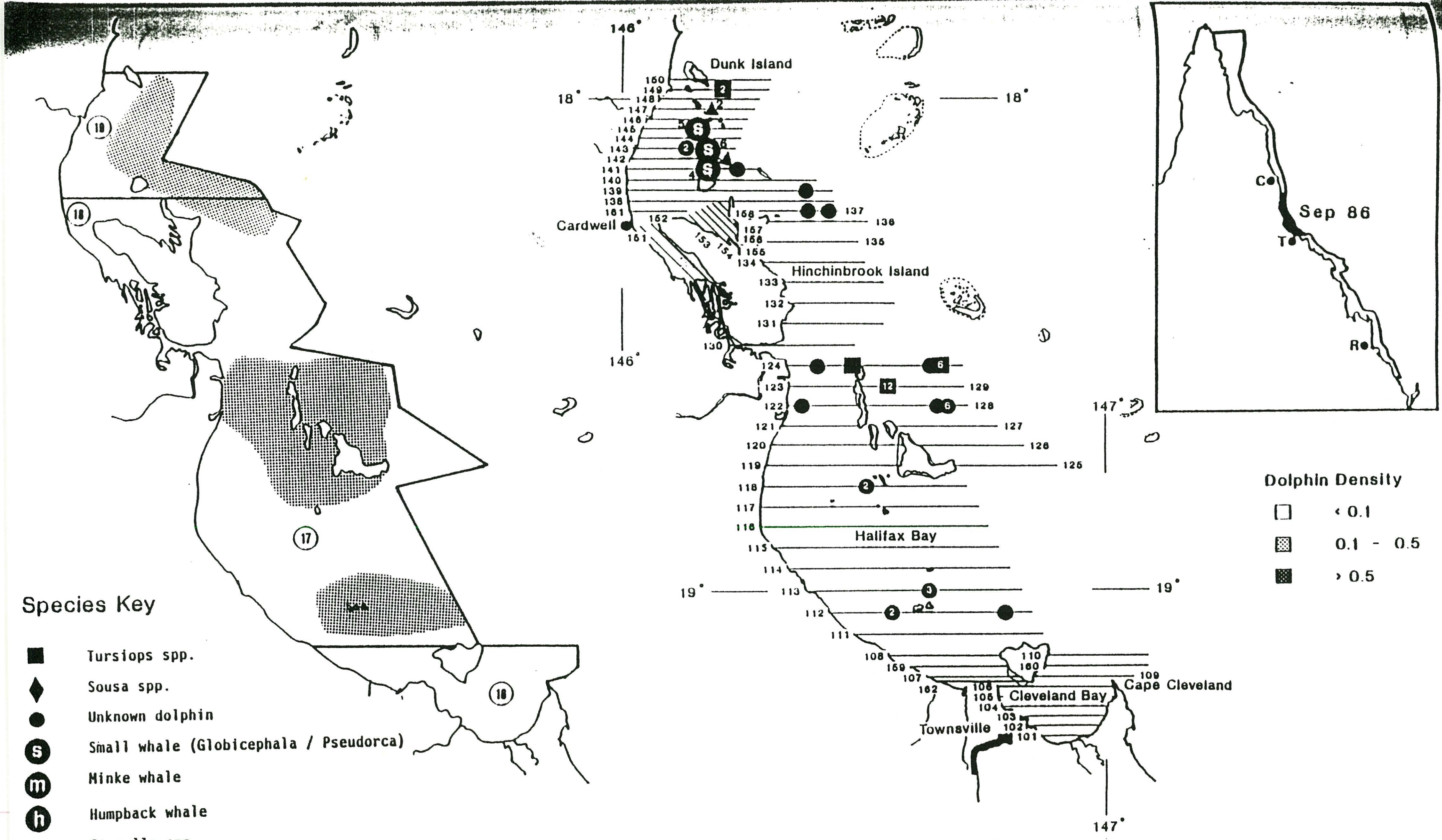

Figure 5 The survey area from Cape Cleveland to the northern boundary of the Central Section showing the survey blocks and the density distribution of dolphins in September 1986 (left) and the transect lines and sightings of individual cetaceans (right).

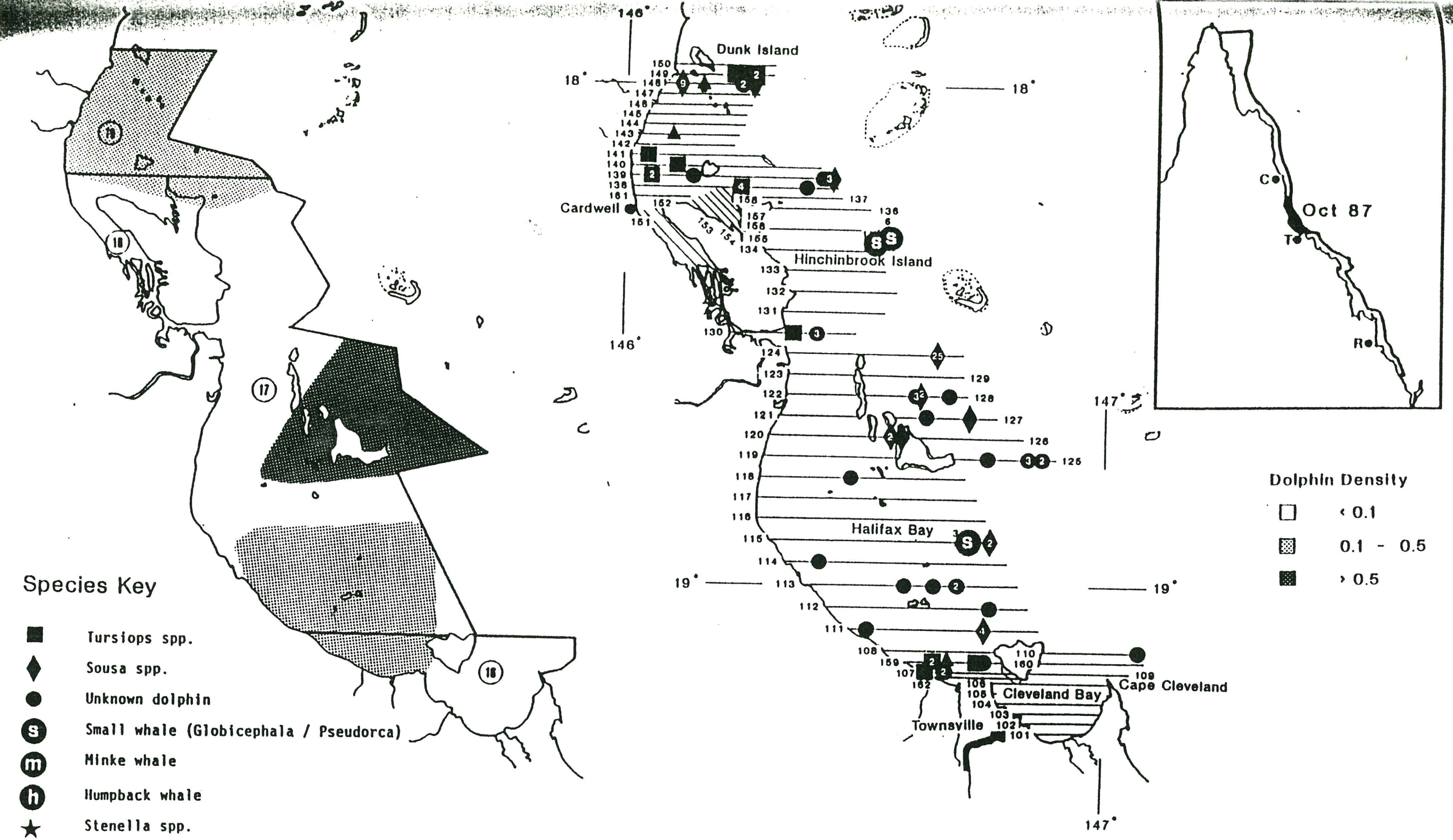

Figure 6 The survey area from Cape Cleveland to the northern boundary of the Central Section showing the survey blocks and the density distribution of dolphins in September - October 1987 (left) and the transect lines and sightings of individual cetaceans (right).

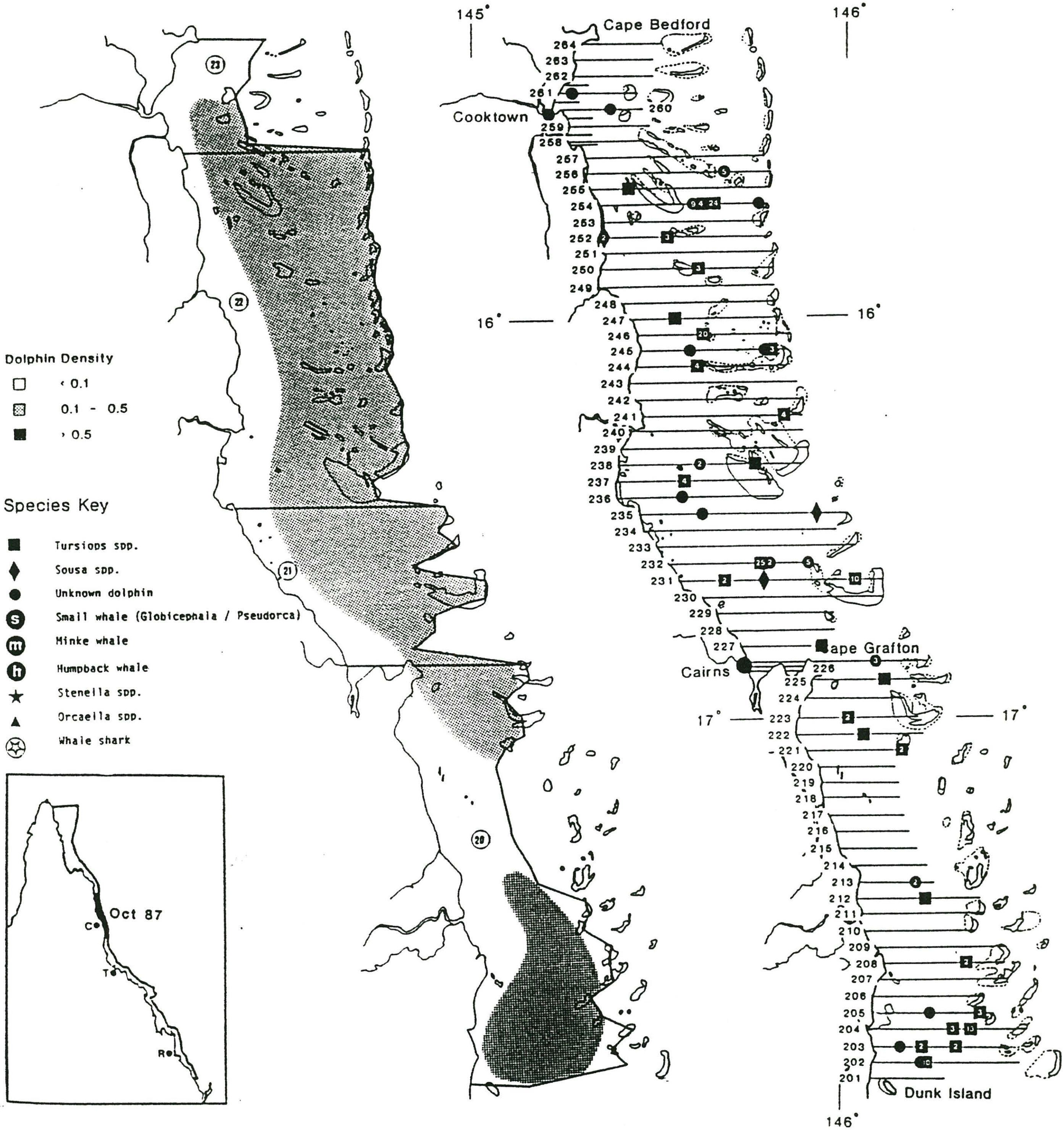

Figure 7 The survey area from the southern boundary of the Cairns Section to Cape Bedford showing the survey blocks and the density distribution of dolphins in October 1987 (left) and the transect lines and sightings of individual cetaceans (right).

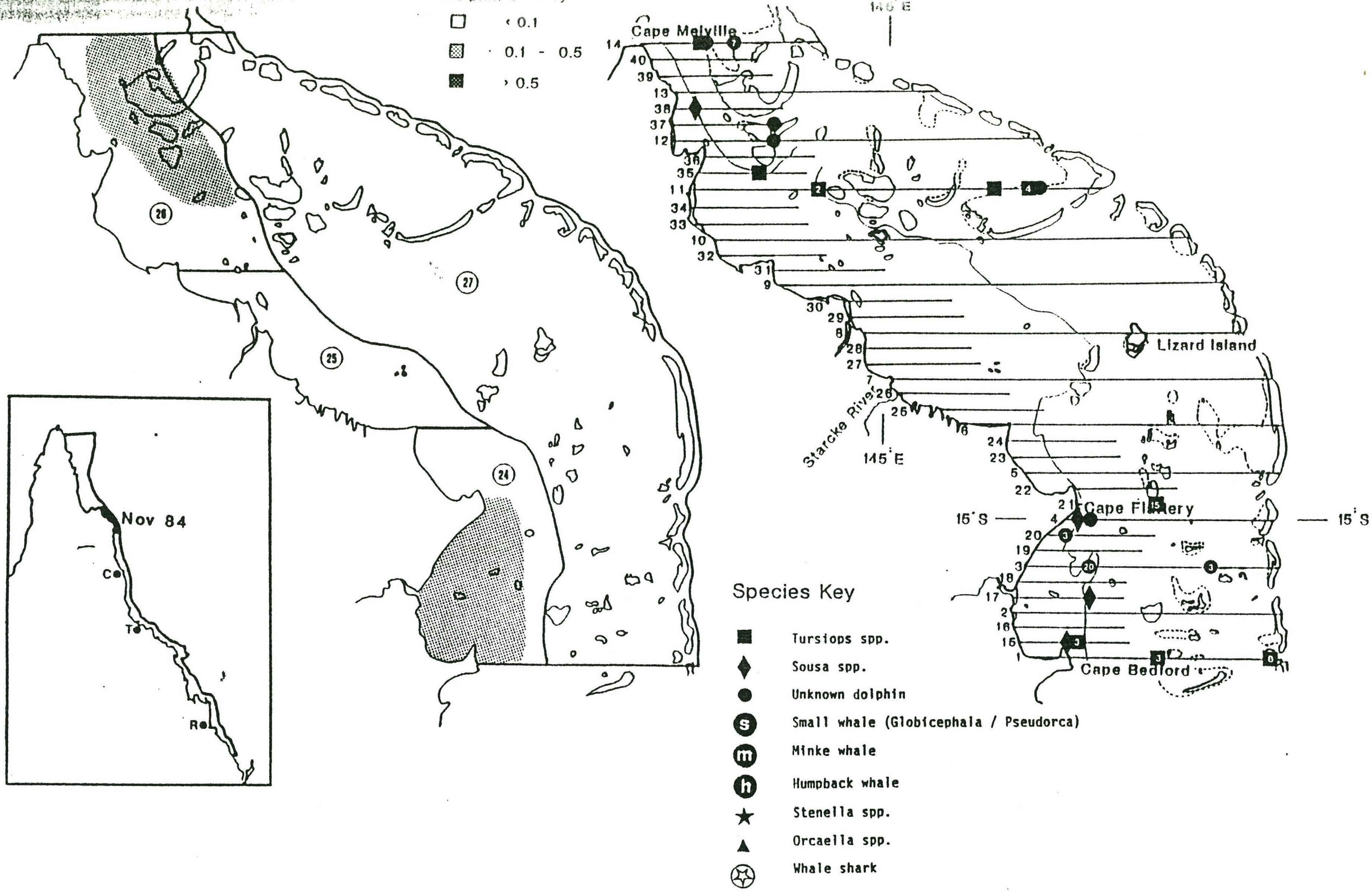

Figure 8 The survey area from Cape Bedford to Cape Melville showing the survey blocks and the density distribution of dolphins in November 1984 (left) and the transect lines and sightings of individual cetaceans (right). A population estimate has not been calculated for this survey as it was conducted whilst the survey technique was being developed.

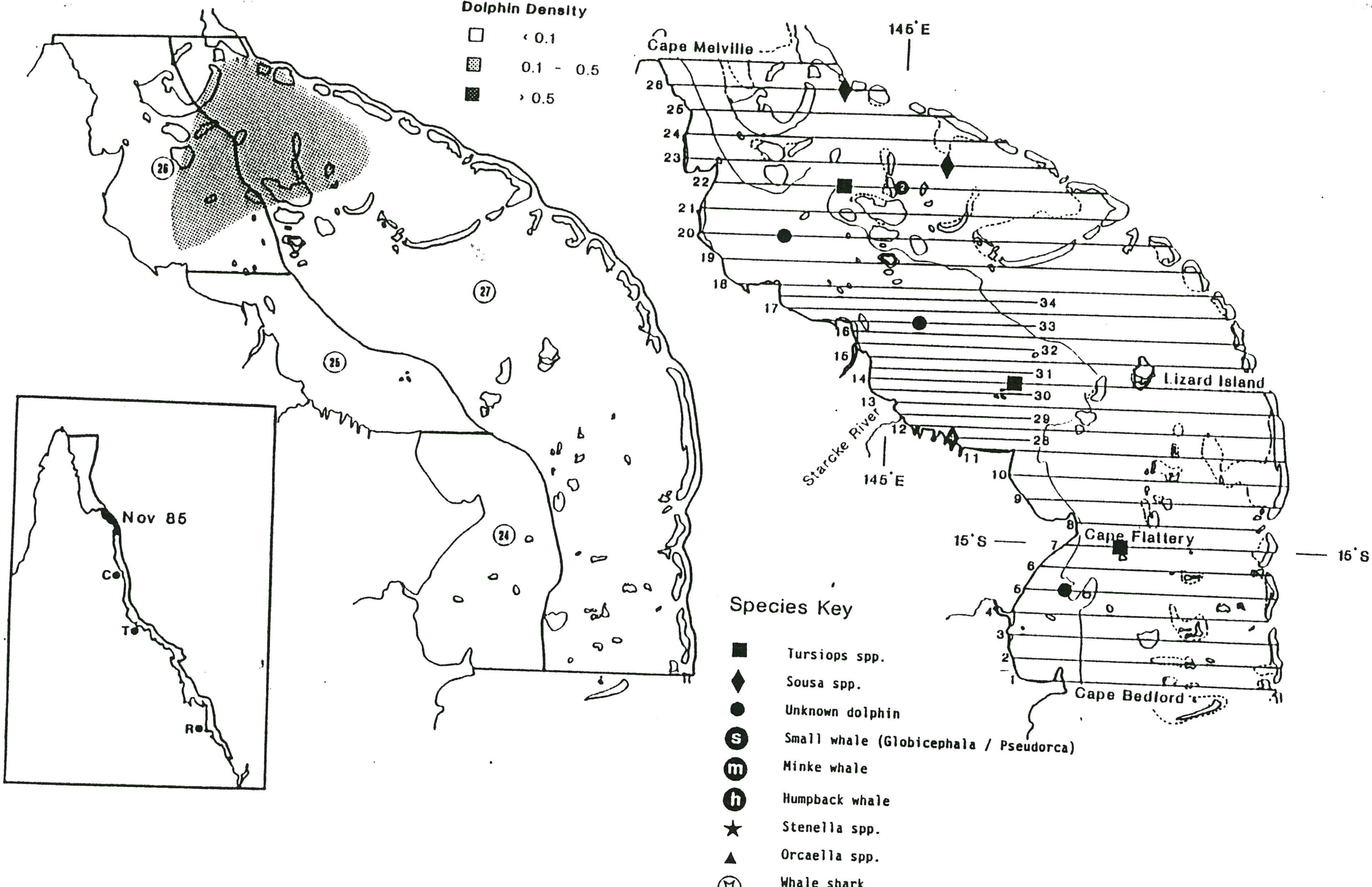

Figure 9 The survey area from Cape Bedford to Cape Melville showing the survey blocks and the density distribution of dolphins in November 1985 (left) and the transect lines and sightings of individual cetaceans (right).

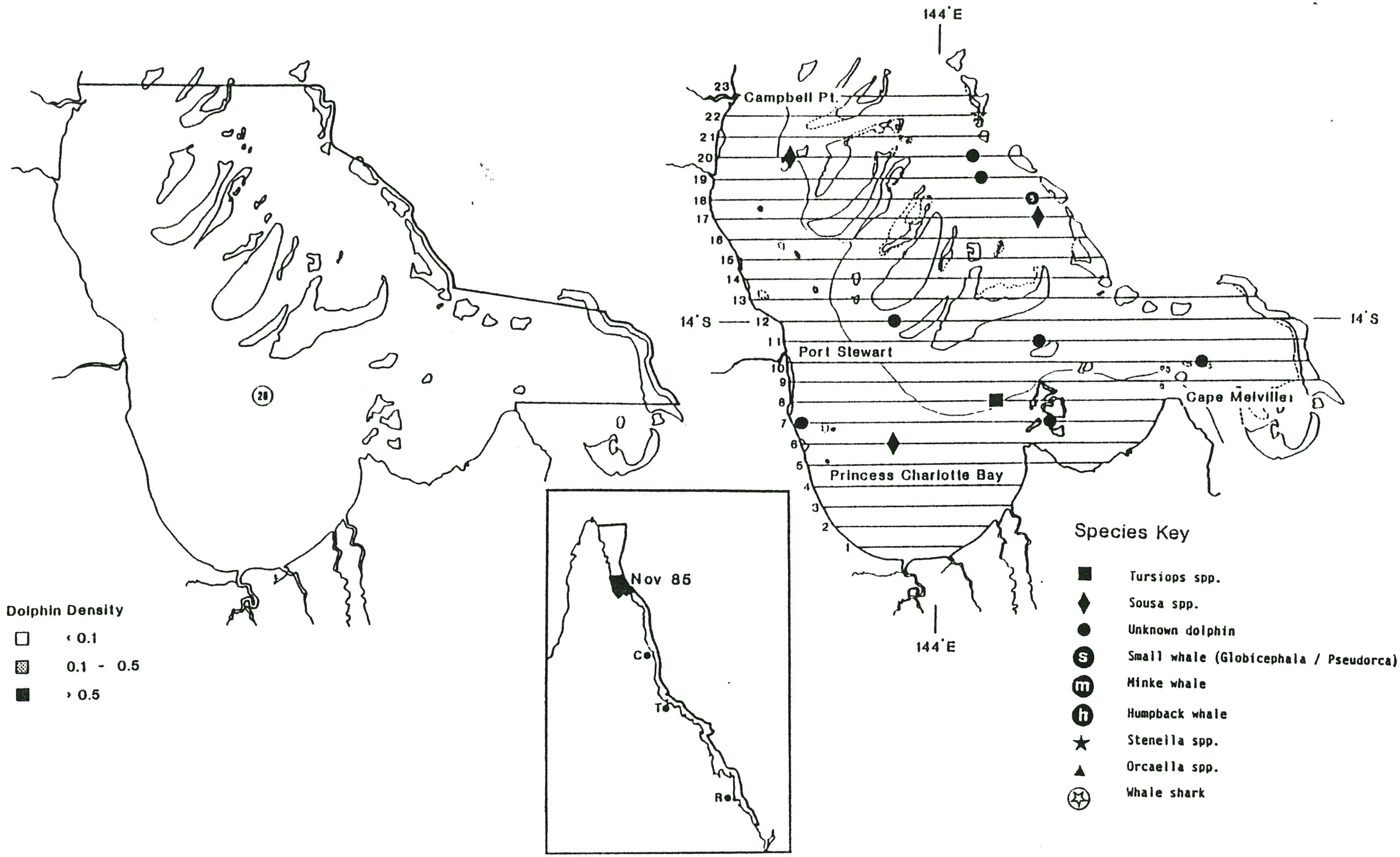

Figure 10 The survey area from Cape Melville to Campbell Point showing the survey blocks and the density distribution of dolphins in November 1985 (left) and the transect lines and sightings of individual cetaceans (right).

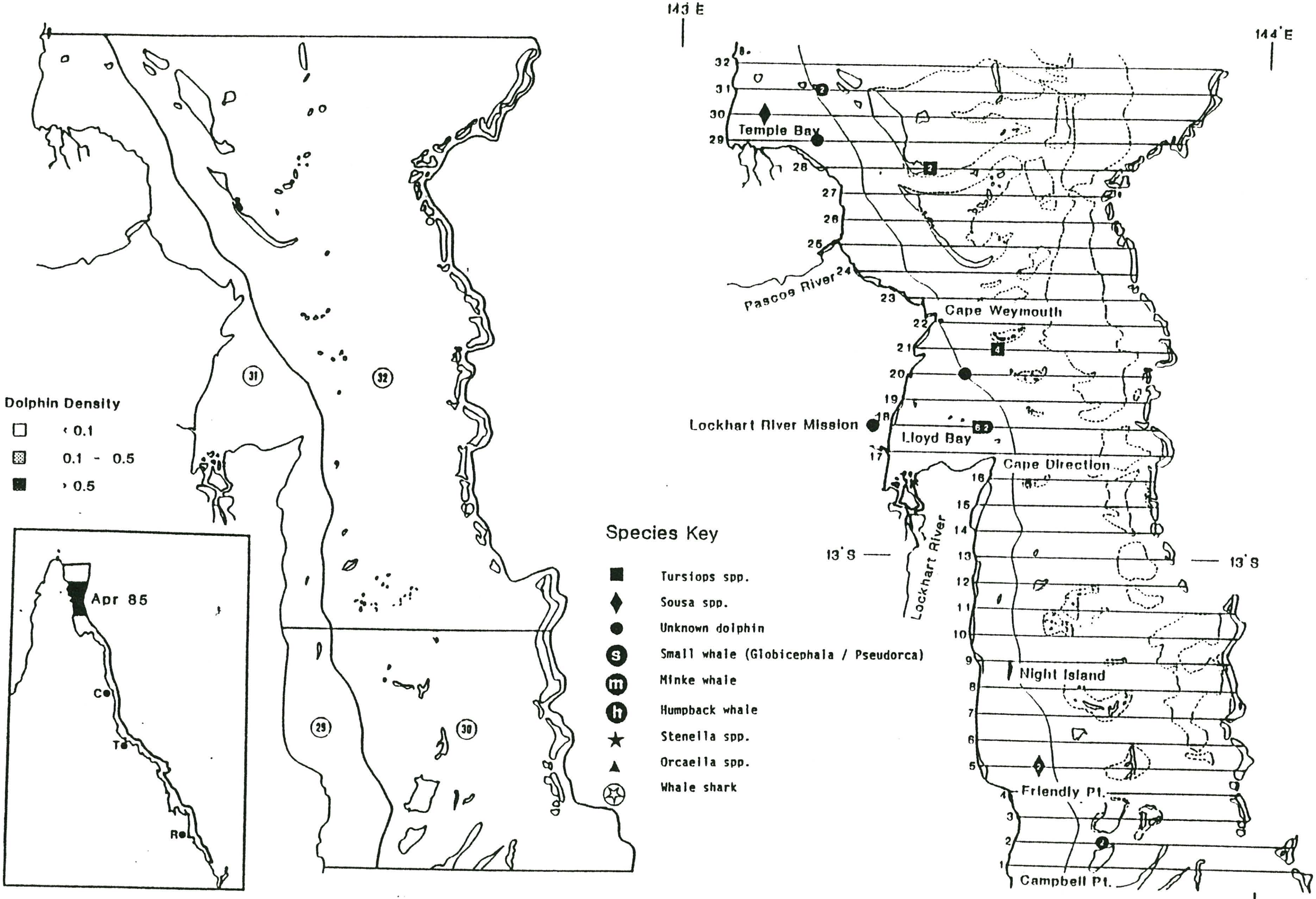

Figure 11 The survey area from Campbell Point to Temple Bay showing the survey blocks and the density distribution of dolphins in April 1985 (left) and the transect lines and sightings of individual cetaceans (right).

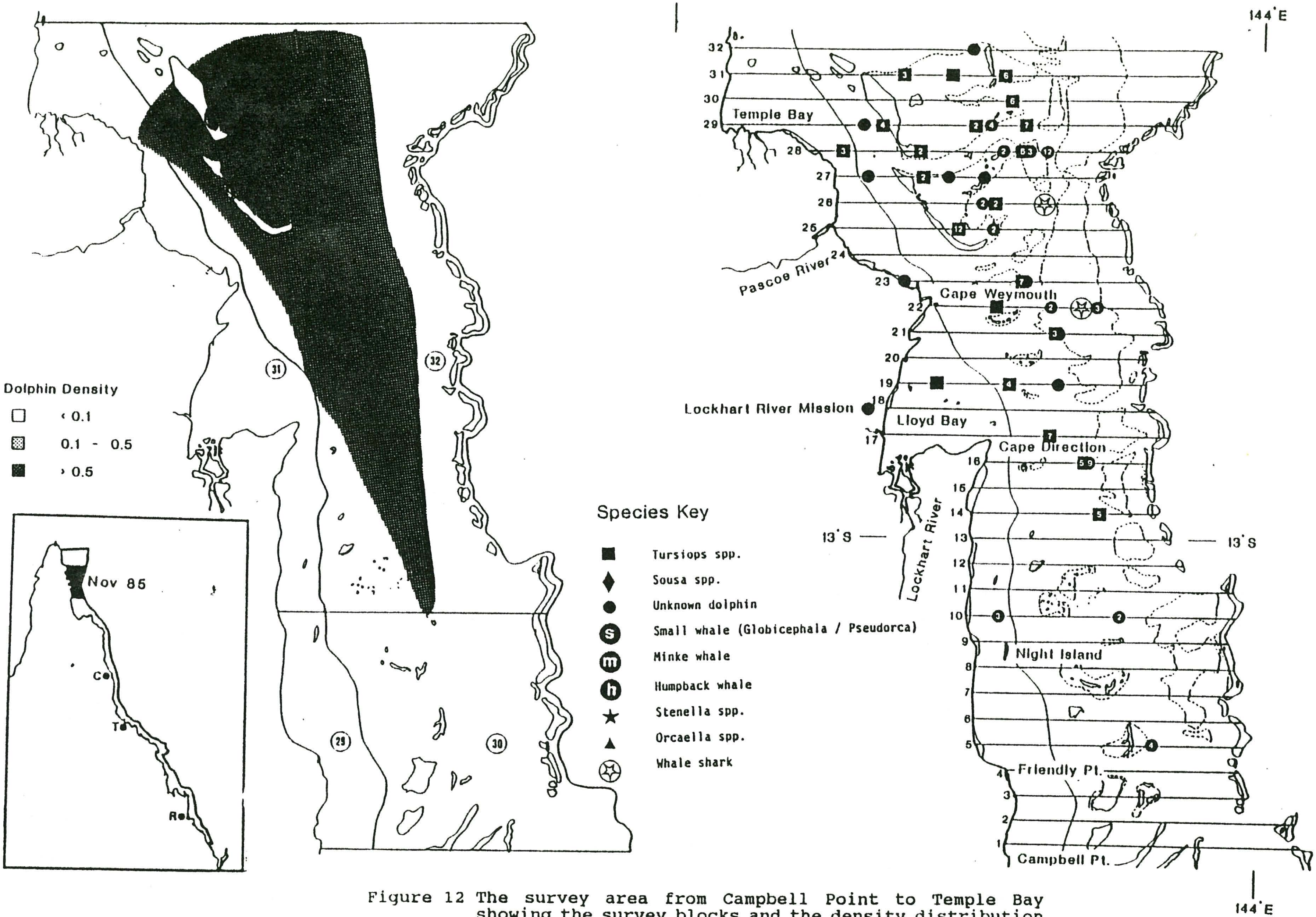

Figure 12 The survey area from Campbell Point to Temple Bay showing the survey blocks and the density distribution of dolphins in November 1985 (left) and the transect lines and sightings of individual cetaceans and whale sharks (right).

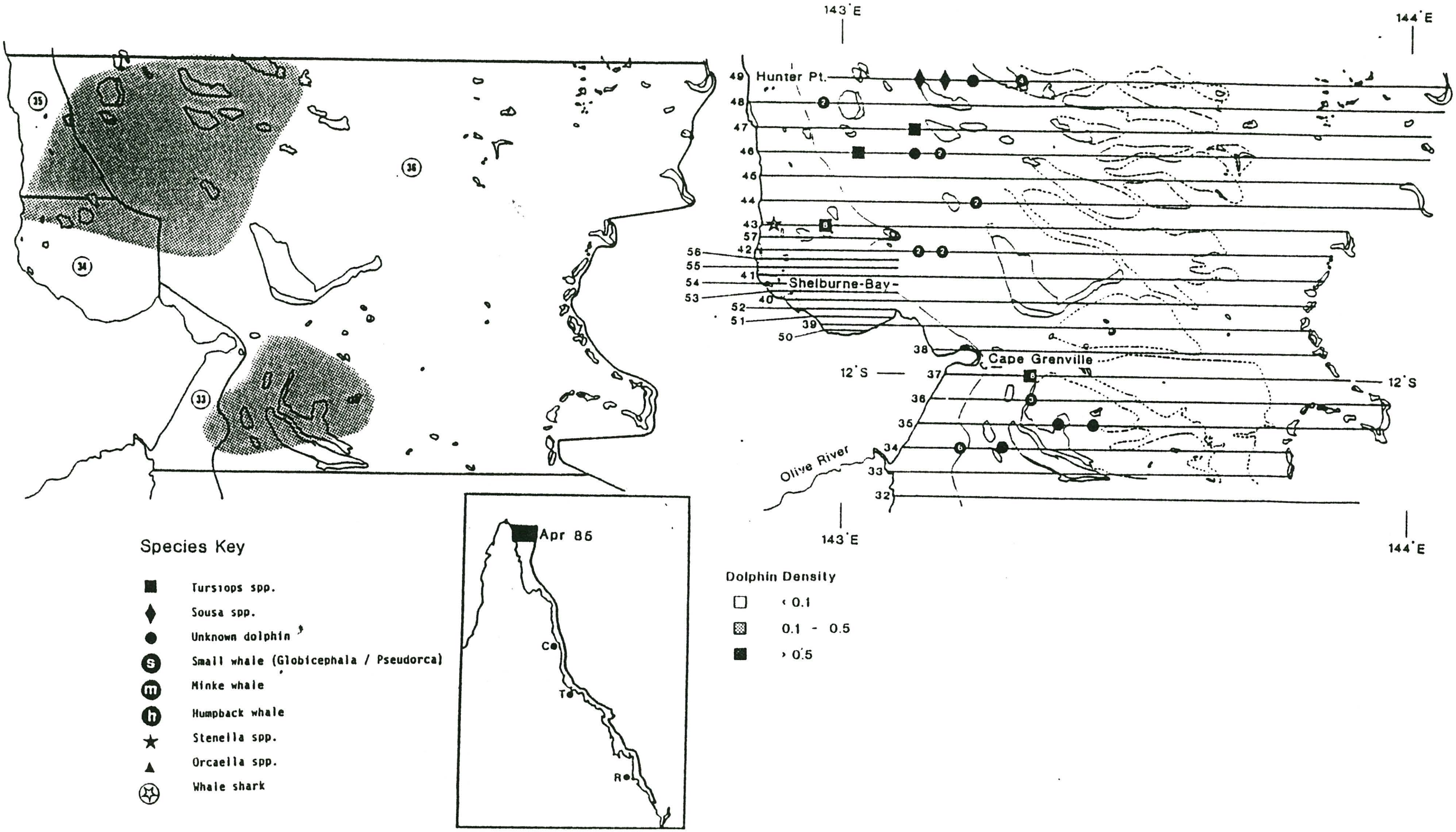

Figure 13 The survey area from the Olive River to Hunter Point showing the survey blocks and the density distribution of dolphins in April 1985 (left) and the transect lines and sightings of individual cetaceans (right).

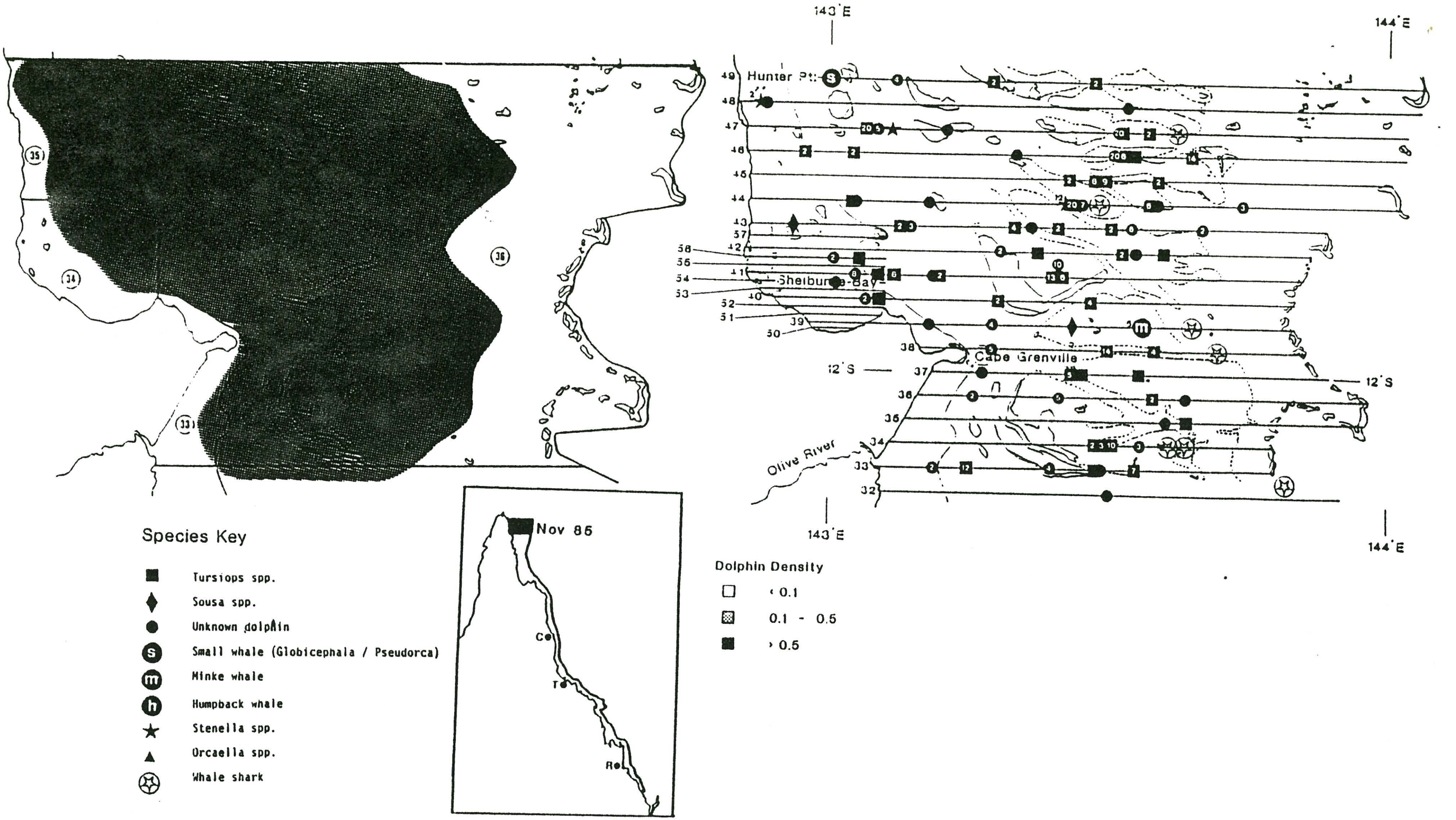

Figure 14 The survey area from the Olive River to Hunter Point showing the survey blocks and the density distribution of dolphins in November 1985 (left) and the transect lines and sightings of individual cetaceans and whale sharks (right).

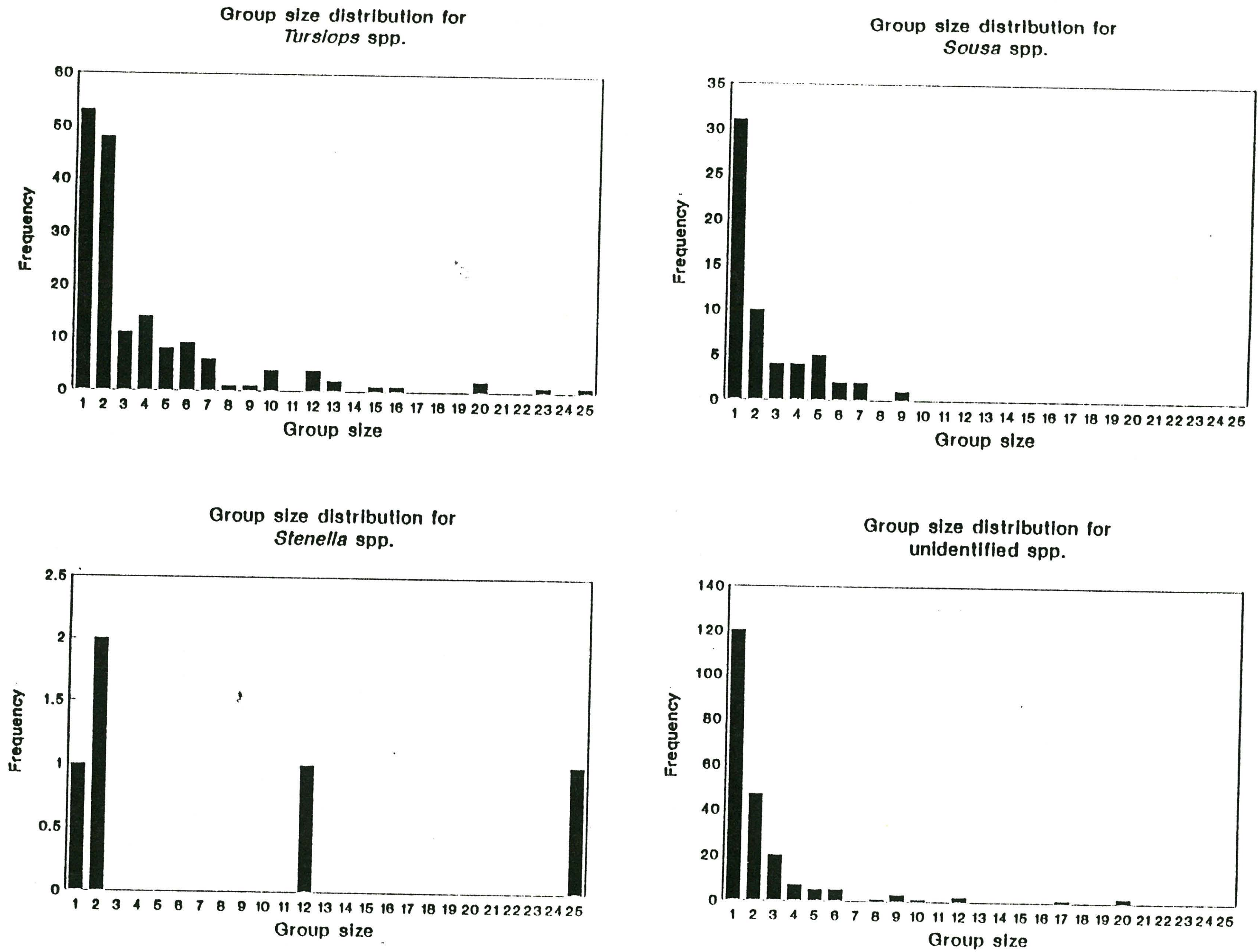

Figure 15 The size frequency distributions of groups of the major categories of dolphins as sighted during the surveys. The distributions are based on the combined data from all surveys. As the counts were obtained during routine transect flying, they are likely to underestimate group sizes.