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FINAL REPORT TO THE FISHERIES RESEARCH AND DEVELOPMENT CORPORATION

A PILOT PROGRAM TO MAXIMISE TASMANIA'S SEA URCHIN (*HELIOCIDARIS ERYTHROGRAMMA*) RESOURCE.

(JC SANDERSON, M LE ROSSIGNOL AND W JAMES)

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FISHERIES RESEARCH & DEVELOPMENT CORPORATION

TASMANIAN SEA URCHIN DEVELOPMENTS

MARINE ENVIRONMENTAL SYSTEMS

A PILOT MANAGEMENT PROGRAM TO MAXIMISE TASMANIA'S SEA URCHIN (*HELIOCIDARIS ERYTHROGRAMMA*) RESOURCE.

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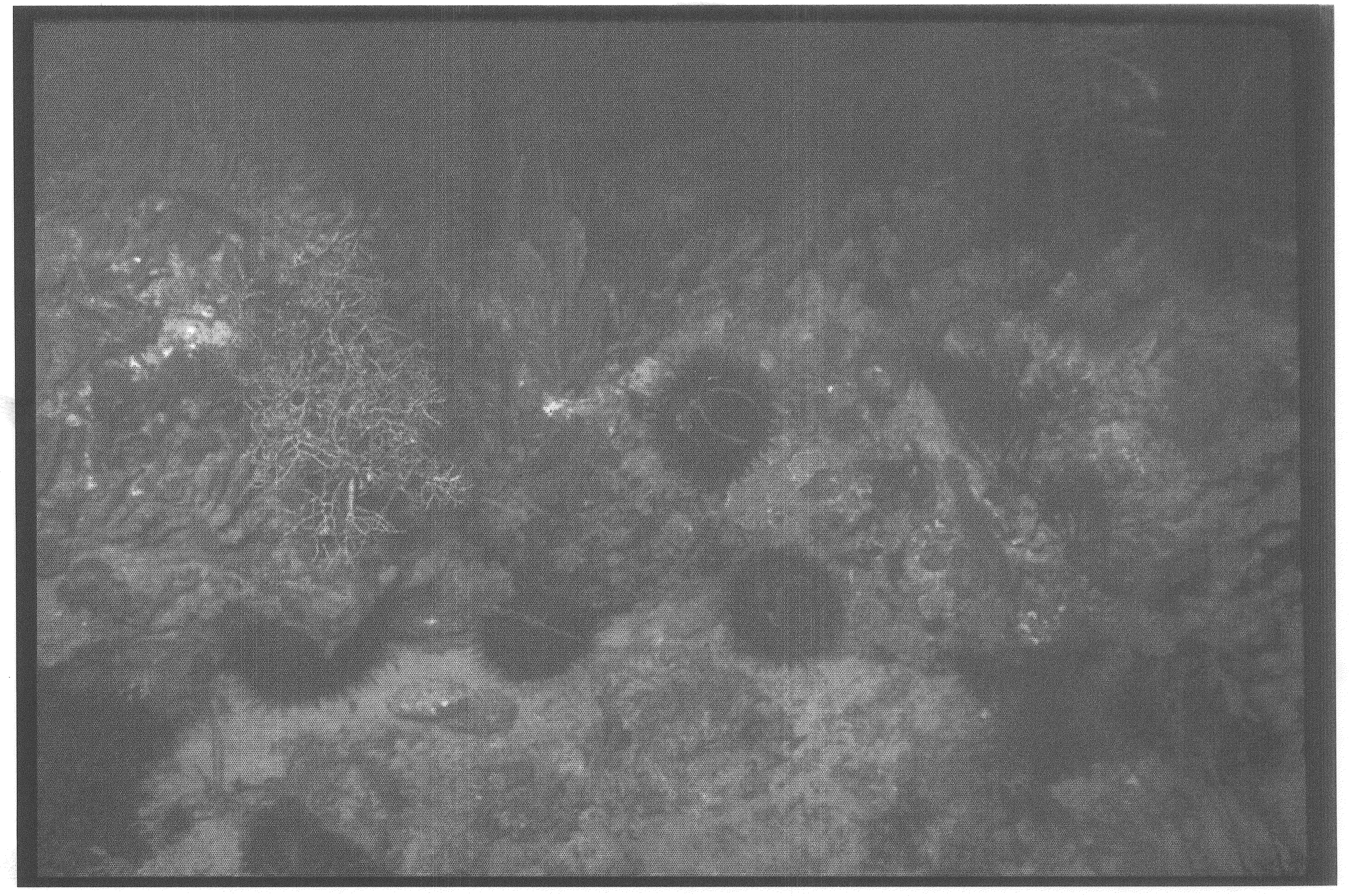
FINAL REPORT TO FRDC



Urchins (*Heliocidaris erythrogramma*) on a rocky reef in NW Tasmania.

INDEX

FRDC FINAL REPORT

Non Technical Summary

The results of this program indicate there is scope to increase the size and returns to the community of the Tasmanian urchin fishery. This would include husbandry of sheltered coastal reef areas where there is an over abundance of urchins resulting in 'barren' areas. Urchin barren areas presently may make up to twenty five percent of all sheltered coastal reef areas between Coles Bay on Tasmania's east coast and Southport in the south. Urchin husbandry will not occur through the current management regime and requires a coordinated effort involving processors and divers.

Although small, the sea urchin fishery is one of Tasmania's most labour-intensive, with a current ratio of two to four processing employees to each of the full-time divers. Management of the current fishery is minimal. Consequently, there is declining availability of premium grade roe and the harvest season is short, which results in minimal returns to all sectors and prevents the fishery realising its full potential.

In many coastal reef areas, 'urchin barrens' are evidenced with reduced availability of preferred foods, including the important native string kelp *Macrocystis pyrifera*. Denied sufficient food, large colonies of sea urchins have minimal roe weights making their harvest unprofitable. At the same time, our observations indicate they are devastating algal growth in the coastal zone to the detriment of other marine species and the coastal ecosystem.

There is an urgent need to develop cost-effective, commercial enhancement techniques for these key areas which will restore biological balance and maximise the fishery's value and employment potential by increasing both roe weight and roe quality.

The main aim of this research program was to determine the potential for culling urchins in some areas and encouraging the return of appropriate seaweed species. Tasmanian Sea Urchin Developments used two widely-separated sub-tidal experimental lease areas. The first, at Meredith Point on the east coast and the second, at Hope Island on the south coast. Both sites have been subject to some overgrazing by urchins.

At Meredith Point, the study area was divided into plots containing urchins at three densities: artificially enhanced, continually harvested and control (undisturbed). Urchin roe condition increased in the low urchin density areas relative to the high and control over a two year period. Thinning of urchin densities in one area that had been a barren resulted in a doubling of roe recovery.

At Hope Island, preliminary short-term trial clearings of urchin from barrens resulted in little recovery of macroalgal vegetation. It was postulated that limpets may be an additional herbivore controlling vegetation so the major manipulation experiment conducted there, was to determine if urchins were the principal herbivore. After two years, vegetation returned to urchin cleared areas but not limpet

cleared areas. Urchins were thus determined to be the principal herbivore. Re-vegetation was augmented by transplanting *M. pyrifera* plants to the site and re-establishment of algal forests has been successful.

Supplementary programs were conducted on gonad condition, urchin movement, aging of urchins, kelp transplants and surveys of remote sites. Monitoring of gonad condition demonstrated a regular seasonality to reproduction with optimum roe recovery from September to December. However, the peak of the season and the extent of the season varied from year to year, and from site to site. This may be due to variation in factors of light and nutrient availability and their effects on macroalgae, the primary dietary item. Male urchin had higher quality roe (white-yellow, fine texture). Quality also varied with age and size of the urchin. Larger, older urchin had poorer quality roe.

Movement of urchins was investigated because an assumption of the manipulation experiments was that movement was negligible. Movement was found to be minimal and seasonal. Most activity was observed from January to July. At Meredith Point, movement was so small that transplanted urchins released from bags and bins did not move far from their release point resulting in localized concentrations of urchins and the formation of small 'barren' areas.

Tetracycline labelling of teeth showed slow growth rates at both sites, with reproductive maturity being attained at 5-10 years of age. This result was at odds with aging of urchins using marginal increment analysis of teeth, the results of which were ambiguous however.

Low recruitment rates, estimated at between 0.3 and 1.0 urchin/m^2/yr at the two research sites, indicate reef areas may be harvested every 2 to 9 years. Observations by urchin diver's and those of the principal investigator suggest low recruitment rates hold true for many areas outside the study areas indicating a precautionary approach to management strategies.

Experimental re-vegetation of *M. pyrifera* using spores was sporadically successful, possibly dependent on conditions when cultivated spores were out-planted, thus only possible at certain times of the year. Transplanting of juvenile *M. pyrifera* plants was successful with beds re-established at Hope Island, Stapleton Point and Oakhampton Bay.

Surveys of urchins at King Island show there is potential for an urchin industry on the island and may be worth further investigation.

Further research and development is indicated for:

1) Best resource management options.

2) Re-seeding reefs or cultivation with preferred urchins for example: white shells, males.

3) Recruitment and growth rates.

4) Coordinated marketing of product to improve profitability.

Background

Trial fishing for the sea urchin, *Heliocidaris erythrogramma,* began in Tasmania in the 1960's, but most of the fish landed were poor quality and there were no established markets. The first quality roe was landed in 1983 for a newly developed market in Melbourne. In 1985 three divers began export sales to Japan sparking a speculative demand for licenses. In that year 250 commercial licenses were issued.

Currently there are about 15 commercial divers working on sea urchins between St Helens on the east coast and Dover in the south. Most are part timers, but about 6 work systematically for not less than eight months a year, each aiming to land an average of 1 tonne (live weight) a week. The divers use hookah gear and work mainly in pairs, although a few work solo or with a deckhand. Most of the total catch is taken inside the seaward limits of bull kelp in relatively sheltered waters. Historically, fish were retrieved from rocky reef areas in water averaging 4 meters depth but in the last few years, divers have been consistantly working shelly sea-bottom areas sbject to tidal currents in depths greater than 12 meters.

Over the period of this program, most sea urchins were sold live to two specialist processors and exporters: Oceania Trading Pty Ltd in southern Tasmania and Tashimi Fish in northern Tasmania. Presently, Oceania supplies local markets in Melbourne and Sydney but in the peak months of September to December, grade and ship roe on traditional wooden display racks for auction in Japan. They employ two to four processing workers for each supplying diver. Tashimi fish sells its roe in bulk for re-packaging overseas employing two to three processing workers for each supplying diver.

Divers are paid for roe weight recovered. In mid 1996 Tashimi Fish paid $35- and $7 /kg for A & B grade roe respectively; and Oceania $35-/kg for A (with some B) grade roe. Prices in Japan for Tasmanian roe fluctuate considerably because of the inconsistency of the product. In 1995 prices typically ranged between $A80- to $A120-/kg and peak at $250-/kg.

Table 1 shows a summary of diver returns to Fisheries management at the Marine Resources Division of DPI. The decline in landings since 1992 may be attributed largely to a moratorium on issuing new commercial dive licenses. Presently, there is some concern by divers at the declining number of urchin in traditional "A-grade" beds.

Table 1.1

Statistics relating to urchin harvests for the years: 1988-1995 (courtesy of the Marine Resource Division of the Department of Primary Industry, Tasmania).

Year	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Total Live Weight (kg)	358,633	213,502	126,484	150,071	253,928	137,454	136,143	39,819
Total Roe Weight Reported (kg)	13,537	8,241	5,122	5,496	8,456	4,152	4,648	1,308
Average Recovery (annual %)	3.77	3.86	4.05	3.66	3.33	3.02	3.41	3.29
Total Dive Hours	5,922.90	2,874.10	1,862.50	2,493.80	4,070.10	2,781	2,607	886.2
Roe Weight Per Dive Hour (kg/hr)	2.286	2.867	2.75	2.204	2.078	1.493	1.783	1.476

Need

Although small, the sea urchin fishery is one of Tasmania's most labour-intensive. Every fish is harvested by hand for its roe. In the processing factories, individual roes are separated, graded and packed by hand, with a current ratio of two to four processing employees to each of the full-time divers.

The current fishery is minimally managed. Consequently, there is declining availability of premium grade roe and the harvest season is short, which results in minimal returns to all sectors and prevents the fishery realising its full potential.

In many areas, 'urchin barrens' are evidenced with reduced availability of their preferred foods, including the important native string kelp Macrocystis pyrifera. Denied sufficient food, vast colonies of sea urchins are unprofitable because of their minimal roe weights while, at the same time, our observations indicate they are devastating algal growth in the coastal zone to the detriment of other marine species and the coastal ecosystem.

There is an urgent need therefore to develop cost-effective, commercial enhancement techniques for these key areas which will restore biological balance and maximise the fishery's value and employment potential by increasing both roe weight and roe quality.

Objectives

With the collaboration of the Marine Resources Division (MRD) of DPI, Tasmanian Sea Urchin Developments trialed enhancement techniques in two widely-separated sub-tidal leases within the framework of a scientific program devised and supervised by the Principal Investigator, in collaboration with the MRD. These techniques are designed to manage both urchin numbers and food supply in each area in a pilot program capable of establishing the potential employment, financial and environmental benefits to Tasmania of:

* Maximising the sea urchin resource by progressing from an unmanaged wild fishery to a managed, enhanced one

* Removing unprofitable fish and controlling urchin numbers

* Encouraging re-establishment of seaweed in key areas, to the potential benefit of other fisheries and the total marine environment.

Through this program, manipulation of urchin densities resulted in increased roe quantities from urchins. However, lower than expected recruitment rates and growth rates, has led to lower than anticipated production rates of urchin from the sites. Monetary benefits will take longer to realize than originally anticipated.

Methods

The company used two widely-separated sub-tidal experimental lease areas. The first, at Meredith Point, Spring Bay, Triabunna, covers about 100 hectares. The second, at Hope Island, Esperance Bay, Dover covers about 20 hectares exposed to a differing water body. Both sites sites have been subject to some overgrazing by urchins. The overall pilot proposal was to:

* Survey both lease areas for urchin density, associated seaweeds and abundance.

*Investigate Tasmania-wide associations of urchin densities and algae.

* Manipulate densities on site with the ultimate aim of maintaining viable urchins on site at commercially beneficial densities by culling old, unprofitable fish.

* Maximise roe quality through a sustainable harvesting program.

Detailed results

See following attached texts.

Benefits

If a full program is commercially successful, it will increase the value and export-earning ability of the Tasmanian sea urchin resource by introducing a labour-intensive ranching/husbandry component to an unmanaged wild fishery.

The consequent control of urchin numbers in key areas and the management of seaweeds on currently denuded bottom resulting from such husbandry would help reverse degradation and re-establish nursery areas for a variety of marine species in the coastal zone. Although we are unable to quantify this benefit, we believe it is potentially significant to fisheries such as abalone and to the overall quality of the coastal zone ecosystem.

Preliminary experiments by Tasmanian Sea Urchin Developments in the wild fishery indicated that the pilot management program had the potential to produce urchins with a quality roe of an average weight equal to 4% (A-grade) of total bodyweight in its first production year (Year 3), with the expectation of higher yields in subsequent years. This compares with averages of about 1.5% from virgin wild stocks and 3% from wild beds fished consistently.

Improved, consistent quality will result in the roe realising at least $150 a kg, FOB Tasmania - a significant premium over the current average price. This is 3 to 10 times the fluctuating wild fishery yield. Value-added, it represents a minimum of $35,000 per hectare ex-factory.

The research program has supported the preliminary results and confirmed the potential for manipulating urchin densities to achieve higher returns to the fishery. However, the long recovery periods of manipulated areas caused by low recruitment levels and low growth rates indicate a slower return on invested resources than anticipated.

Intellectual Property and valuable information

Nil.

Further Development

The following are further options for development of the industry:

• The research indicates the potential for husbandry of urchins on coastal reefs and indicates a change in management strategy. One of the principal impediments to carrying out the process is that divers are not convinced that by thinning urchin densities in some areas, there will be sufficient monetary return to them in the long term. They also have no control who will be diving on a particular area, so no control over who would benefit from their urchin thinning activities.
Two possible solutions for doing this are to:
1/ Improve returns to the divers by either subsidising lower grade urchin roe recoveries to encourage the fishing of beds that are not presently utilized or developing products and/or a market for lower grades of roe.
2/ Processors and/or urchin divers to have the 'rights' to areas of coast. This would encourage them to maximise the returns from those areas. In the long term this would include thinning out unprofitable 'barrens' areas as indicated by this project. An urchin diver co-operative with an interest in processing may be worth consideration.

- All options would be expedited by a greater return for premium urchin roe. This may be achieved by a co-ordinated marketing approach and the consistant supply of good quality roe into the Japanese market.

- Access and appropriate use of accurate detailed catch data is essential to maximising returns from the fishery.

- Ideally, management should be done in conjunction with surveys of reef areas and independent roe sampling. However, the value of the fishery probably would only justify minimal research and monitoring. If the value to other fisheries is considered (in terms of benefit to the environment), there may be a case for getting this industry on a more solid footing and thus justifying increased expenditure by MRD.

- Contact with urchin buyers in Japan (AUSTRADE) indicated the potential for exporting urchins live to Japan. Prices indicated were $15/kg (1995, before freight and transport costs). This compares with approximately $1/kg the divers are presently receiving from local processors. *Heliocidaris erythrogramma* occurs in a number of colours, predominantly purple. Urchins left unprocessed for periods of time exceeding two or more days are likely to have the colour leach and the roe discoloured. This also affects the flavour, making it more bitter. As a result, trial shipments of these urchins resulted in the targetting of 'white' urchins by the Japanese processors. Here lies potential for reseeding reefs or cultivation with 'white' only bred urchins.

- As noted in the analysis of roe quality, the male urchin has the higher valued roe, being light in colour (white-yellow) and of a fine texture. It is presently possible to breed female only salmon, is it possible also to breed male only urchins for reseeding reefs and/or cultivation?

- What are the economics of breeding urchins in the culture situation? - especially where there may be greater control over the quality and quantity of the resultant product.

- Indications of low recruitment and low growth of urchins obtained from this program need to be confirmed as this is fundamental to determining levels of profitability of the industry and future options.

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SECTION 1: INTRODUCTION

1. RESEARCH SITES

The principal aims of the project as detailed in the application entails manipulating densities of urchins and monitoring resulting roe yield and quality. To this end two lease sites have been allocated to Tasmanian Sea Urchin Developments for the project by the Department of Primary industry and Fisheries, one at Hope Island in the south and the second at Meredith Point on the east coast (Fig. 1.1). These areas are restricted to other urchin divers allowing control over experimental conditions.

Hope Island.

Hope Island is an island 2-3 km from the jetty at Dover in Port Esperence (Fig. 1.2). Rock type is predominantly dolerite. It receives slight swell action on its south east corner during a large southerly roll (infrequent). Maximum depth for most of the island is less than 12m within 50m of the island. A shallow sand bottom broken by occasional low reef, at less than 6m depth extends from the north western side towards Faith and Charity Islands.

Macroalgal vegetation is confined to a fringing rim to less than 2m depth for most of the island except for the south eastern and the south western corner where the vegetation can extend to the limit of firm substrate. The dominant algae on the wave exposed side consists of *Phyllospora comosa*, *Cystophora moniliformis*, *Acrocarpia panniculata* and *Carpoglossum confluens*. On the more sheltered side, dominant algae are *Phyllospora comosa*, *Macrocystis pyrifera*, *Ecklonia radiata*, *Cystophora retroflexa* and *Sargassum fallax*.

Below the fringing algal rim, the rocks are mostly bare except for some encrusting coralline algae. Most of these 'bare' rock surfaces are free of silt or turfing algae possibly due to the action of tidal currents in the area (tidal range of approx. 1 meter) and/or the action of herbivores continually scraping the rock surfaces. These areas are termed 'urchin barrens'.

Caulerpa species can be found on the sand adjacent to the reef and the seagrass *Heterozostera tasmanica* is found further out on the sand. Also on the sand on the north western side shells and shell fragments are common. Occasional urchins can be found on the sand in this area using shell fragments for camouflage.

Anecdotally, Hope Island is poor for sea urchin roe recovery with only the infrequent bin harvested. This reflects the situation for much of the D'Entrecasteaux Channel. The urchin divers believed the research program may lead to improved management of these areas and improved urchin harvests from this area.

To assist sampling, the island was divided into twelve roughly equivalent sections. The boundaries were marked by numbered plates attached to trees on the shore. Samples locations relate to these numbers. A suffix of S or D refers to shallow or deep and is 1 - 4 m and 4-7m respectively.

Meredith Point

In contrast to Hope Island, Meredith Point (Fig. 1.3) is an area of good recovery in terms of urchin roe yield. According to local divers in 1992, 10-20 tonnes of urchin were harvested from this approximate 2.0 km of shoreline. The substrate here is predominantly dolerite with sandstone towards the western edge of the lease area. Depths are maximum on the eastern side where they can reach 8-12 m within 100 m of the shore. From the south eastern corner of the shoreline, a reef extends south outside the lease area to approximately 1km (?) off-shore, averaging 4-5m depth to the top of the reef. For the remainder of the site, the reef meets the sand at 4-5 m depth.

On the eastern section of the lease area, there is a fringing band of macroalgal vegetation in shallow waters and barrens below. This band consists mainly of *Colpomenia* sp., *Zonaria* sp., *Cystophora* spp. and *Caulocytsis cephalinorthis*. Below this the rocks are bare until the reef - sand edge where *Caulerpa flexilis* is dominant. Over the 'bare rocks' a fine turfing alga is sometimes common with much silt. The introduced alga*Undaria pinnatifida* is a rapid colonizer of these bare areas in the spring to late summer.

From the south eastern corner to the western edge of the lease, macroalgal cover extends from the low tide level to the extent of hard substrate. *Cystophora* spp., *Sargassum* sp., *Acrocarpia panniculata*, *Caulocystis cephalinorthos* and *Zonaria* sp. are common in the shallows. *Sargassum fallax* (?), *Caulerpa flexilis* and other *Caulerpa* spp. become more common in the deeper waters (>2m). *Heterozostera tasmanica* is on the sand beyond the reef edge.

Tasmania's predominant swell direction is from the west. Easterly swells are infrequent and are more likely to occur late summer. Meredith Point is protected from direct easterly swells by Maria Island but occasional swell action can be significant.

To assist sampling, the site was divided into twelve roughly equivalent sections. The boundaries were marked by numbered plates attached to trees on the shore. Samples locations relate to these numbers. A suffix of S or D refers to shallow or deep and is 1 - 4 m and 4-7m respectively.

In Fig 1.4, average monthly temperatures for the two sites are compared (measured on site). For 1993/96, Meredith Pt has slightly higher maxima and slightly lower minima, with average temperatures 0.5 - 1.0 ^{o}C higher than at Hope Is.

2. ROE ANALYSIS.

Assessment of roe quality and quantity was based on commercial practices. For our purposes, 'Roe' is equivalent to urchin gonad which may be either female or male.

METHOD

Percentage recovery was determined as:

(wet weight of roe / the wet weight of the total urchin) x 100

The condition of roes has importance commercially. Colour and coarseness is considered. For colour, a coding from white (1), yellow (2), orange (3), brown (4) and black (5) was used. For coarseness, roes were divided into very fine (VF), fine (F), medium (M), coarse (C) and very coarse (VC). The scale of 'coarsness' is related to granulations on the surface of the roe. For VF roes, granulations are not distinguishable. F roes have granulations to 0.5mm, M roes: to 1mm, C roes: to 2mm and VC: $>$ 2mm. Male urchins have finer, lighter coloured roe. 'A' grade roe, suitable for the Japanese market, is white-yellow and fine-very fine. 'B' grade roe includes these and orange and medium - coarse grades. 'B' grade roe is sold mosly on the local market into Melbourne and Sydney.

3. QUADRAT SIZE

To ensure optimal sampling strategy in determining density of urchins at the various sites, quadrats of varying sizes were assessed. By combining quadrats in various combinations, the precision of using varying quadrat sizes for calculating urchin density could be determined (see Andrew and Mapstone 1985).

RESULTS

1. Quadrat size

The quadrat size for greatest precision for equivalent number of quadrats was the largest: 25 x 1m, although there was little difference between these, 5 x1m , 10 x 1m and 20 x 1m sizes. As searching time is linearly related to the area searched, 5 x 1m quadrats would appear to give the best result for least time involvement.

The mean standard error as a percentage of the mean (also a measure of precison) for various clumpings of 5 x 1m quadrats indicated a minimal area of 15 quadrats to be sampled for acceptable precision of less than 15%.

REFERENCES

Andrew, NL and BD Mapstone 1987 Sampling and the description of spatial pattern in marine ecology. Oceanogr. Mar. Biol. Ann. Rev., 25: 39-90.

FIGURE 1.1 Map showing locations mentioned in the text.

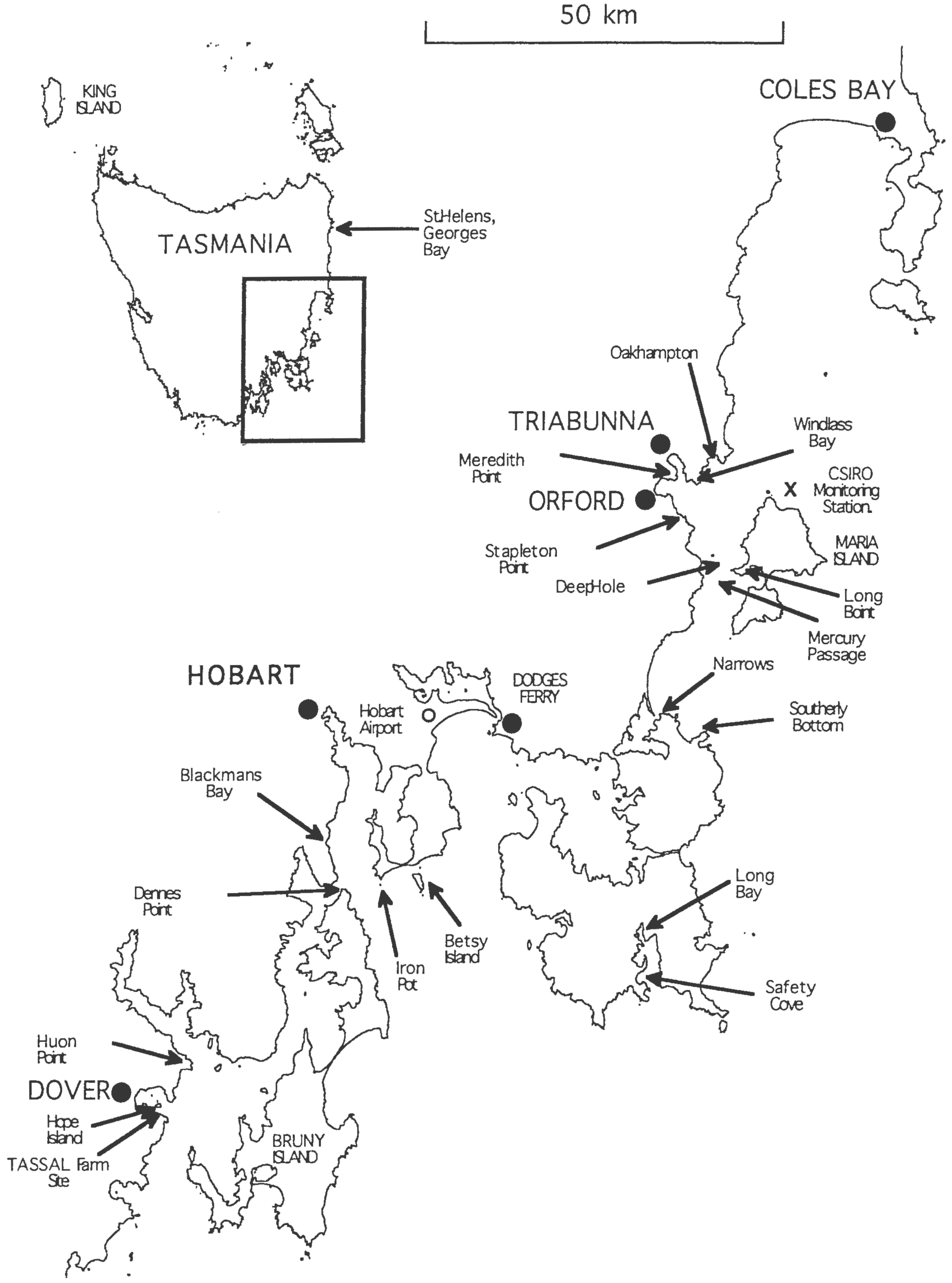


FIGURE 1.2 Map showing location of sampling sites and treatment blocks for Hope Is.

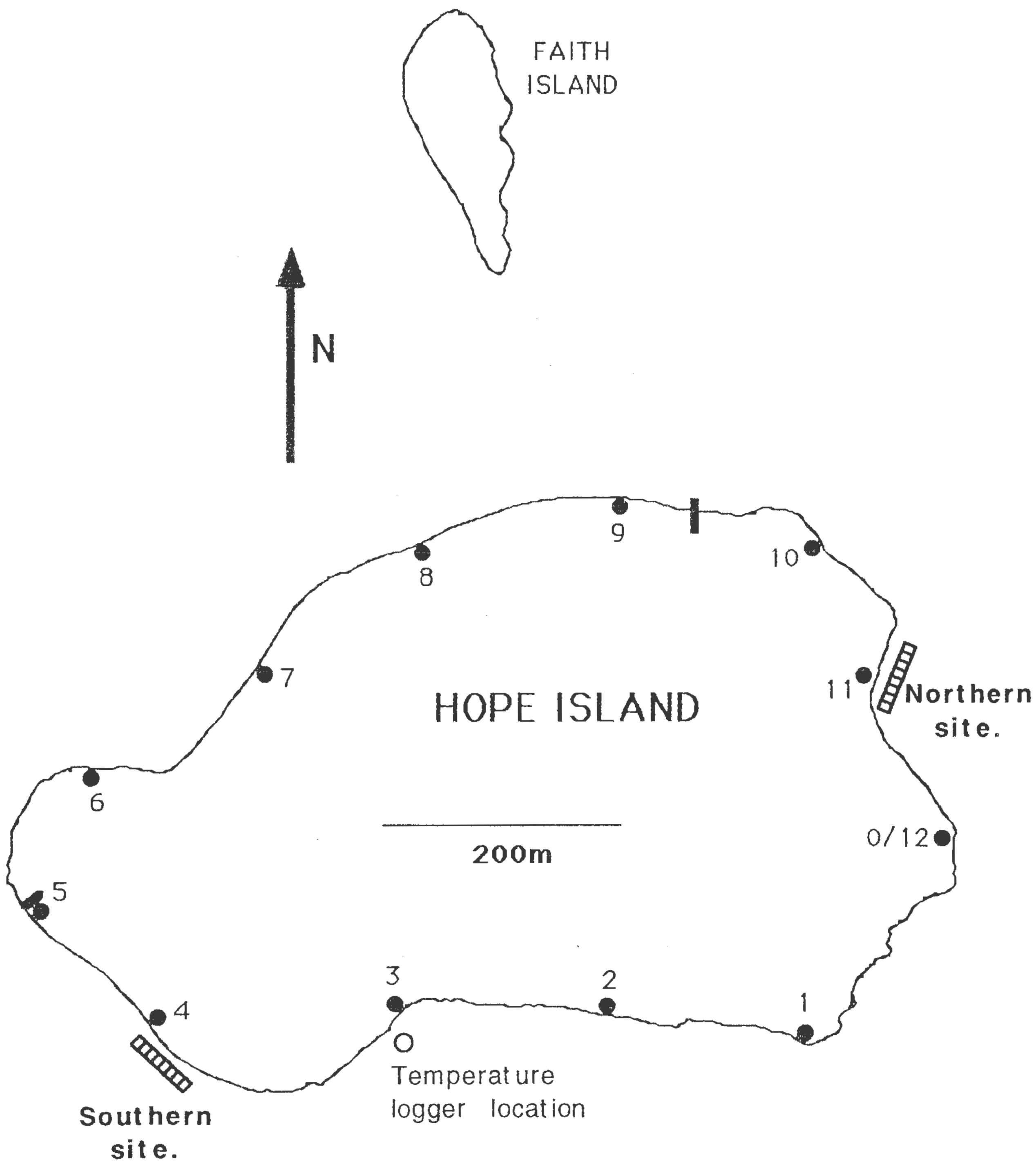


FIGURE 1.3 Map showing location of sampling sites and treatment blocks for Meredith Pt.

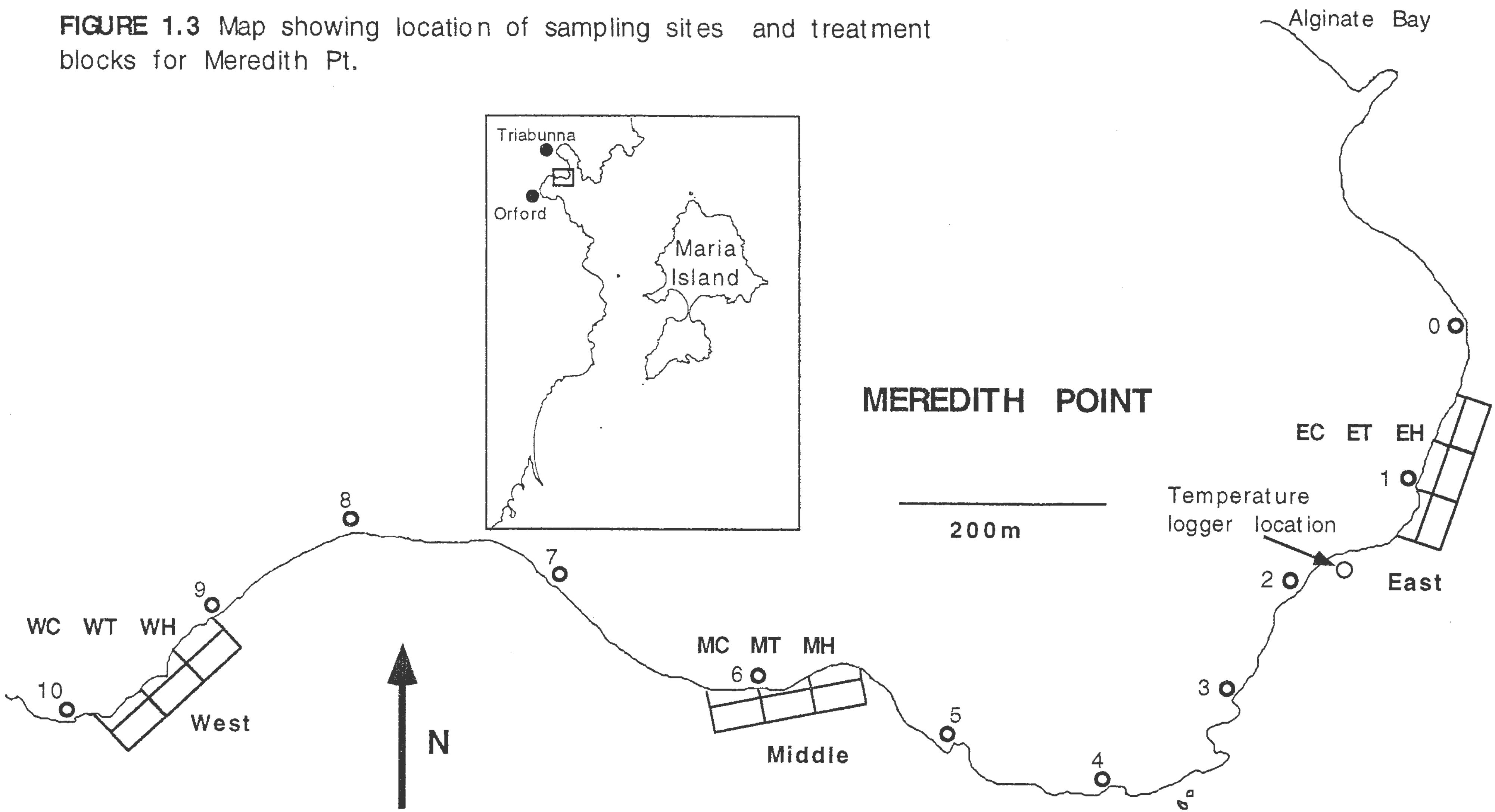
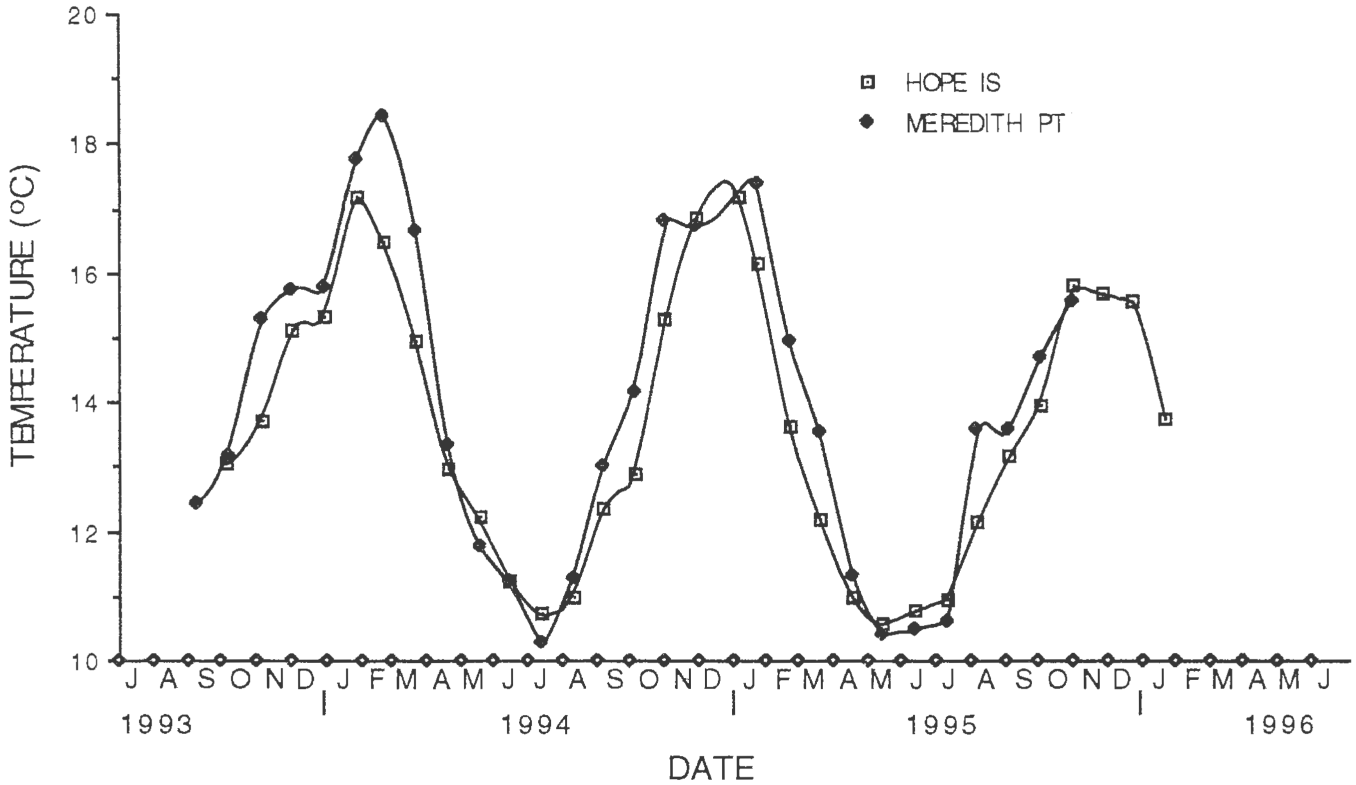


FIGURE 1.4 Average monthly temperatures for the two sites from onsite loggers.



SECTION 2: GONAD ANALYSIS

INTRODUCTION

Urchins have been sampled monthly at both sites to determine periodicity of the reproductive cycle and to potentially tie this in to environmental factors.

METHOD

Samples for determining gonad/roe recovery each consisted of twenty five urchins. Every urchin was weighed, diameter measured, roe extracted and weighed. Each roe was given a rating for texture and colour.

Samples were taken from shore marked areas (see maps in Section 1) at defined depths, these were: shallow (S): 1-4 m or deep (D): 4-7m depth. On-going samples were taken from vegetated areas at both sites for the entire length of the program or three reproductive seasons. This was at 5S at Meredith and 1D at Hope Island. For comparison, samples were also taken from barren areas at both sites for the first reproductive season. This was at 2D at Meredith and 2D at Hope Island. At Hope Island samples were also taken from a site of a semi-permanent *Macrocystis* bed on the SW corner of the Island (5S) and over a scallop shell bed on the NW corner of the island (8S). Good urchin recoveries have been experienced by divers in areas with shelly sea-bottom and it was hoped to be determined if this shelly sea-bottom bed yielded similar high roe quality/quality urchins. At Meredith, a sample of 25 urchins was also taken from one of the squares containing the transplanted urchins (MT) for the first few months after tranplantation to see how they compared with urchins on-site.

Temperature loggers were installed at both sites. Logger failure was experienced at both sites and gaps in data were filled with data obtained from commercial aquaculture enterprises conducting measurements in the near vicinity.

RESULTS

A scatter plot of recovery versus diameter for all urchins sampled from 'barrens' and 'vegetated' areas for both sites is presented in Fig 2.1a. They demonstrate a classical response, with optimum recoveries occuring at diameters less than the maximum. Recoveries in the barrens areas is less than vegetated. At Meredith the barrens area has diameters greater than the vegetated area whereas at Hope Is this trend is reversed.

Analysis of roe quality show that the male urchins nearly always have good colour and fine texture (see Fig. 2.1b). The females have the darker colour roe.

For the females only, there is a clear relationship for the size of the urchin and the colour and texture of the roe (Fig. 2.2 a-b). Larger urchins had progressively poorer quality roes with coarser texture and darker colour. The number of ridges in the teeth of the urchin are belived to be related to the age of the urchin (Section 6) and a relationship can be determined between the colour of the roe and the number of ridges (Fig. 2.2c). A deterioration in colour was noted in the Meredith Point urchins over the period of the study (Fig. 2.3b) agreeing with an aging of the population (Fig 2.2 d).

Of the two sites, Meredith Pt shows best percent recovery, although the maximum varys from year to year (Fig. 2.3 a). In 1993, Meredith peaked at around 14.5% total gonad recovery while in 1995, this was approximately 11%. The extent of the season also shows variation between years and between sites. At Hope Is. (Fig. 2.4) the season was short in 1993, approx. 2 months, while in 1995 it was extended for four+ months.

The barrens areas at Meredith (2D, Fig. 2.5) and at Hope (2D, Fig. 2.6) had anticipated lower percentage recoveries compared to vegetated areas. The ratio of percent recoveries at the peak of the season for barrens: vegetetated areas in 1993/4 was 9:14.5 at Meredith and 6:9.5 for Hope Island .

Although not presented here, the transplanted urchins from Meredith (MT), did not show a significant increase from their original roe recoveries. They were also lower than urchins sampled within the site. This may have been due to the fact that they were placed on site over the side of the boat straight from bags and bins with no effort to disperse them. The result was high concentrations of urchins and some barrens were evidenced in the immediate vicinity. Food was thus probably limiting and this was reflected in low roe recoveries.

At Hope Island, the shell covered sea-bottom (8S, Fig. 2.7) did not have higher percentage recovery urchins with a maximum recovery of only 7%. This contrasts with the results of sampling at the semi-permanent *Macrocystis* bed (5S) with a maximum recovery of nearly 13%. This value was the highest recorded roe recovery for Hope Is over the entire program. The urchins were old however and their roes were discoloured.

Some periodicity is evident in the colour and the texture of female roes at both sites (Figs 2.3-2.4). Colour shows little variation with season at Meredith, but at Hope they are darkest at peak condition of roe. At both sites, roes were coarsest during the late spring-early summer period paralleling increases in roe condition. This is not surprising as the ova are generally orange in colour. As the gonad fills, the outside appearance becomes coarser due to the ova and the colour more orange.

Roe recoveries can be broken down into A, B, C & D grades (see Table 2.1-2.2, Figs 2.5-2.7). Barrens sites and sites with older urchins have a greater proportion of the lower grade roes.

TABLE 2.1 Breakdown of roe recoveries into A, B, C & D grades from all samples irrespective of time of year at both sites.

SITELOCATION		GRADE	A	B	C	D	TOTAL	N
MERIDITH PT		5S	2.62	4.87	1.06	0.96	9.52	28
	s.e.		0.35	0.28	0.31	0.18	0.49	
		2D	0.90	2.38	0.42	2.60	6.29	12
	s.e.		0.13	0.24	0.16	0.42	0.56	
HOPE IS		1D	1.81	3.13	0.66	1.45	7.05	29
	s.e.		0.16	0.19	0.17	0.19	0.30	
		2D	1.04	2.04	0.02	0.66	3.76	14
	s.e.		0.22	0.25	0.02	0.15	0.38	
		5S	0.43	3.05	0.77	4.17	8.42	5
	s.e.		0.11	0.48	0.39	0.79	1.05	
		8S	0.56	2.81	0.00	1.67	5.04	8
	s.e.		0.10	0.23	0.00	0.25	0.38	

TABLE 2.2 Relative percentages of each of the roe grades for the regulartly monitored sites.

SITE	NO.	GRADE A	B	C	D
HOPE IS	1D	25.7	44.4	9.4	20.6
HOPE IS	2D	27.7	54.3	0.5	17.6
HOPE IS	5S	5.1	36.2	9.1	49.5
HOPE IS	8S	11.1	55.8	0.0	33.1
MERIDITH PT	2D	14.3	37.8	6.7	41.3
MERIDITH PT	5S	27.5	51.2	11.1	10.1

DISCUSSION

Urchin divers presently target areas that yield high proportions of A-grade roe. As a rule of thumb they only work areas that yield at least 3% A-grade. Our results agree with anecdotal evidence for these sites ie. of the sites investigated, Meredith Pt only has urchins that were worth harvesting and generally only for the period September to December.

It is interesting to note that the length of the peak season at Meredith decreases for the years from 1993 to 1996 whereas at Hope the length of the peak season increases. In fact, there did not appear to be a mass spawning for the Hope Island urchins in the 1995/6 season. These changes may be due to factors of water temperature and light. At Meredith, a decrease in water temperatures and/or amount of available light (see Figs 2.8 to 2.10) may have resulted in less productive urchins. The amount of light will have an effect on macroalgal production and thus the amount of feed available to the urchins. At Hope the cooler temperature may not have triggered the spawning although nutrients in the water may be a contributing factor.

Nutrient levels of the water appear to relate closely to gonad condition. In Tasmania generally, levels of nutrients in oceanic waters decrease dramatically in late December (Harris et al), coincident with spawning. The nutrient levels may stimulate algal growth which may have a direct effect on roe condition.

Best recovery urchins either come from areas of high nutrient input, high current flow/water movement areas and/or areas where there is much drift algae available. High nutrient areas that have high yielding urchins are: the mouth of the Derwent River and east coincident with water flow from the river mouth ie. Iron Pot, Betsy Island, Black Jack Rocks and off the Blackmans Bay sewage pipe. High current areas are the mouth of Georges Bay at St Helens, the Narrows at Blackman Bay and the channel at Dodges Ferry. High water movement areas are on most of the points in the D'Entrecasteaux Channel and in Frederick Henry Bay. Macroalgal drift areas with good current flow are Deep Hole in the Mercury Passage and Dennes Pt at the top of the D'Entrecasteaux Channel.

In agreement with the claims of the divers, *Macrocystis* beds also give high roe recovery urchins. This was demonstrated in this study at Hope Island. Urchin divers have got some of their best recovery urchins from Southerly Bottom - the site of a semi-permanent large *Macrocystis* bed. Studies by Sanderson (1990) suggest that *Macrocystis* beds may provide 3-4 times as much organic matter for adjacent reef communities per unit area than other brown algal community dominants. This may contribute to these areas being relatively good for urchin roe recovery. *Macrocystis* beds are however most succesful in areas of high nutrient availability - it is difficult to seperate the contribution of these two factors in many areas to high roe recoveries.

Harris GP, FB Griffiths, LA Clementson, V Lyne and H Van der Doe (1991) Seasonal and interannual variability in physical processes, nutrient cyucling and the structure of the food chain in Tasmanian shelf waters. J. Phytoplanktojn Res. 13: 109-131.

Sanderson JC (1990) Master of Science, Dept of Plant Sciences, Uni. of Tas. Title of thesis: 'Subtidal Macroalgal Studies in South Eastern and Eastern Tasmanian Coastal Waters.'

FIGURE 2.1 a) Percentage recovery versus diameter for vegetated sites (left) and barrens areas (right) at both sites.

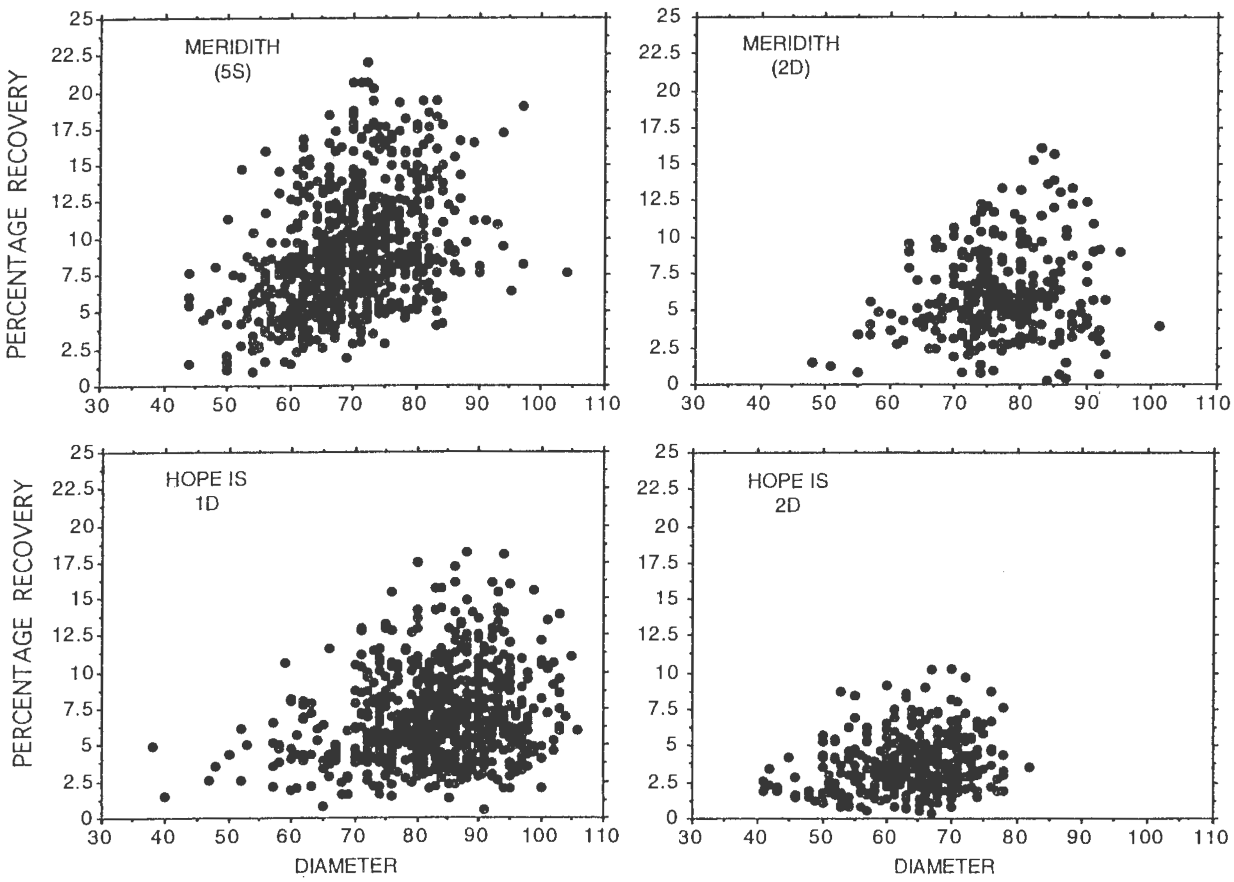


FIGURE 2.1 b) Comparison of textures of male and female urchins from both sites. VF: very fine; F: fine; M: medium; C: coarse and VC: very coarse.

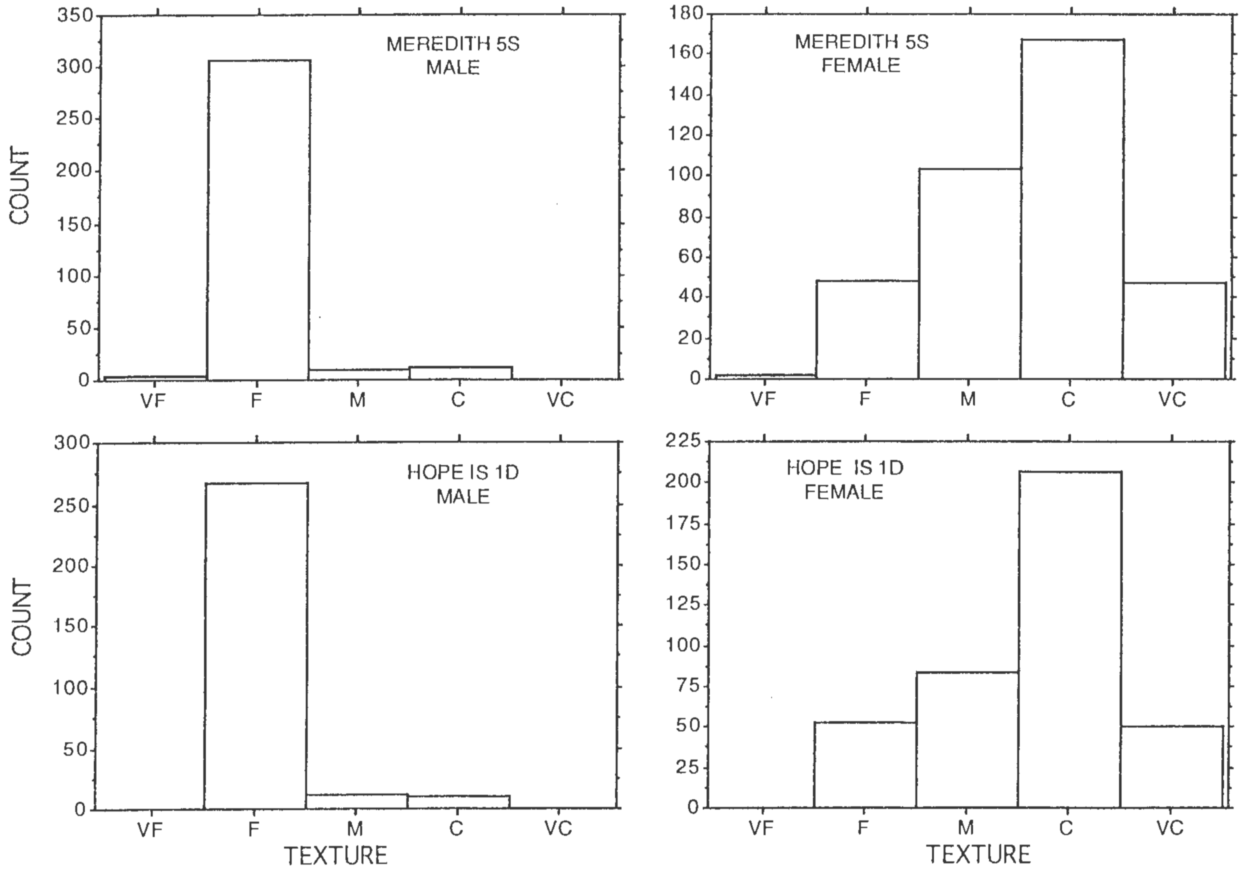


FIGURE 2.1 c) Comparison of colours of male and female urchin roe from both sites. 1: white, 2: yellow, 3: orange, 4: brown, 5: black.

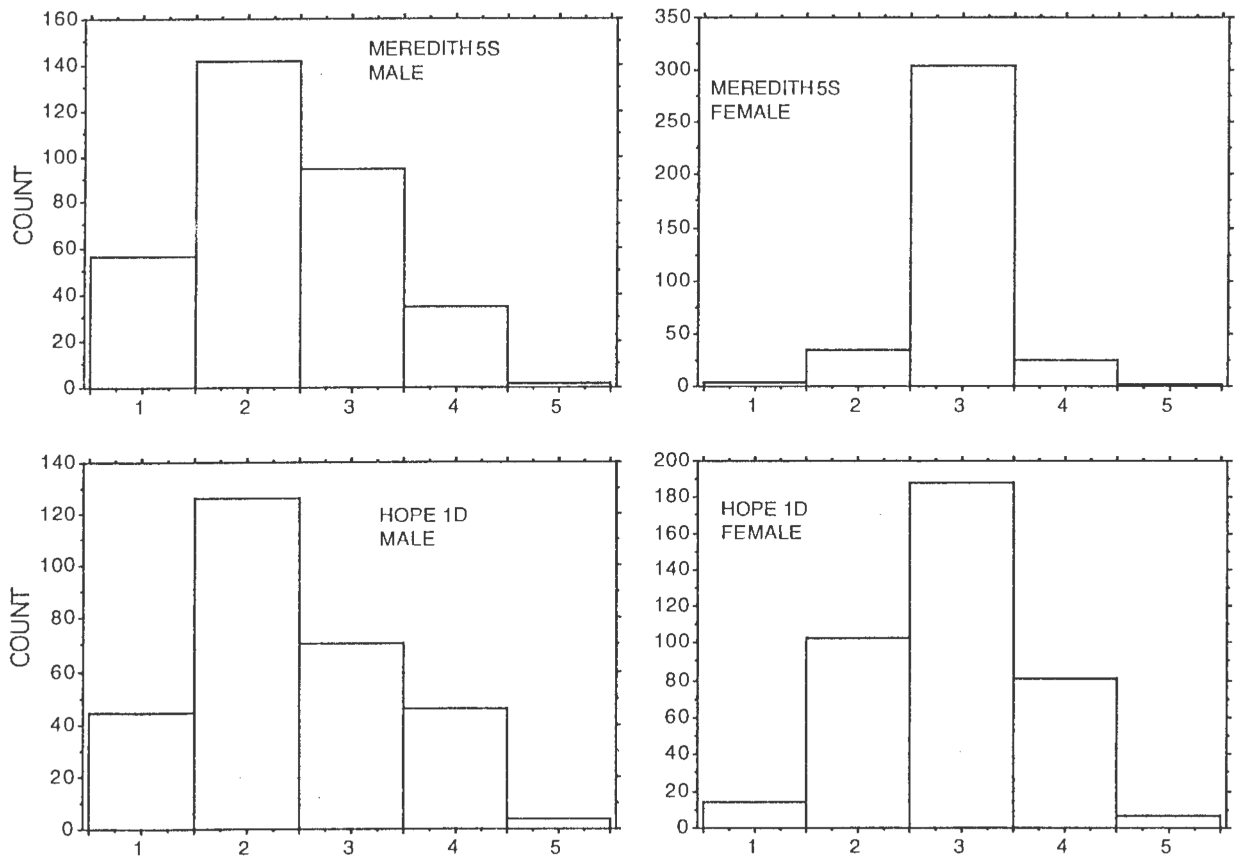


FIGURE 2.2 a) Change in mean diameter with size of the urchin frorMeredith Pt (5s) urchins b) change in colour with diameter c) number of ridgeson the teeth for roe colour. d) Variation in the mean number of ridges per tooth with time.

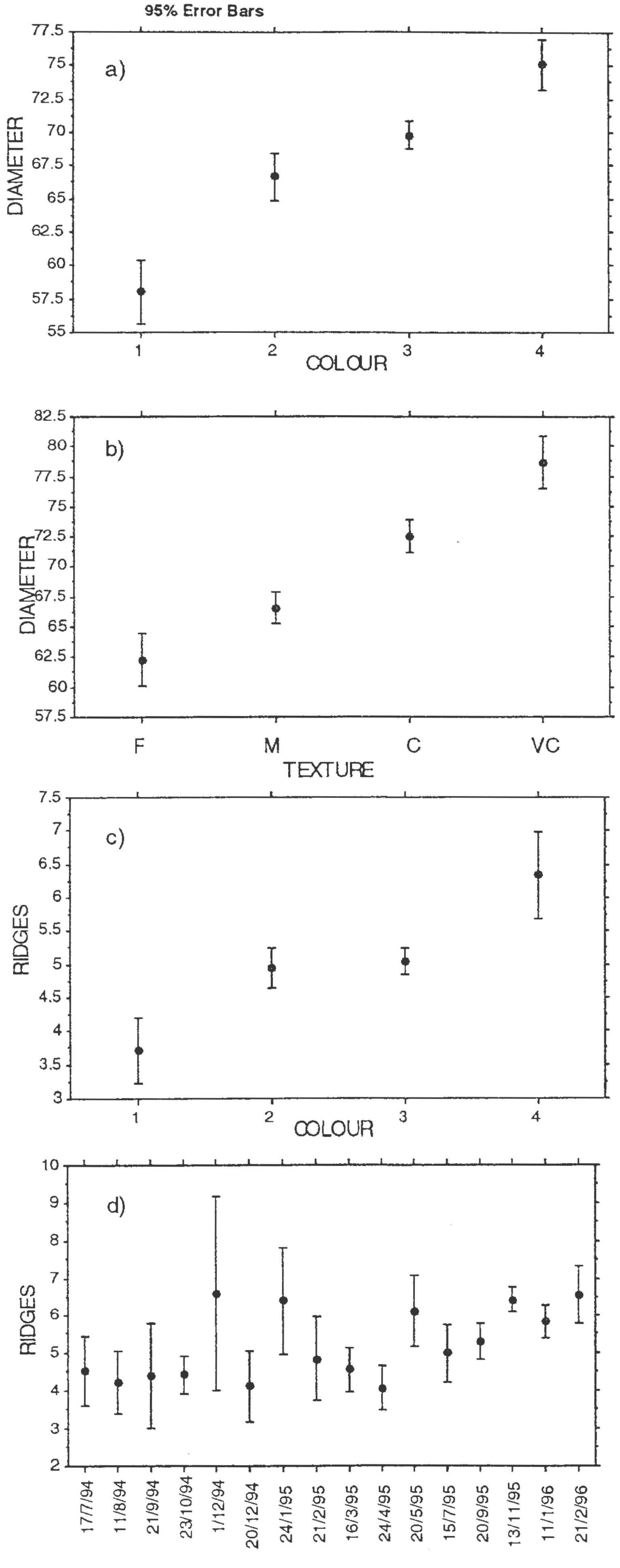


FIGURE 2.3 a) Variation in percent recovery of roe from urchins collected from Meredith Pt (5s) throughout the program **b)** variation in colour of female urchins, **c)** variation in texture of female urchins (95% CI).

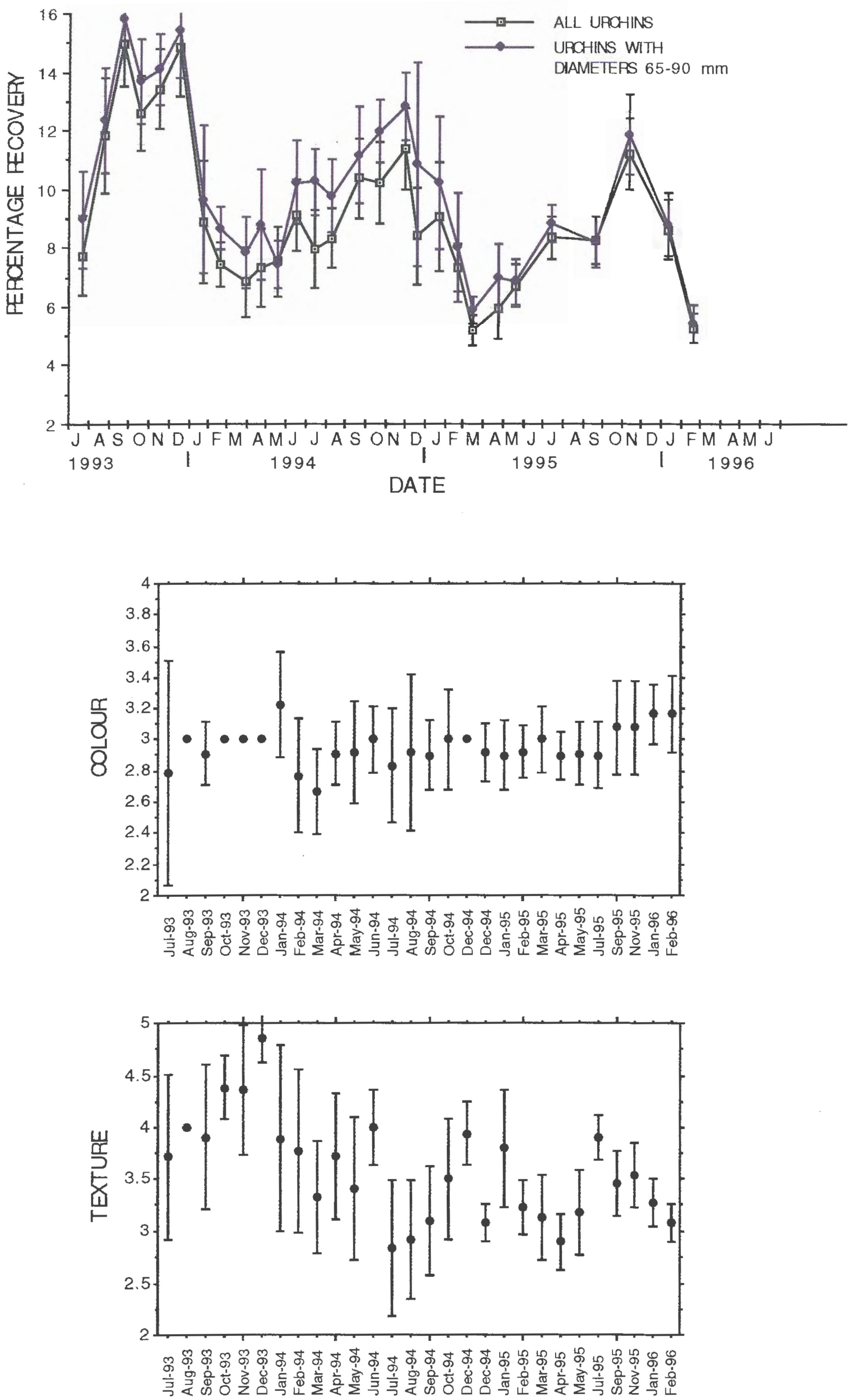


FIGURE 2.4 a) Variation in percent recovery of roe from urchins collected from Hope Island (1D) throughout the program **b)** variation in colour of female urchins, **c)** variation in texture of female urchins (95% CI).

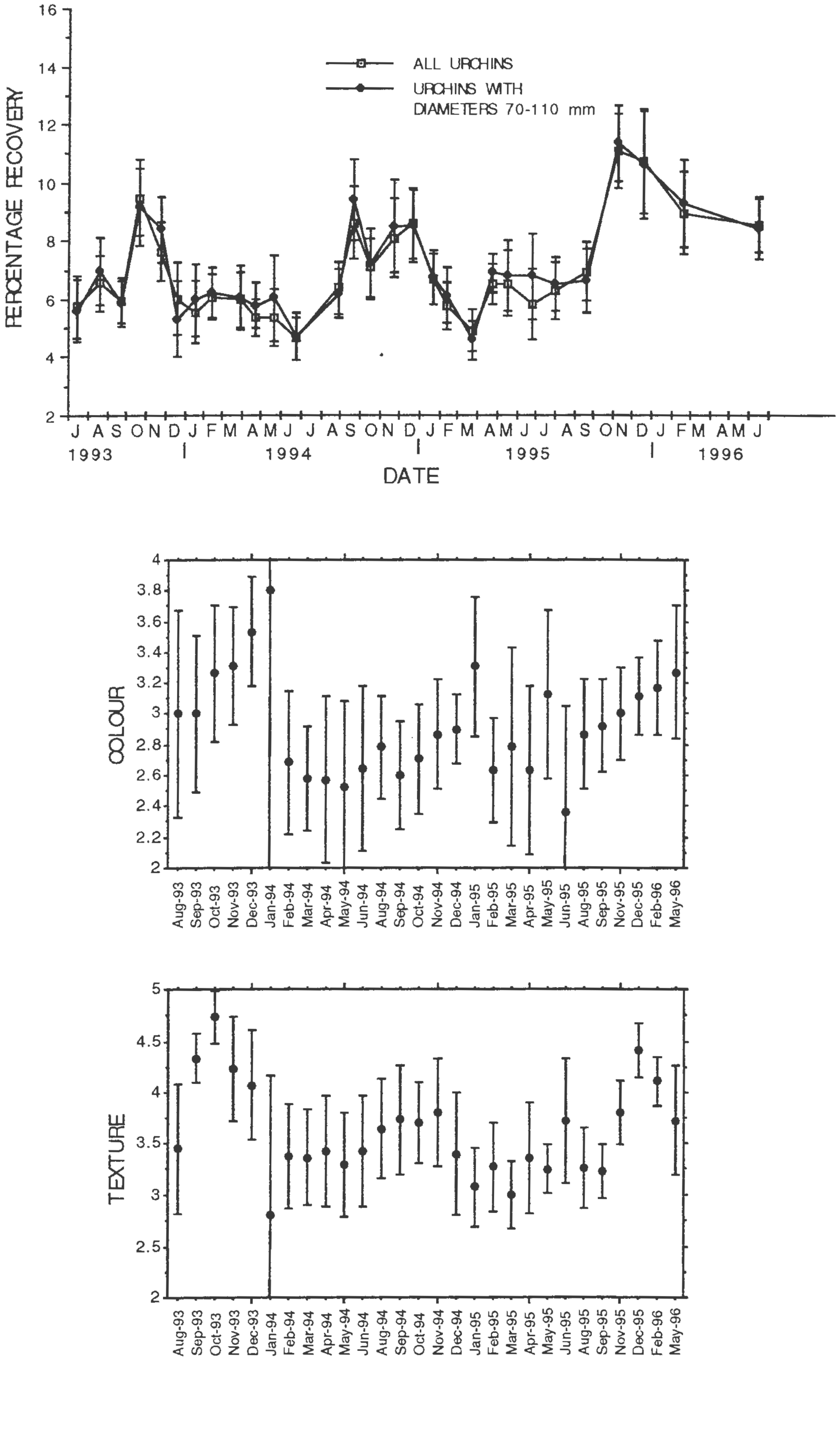
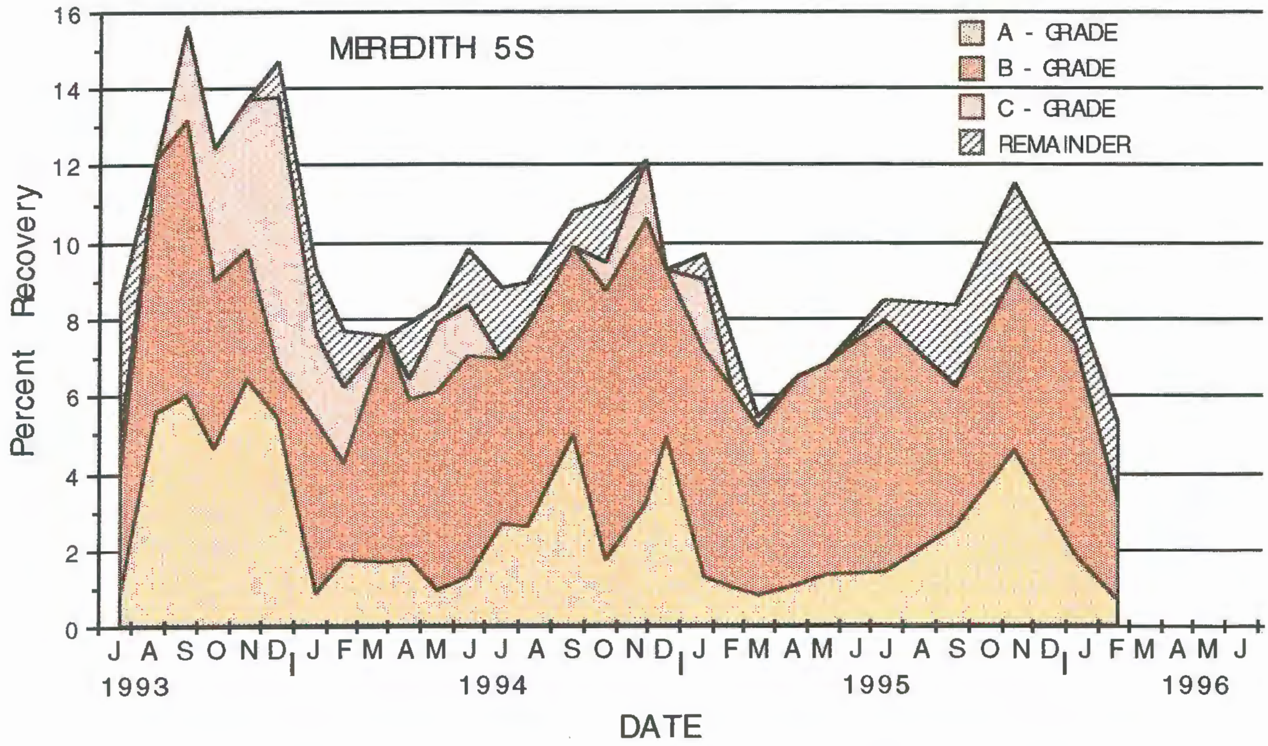


FIGURE 2.5 Breakdown of roes into grades for each month for a vegetated site (above) and a barrens site (below) at Meredith Pt.



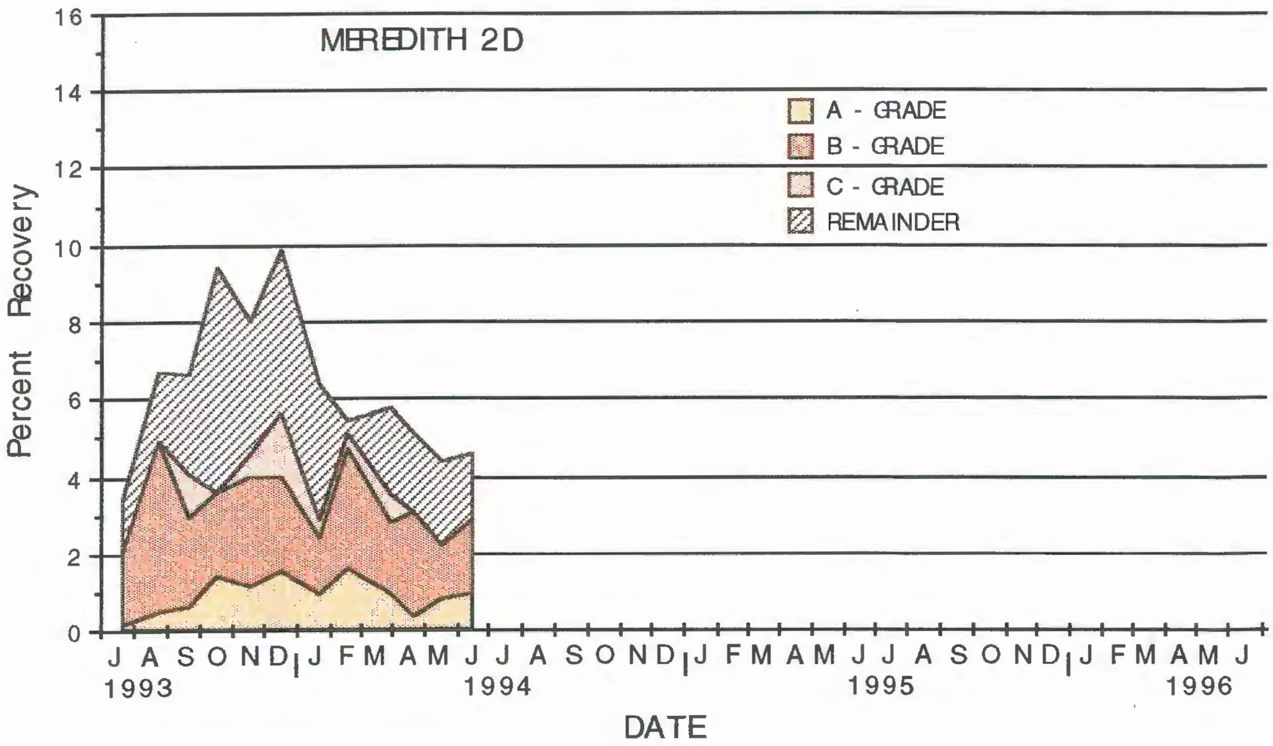
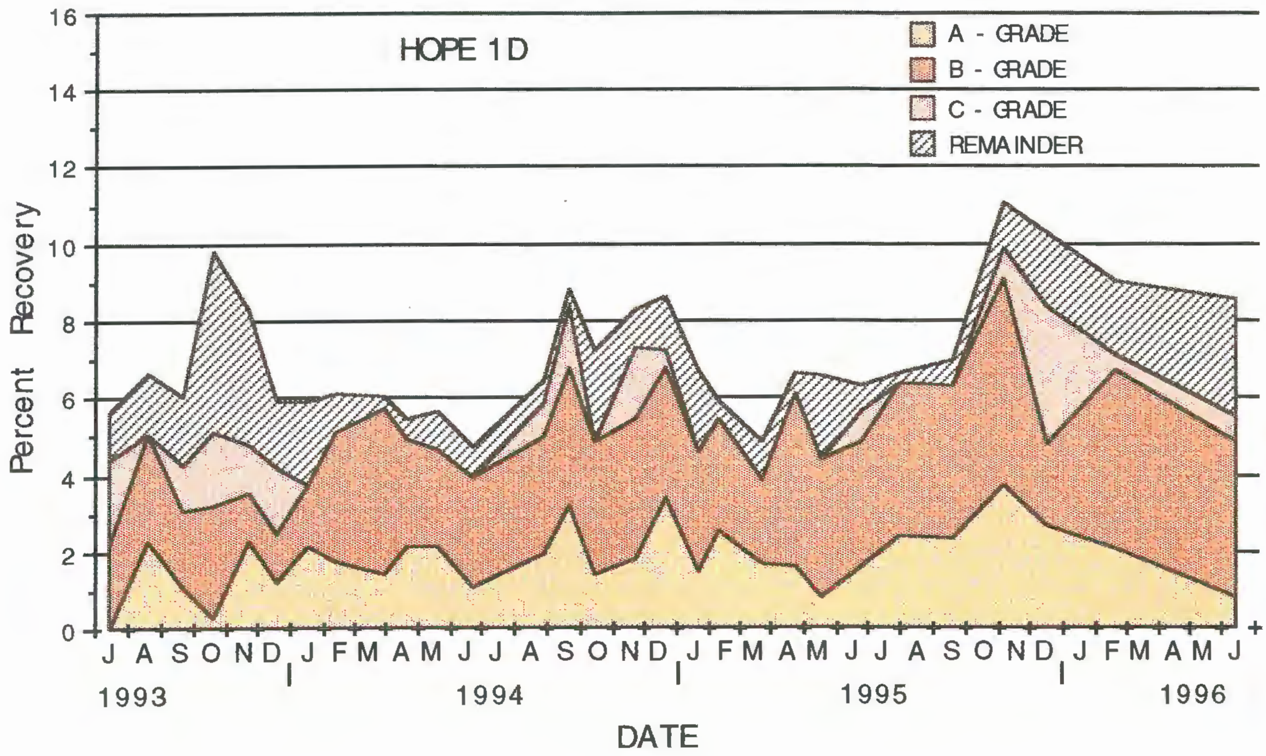


FIGURE 2.6 Breakdown of roes into grades for each month for a vegetated site (above) and a barrens site (below) at Hope Island.



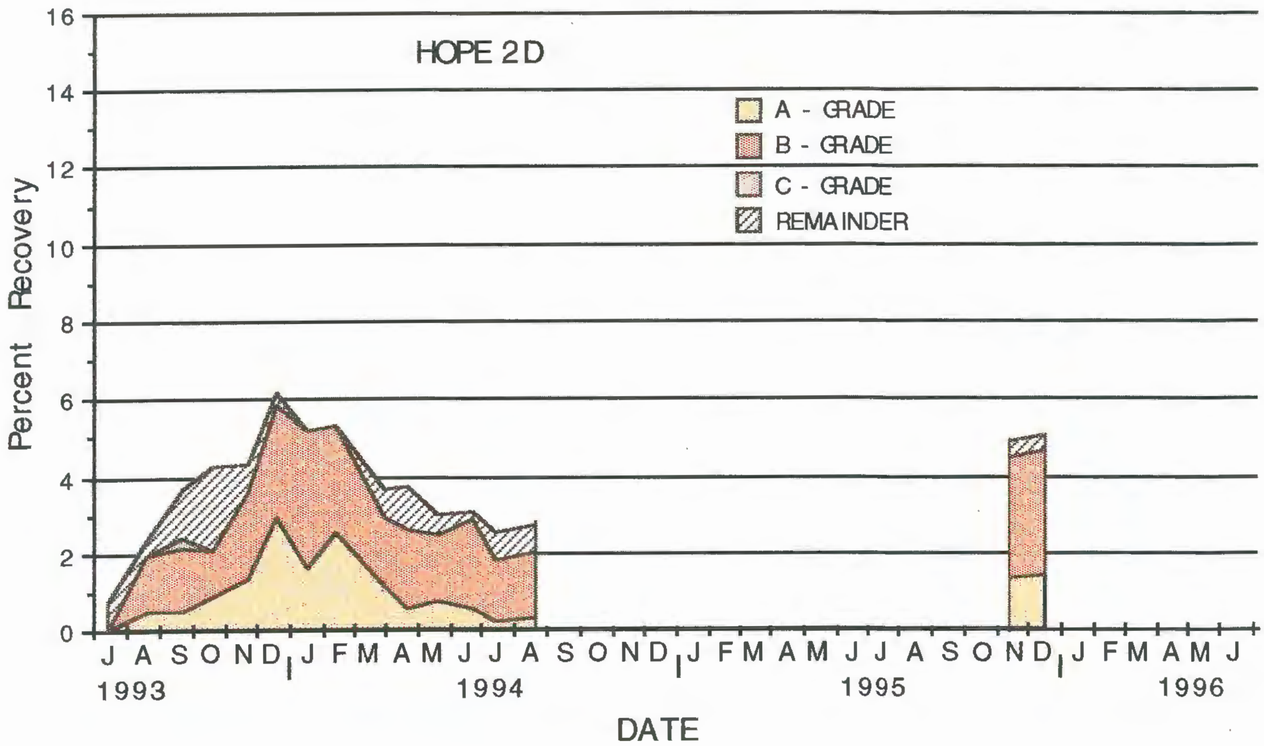


FIGURE 2.7 Breakdown of roes into grades for sampled months for a *Macrocystis* site (above) and a shelly site (below) at Hope Island.

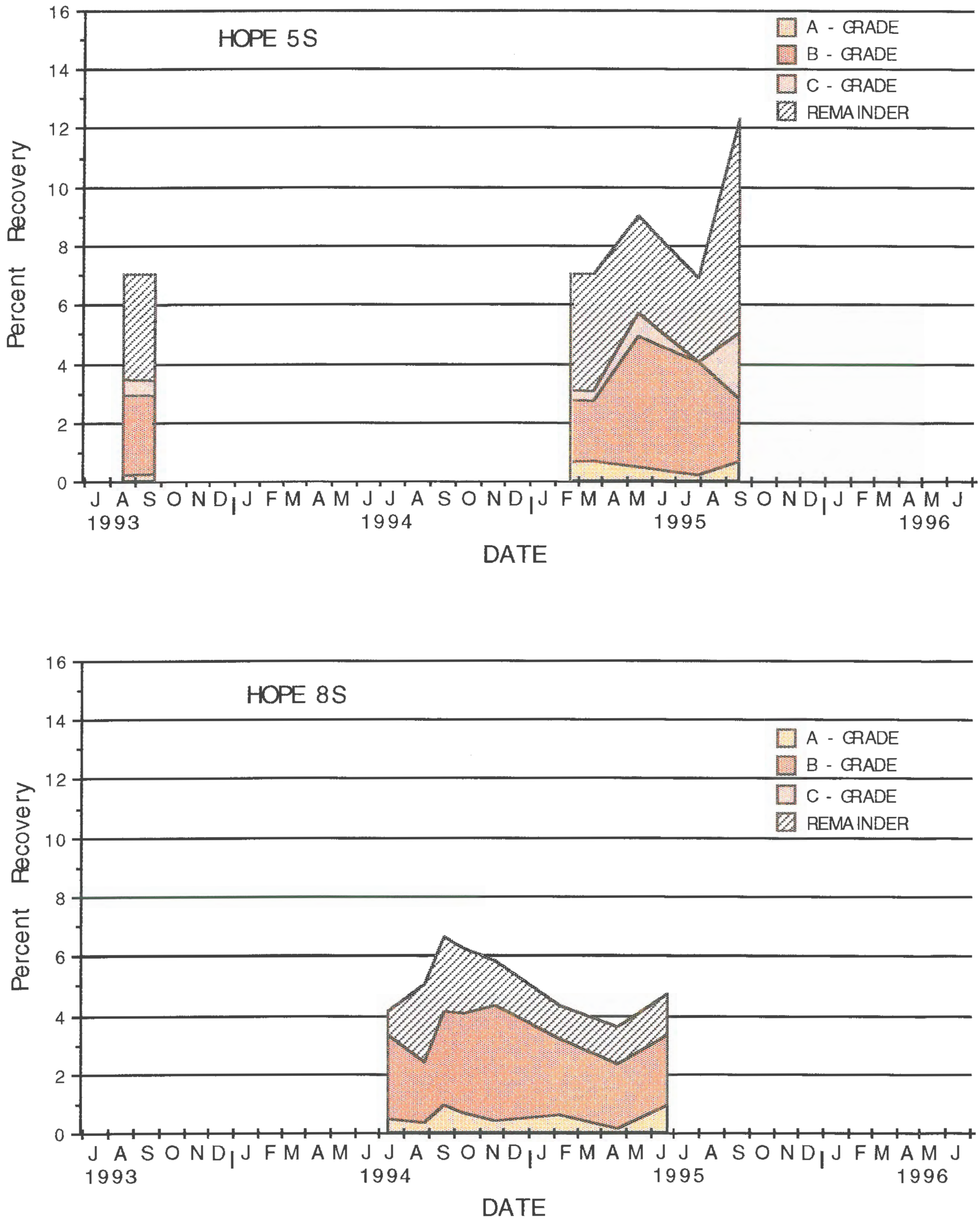
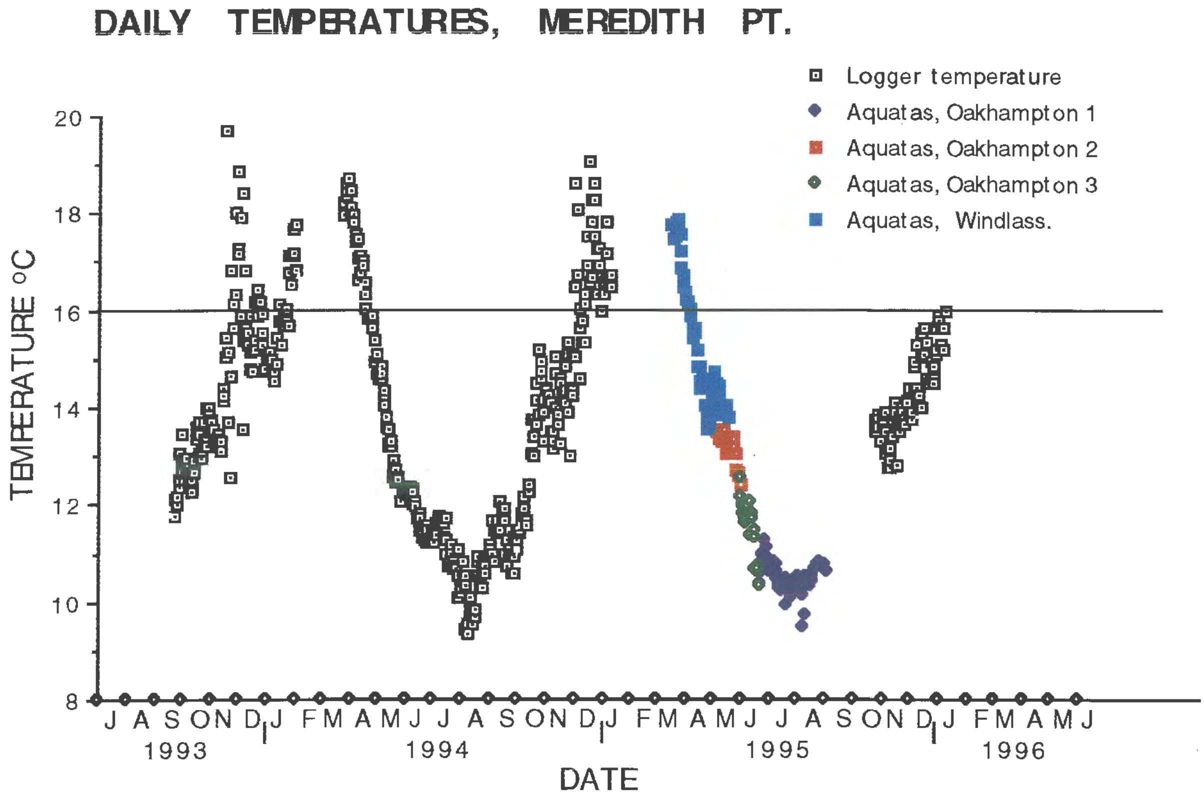


FIGURE 2.8 Daily and monthly temperatures as measured at Meredith Point, except for times of logger failure where data has been used from nearby sites (see Fig. 1.1-1.3 for site locations).



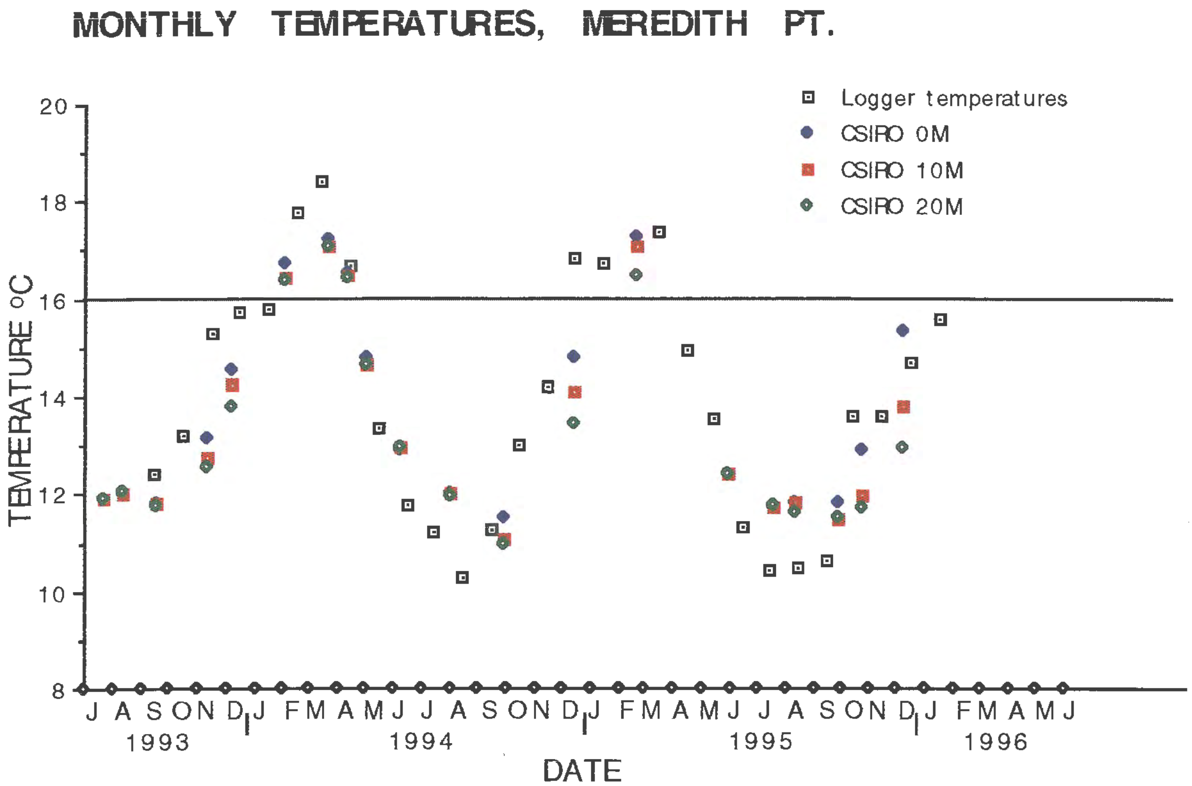
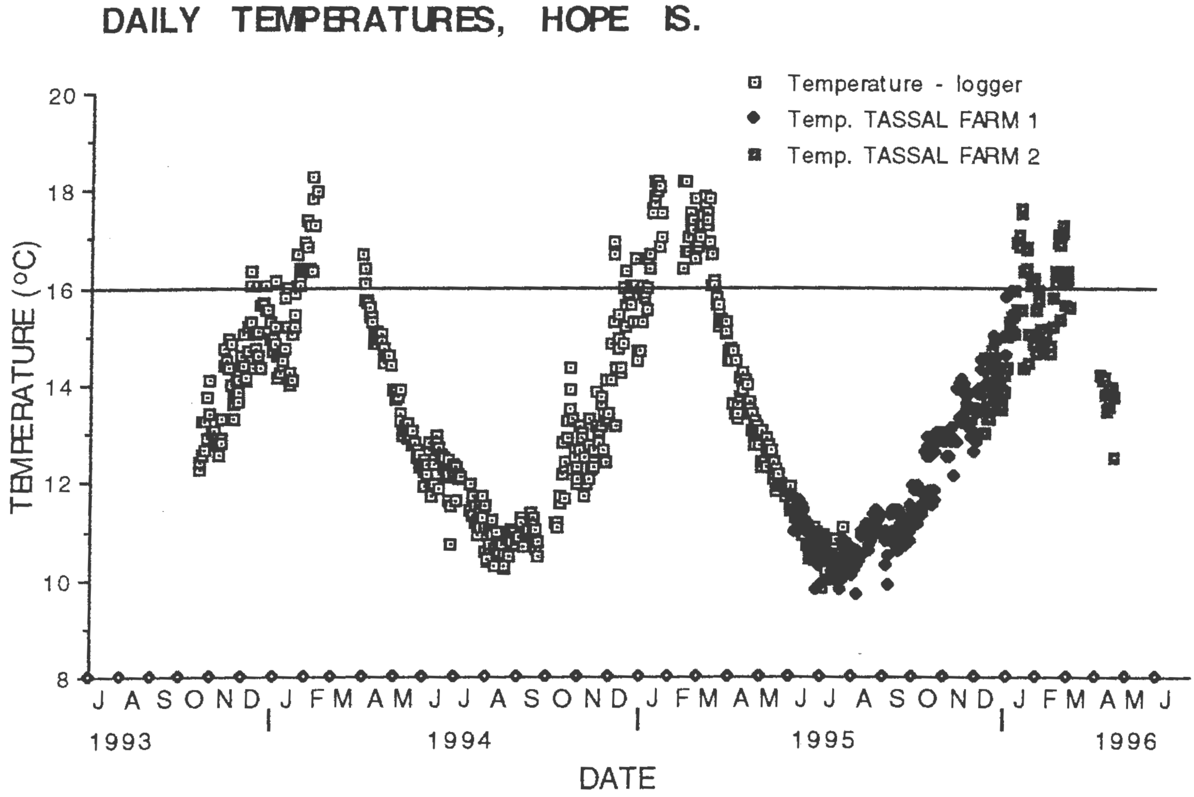


FIGURE 2.9 Daily and monthly temperatures as measured at Hope Island, except for times of logger failure where data has been used from nearby sites (see Fig. 1.1-1.3 for site locations).



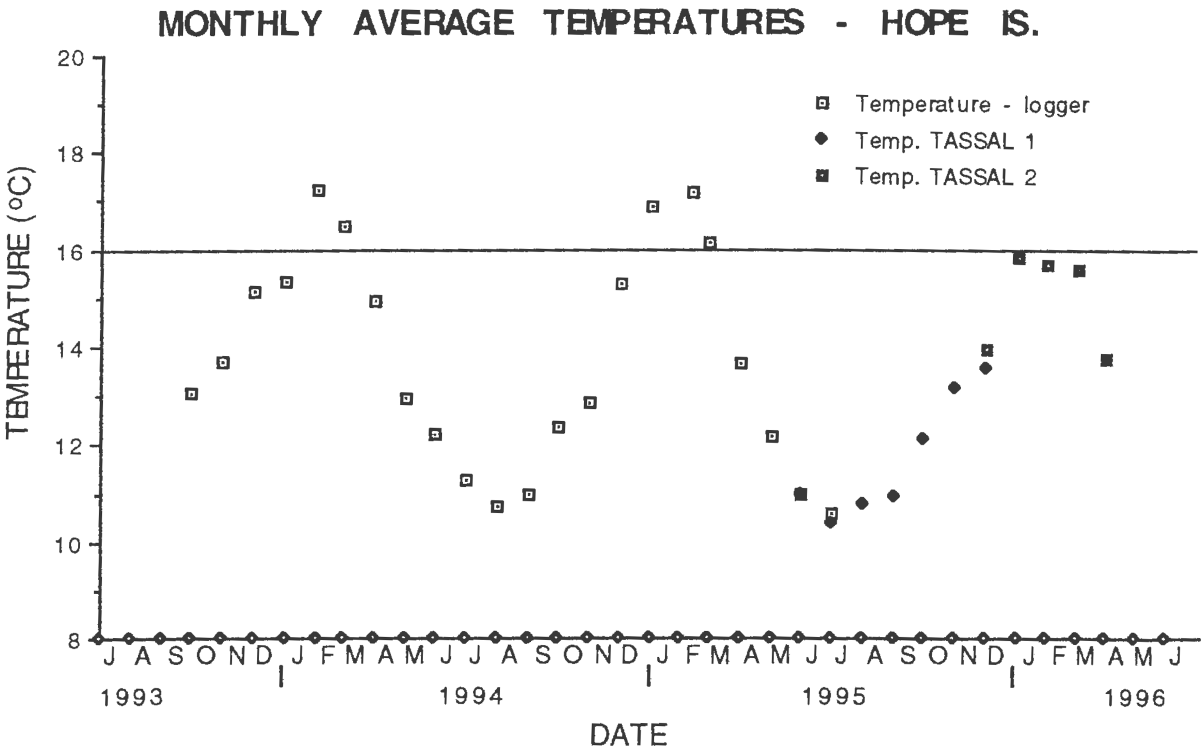
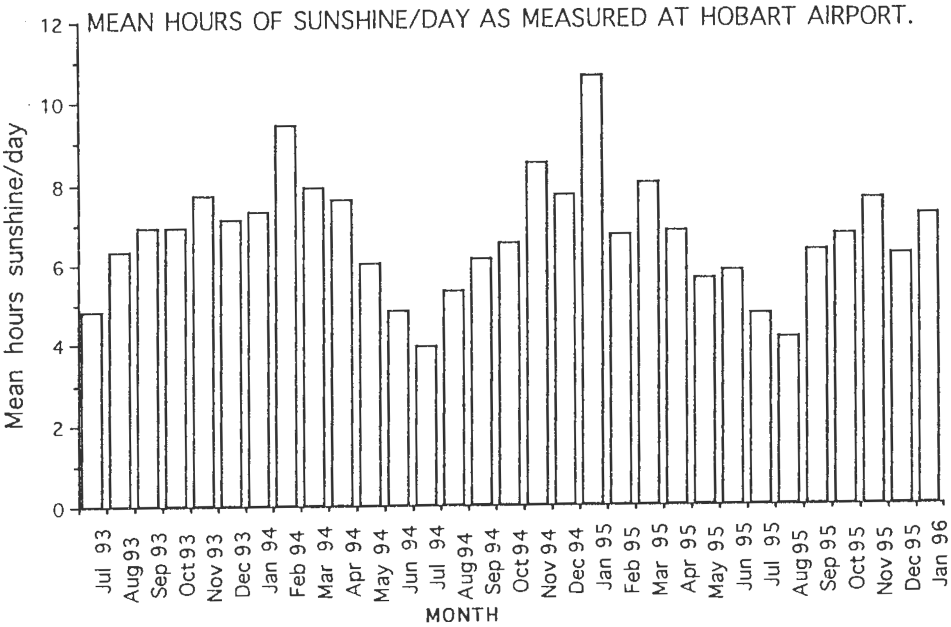
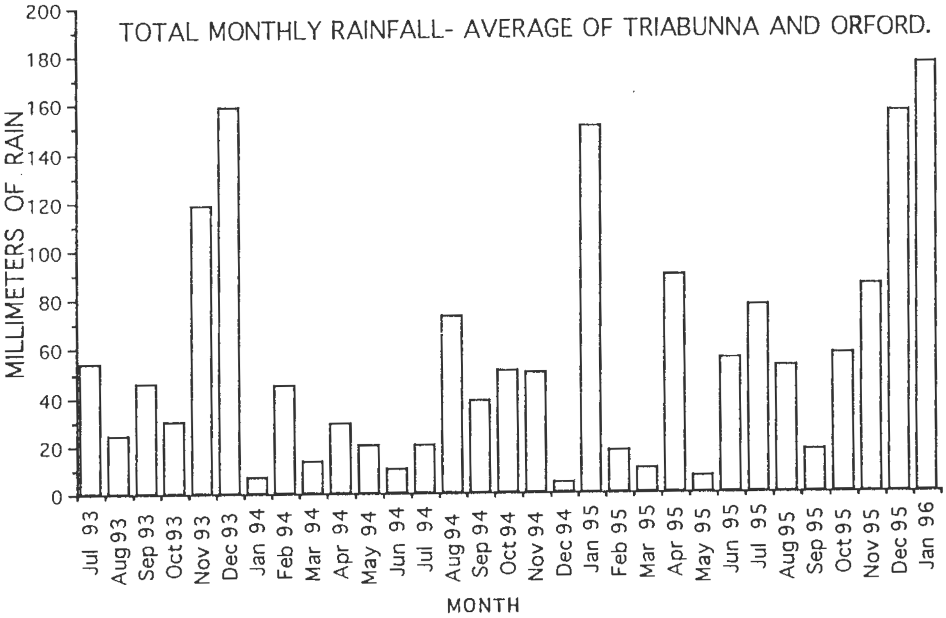


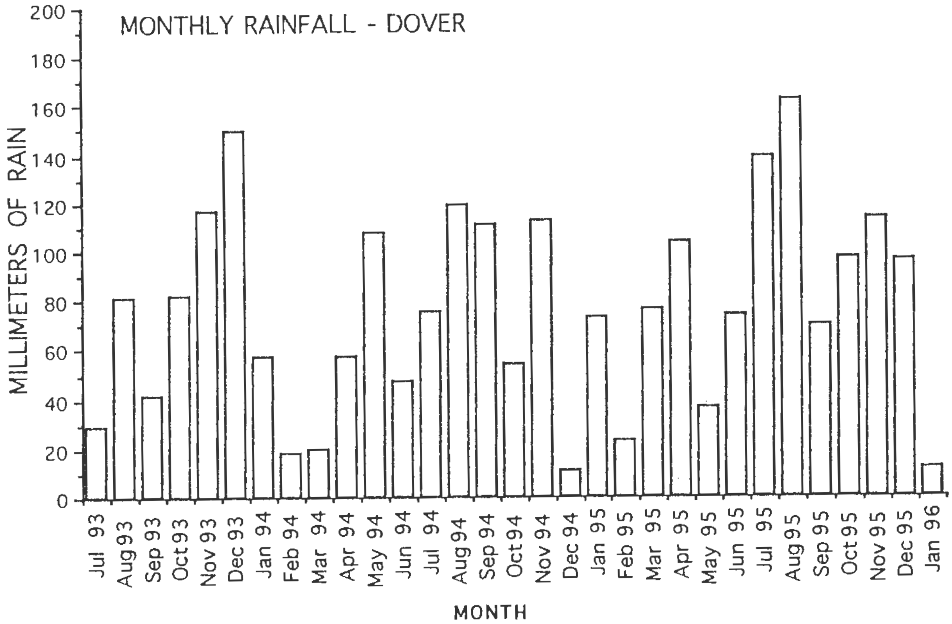
FIGURE 2.10



MEAN HOURS OF SUNSHINE/DAY AS MEASURED AT HOBART AIRPORT.
Mean hours sunshine/day
12
10
8
6
4
2
0
Jul 93
Aug93
Sep 93
Oct93
Nov 93
Dec 93
Jan 94
Feb 94
Mar 94
Apr 94
May 94
Jun 94
Jul 94
Aug94
Sep 94
Oct94
Nov 94
Dec 94
Jan 95
Feb 95
Mar 95
Apr 95
May 95
Jun 95
Jul 95
Aug95
Sep 95
Oct95
Nov 95
Dec 95
Jan 96
MONTH



TOTAL MONTHLY RAINFALL- AVERAGE OF TRIABUNNA AND ORFORD.
MILLIMETERS OF RAIN
200
180
160
140
120
100
80
60
40
20
0
Jul 93
Aug93
Sep 93
Oct93
Nov 93
Dec 93
Jan 94
Feb 94
Mar 94
Apr 94
May 94
Jun 94
Jul 94
Aug94
Sep 94
Oct94
Nov 94
Dec 94
Jan 95
Feb 95
Mar 95
Apr 95
May 95
Jun 95
Jul 95
Aug95
Sep 95
Oct95
Nov 95
Dec 95
Jan 96
MONTH



MONTHLY RAINFALL - DOVER
MILLIMETERS OF RAIN
200
180
160
140
120
100
80
60
40
20
0
Jul 93
Aug93
Sep 93
Oct93
Nov 93
Dec 93
Jan 94
Feb 94
Mar 94
Apr 94
May 94
Jun 94
Jul 94
Aug94
Sep 94
Oct94
Nov 94
Dec 94
Jan 95
Feb 95
Mar 95
Apr 95
May 95
Jun 95
Jul 95
Aug95
Sep 95
Oct95
Nov 95
Dec 95
Jan 96
MONTH

SECTION 3:

MEREDITH POINT, URCHIN DENSITY MANIPULATIONS

INTRODUCTION

At Meredith Pt, the effect of varying urchin densities obtained through differing harvesting strategies on roe yield of urchins was investigated. This was determined by partioning parts of the coast into plots (squares) and subjecting each to differing treatments.

These treatments were:

1/ Control squares. These were left relatively untouched for the period of the project.

2/ Transplants. Urchins were transplanted into these areas from outside the lease site. This would show the effect of elavated densities on roe condition. It may also show if it was possible to improve the roe quality of the transplanted urchins. Transplanted urchins were from an area of low roe recovery.

3/ Harvested squares. These squares were continuosly harvested for the period of the project and so maintained a low density.

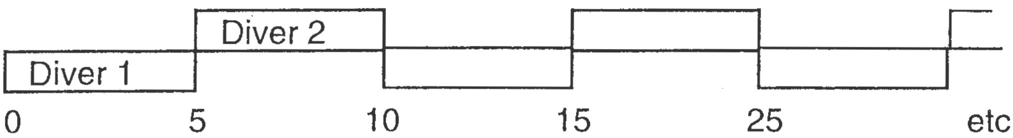
The squares consisted of 50m sections of the coast (see fig.1.3) with the boundaries perpendiular to the shore to the limit of hard substrate, marked by ropes weighted with concrete filled tyres. There were three blocks, each with three treatments. The three blocks are the eastern (E), middle (M) and western (W).

Urchin density was monitored through 20 - 5 x 1 m quadrats and vegetation with 20 - 0.5 x 0.5 m quadrats for each square. The 0.5 x 0.5 m quadrat used for vegetation and substrate cover was subdivided with seven horizontal and vertical lines giving 49 intersection points. These and one of the corners gave 50 points. Algal cover and substrate were given a reading based on the number of points intersected. Total cover for algae can come to a number greater than 50 (100%) due to successive layers of algae. Algae were divided into species as best as possible underwater.

For urchin density and algal cover, two transects were laid parallel to the coast for each square at distances of approximately, 15 and 25 m from shore. For urchin density, the diver recorded the number of urchins in contiguous 5 meter quadrats (see fig. 3.1). For algae and substrate, the diver used a $0.25m^2$ quadrat, positioned at each 10m mark.

Gonad condition was monitored from 25 urchins sampled from within each of the treatment squares.

Figure 3.1 Diagram showing contiguous arrangement of quadrats about the transect line (numbers are distance along the transect line in meters).



Density of the urchins was determined approximately every six months, while gonad analysis was conducted at the likely time of optimal condition, either November or December for each of 1993, 1994 and 1995. 1993 was the pre-treatment survey.

Approximately every six months, the diameter of 50-100 urchins was measured from each of the squares. This was to determine if size cohorts could be followed through time within each of the squares.

To see how well our estimates of gonad condition agreed with processor results, 120 urchins (approx. one bin) were harvested from each of the squares in January 1996 and sent to Oceania, a local processor. The time taken to harvest each of these bins was recorded to determine economics of harvesting beds at different densities.

RESULTS

Transect results are presented in detail in Appendix 1. Combined transect results are presented for each of the squares in Figure 3:2 for monitoring sessions: Jan, June, Oct and December 1994, July and November 1995 and May 1996 (urchins only were surveyed in December1994 ie. no algal cover).

A decline in urchin numbers for harvested squares is demonstrated. Transplanted squares show an increase in urchin numbers with high variability in density estimates (most apparent in Appendices 1.4-1.6). The high variability is due to the urchins being dumped within the designated areas straight out of the nets/bins. The urchins have not moved very much from where they were released and thus remain quite clumped in distribution.

Overall, vegetation shows no significant difference between treatments at the end of the experiment. Initially, there were no obvious barrens on these sites except for EH. If we look at the results for this square only (EH) in Appendix 1 however, we observe a substantial increase in vegetation for this square (corresponding also to a large decrease in urchin density).

Post treatment gonad analysis of the urchins from harvested squares is significantly different (see Table 3.1, Fig. 3.3) from the control and transplant squares (EC is an outlier however, which when dropped from the analysis, greatly improves the significance, p=.006).

TABLE 3.1
ANOVA for difference between treatments for percentage recovery for squares at Meredith, November 1995.

SOURCE	S-S	DF	M-S	F-RATIO	P
TREATMENT	15.832	2	7.916	9.915	0.013
ERROR	4.790	6	0.798		

There appears to be a strong linear relationship between urchin density and roe yield (Fig. 3.3-3.5). This is also true for the final post-treatment harvest in 1995 after manipulations. The density of the urchins also has an effect on the catch rate of the urchins. At lower densities, yield per urchin is improved but the rate of harvest declines. As both catch rate and roe recovery are related to urchin density, we can relate diver earnings to densities (Fig 3.4 b). This relationship also incorporates an anticipated negative relationship between density of urchins and proportion of A grade roe. At low densities, there is a higher proportion of A grade roe, values used are based on those in Table 2.1. These results appear relate well to diver experience.

There is also a good relationship between our determinations of percentage recovery and that of the processor (Fig. 3.5), although their's is less than half our results. This may be attributed to more selective processing on their part and less efficiency. Also, their samples were processed in January, past the peak season, whereas ours were done in November.

Relative proportions of roes with differing colours and textures do not seem to show any significant difference (Figs 3.6-3.7) as a result of the treatments. Overall there seems to be an increase in darker coloured roes from 1993-1996. This complies with a trend towards darker coloured roes over this period. (Section 2).

DISCUSSION

The poor condition of 'Transplanted' urchins may be attributed to the fact that they were dumped in localized areas. In fact 'barrens' have developed in the immediate vicinity of dumped urchins. Other possible reasons may be the slow adaptation time of these urchins to their new environment or perhaps energy is being put into growth rather than gonad.

This experiment has shown the value of reduction of densities of urchins on increasing gonad yield. Results have taken two years to realize from time of treatment and are best for barrens areas.

Change in urchin density over the term of the experiment in any combination of squares (C, T or H, Fig. 3.2.1) shows minimal recruitment after treatments. As none of the control squares were originally barrens, and there was heavy fishing pressure on the site before closure, we may assume that they were not originally at maximum density levels and will recruit. The control squares show a small increase over the term of the program, while the regression is not significantly different from 0, if the May 96 survey is deleted from the analysis, then it is significant at the .05 level (recruitment = 2.5 per 5 x 1m per yr). The increase in urchin density over the program for the control squares (May 96 survey included, Fig 3.8) may be considered as equivalent to recruitment of 1.4 urchins per 5 x 1m per yr (0.9 deep, 1.8 shallow) or approximately $0.3/m^2/yr$.

FIGURE 3.2.1 Graphs showing the results of surveys for treatment squares at Meredith Pt; urchin, Undaria and Fucales (+/- stdev).

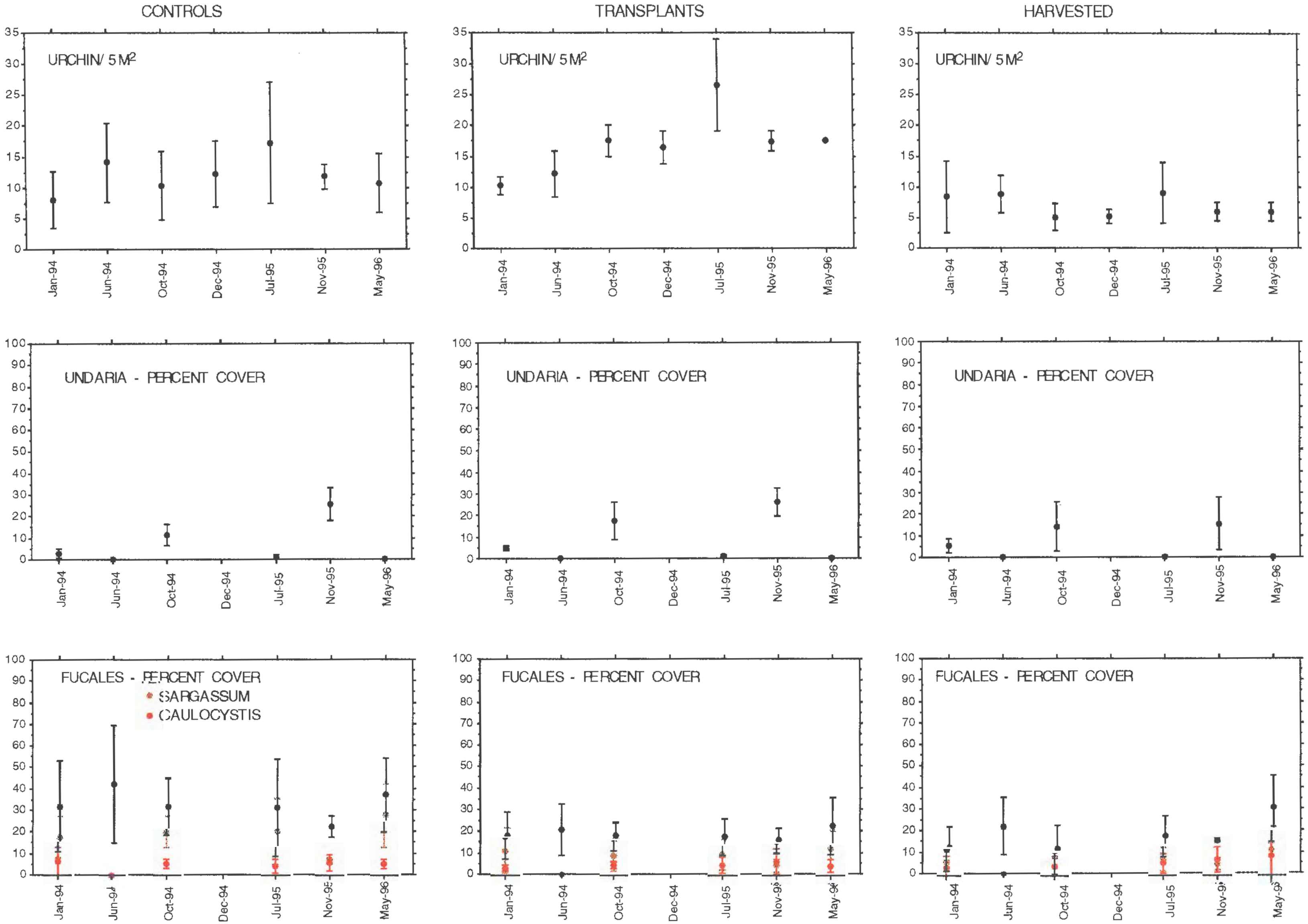


FIGURE 3.2.2 Graphs showing the results of surveys for treatment squares at Meredith Pt; fine algae, Caulerpa and seagrass (+/- stdev).

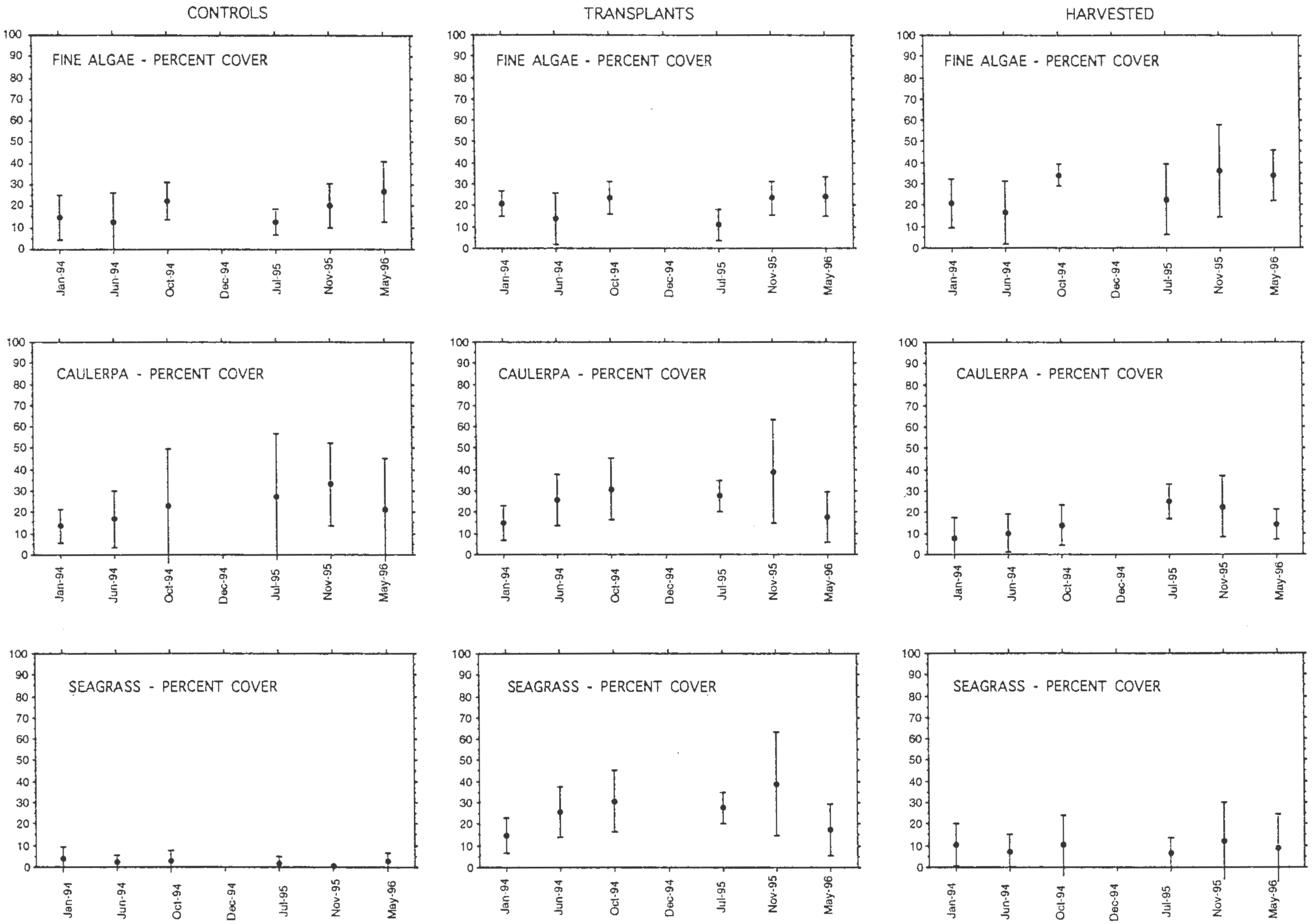


FIGURE 3.2.3 Graphs showing the results of surveys for treatment squares at Meredith Pt; urchin, Undaria and Fucales (+/- stdev).

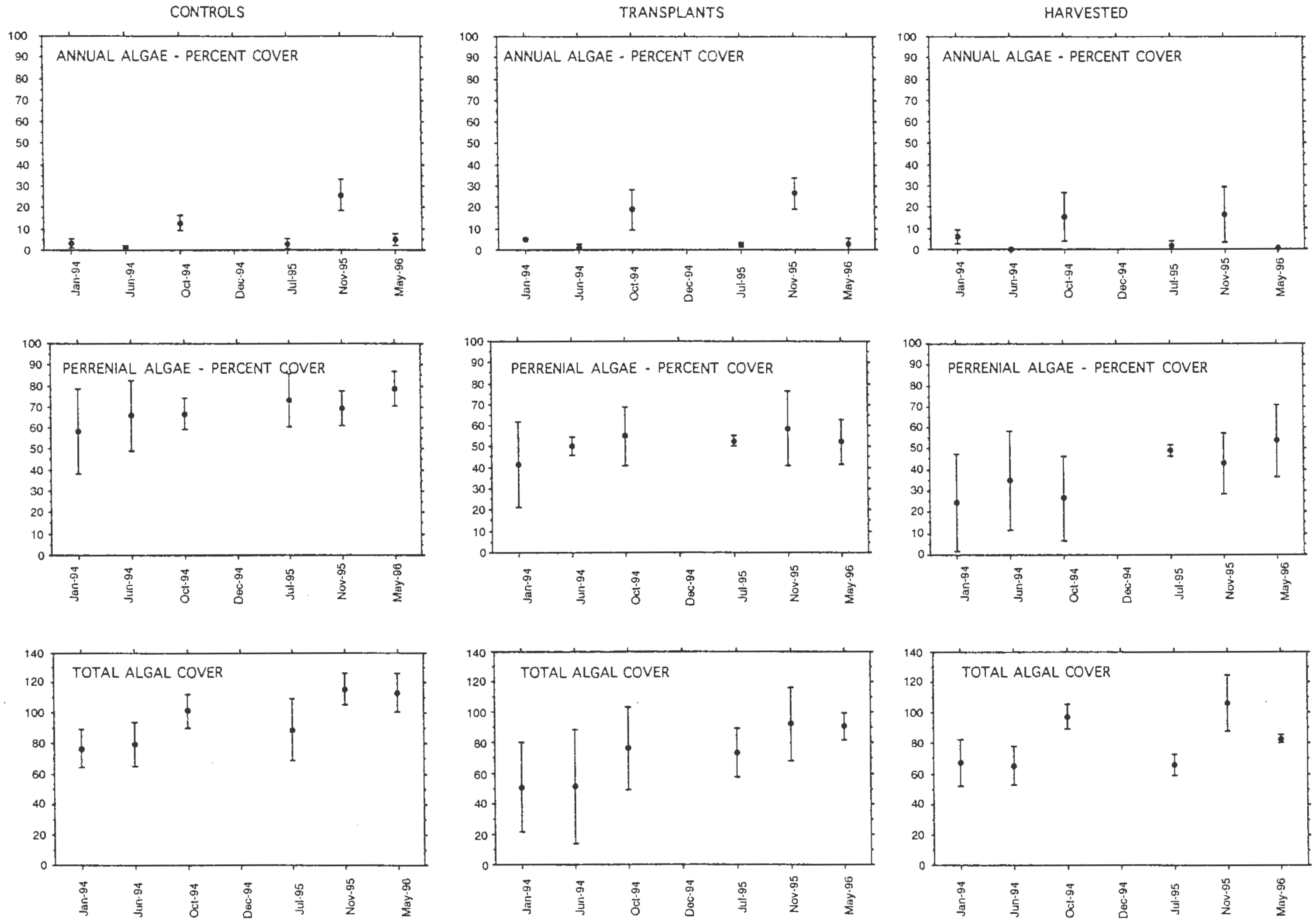


FIGURE 3.3 Density of urchins for each of the treatment squares versus percentage recovery of roe.

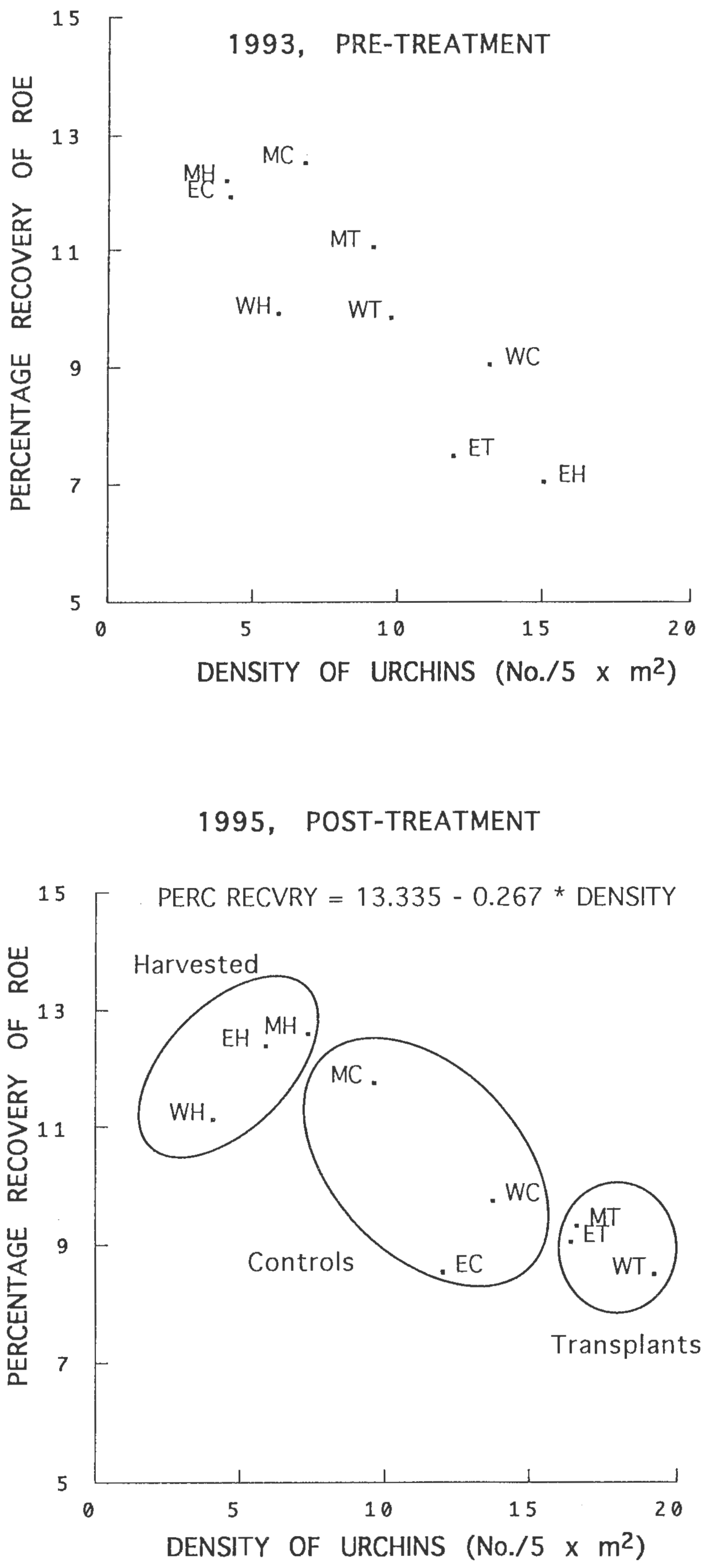


FIGURE 3.4 a) TIME TO HARVEST 120 URCHINS
(APPROX. 1 BIN, 20 KG)

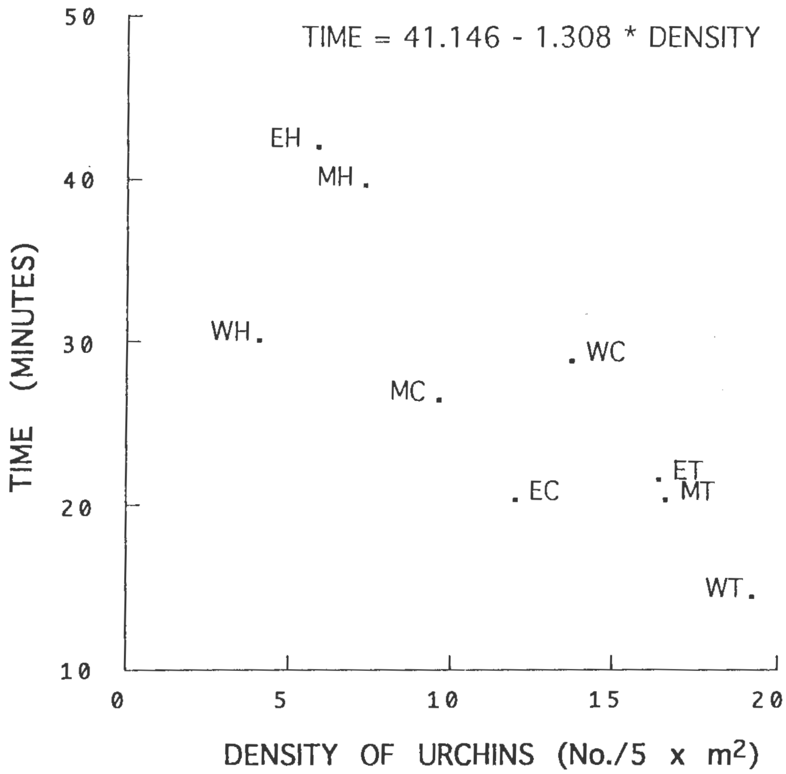


FIGURE 3.4 **b)** Return to diver, calculated from estimated catch rates, roe recovery rates and roe grade proportions as they vary with density of urchins. (Agrade: $35-/kg, B grade: $7-/kg)

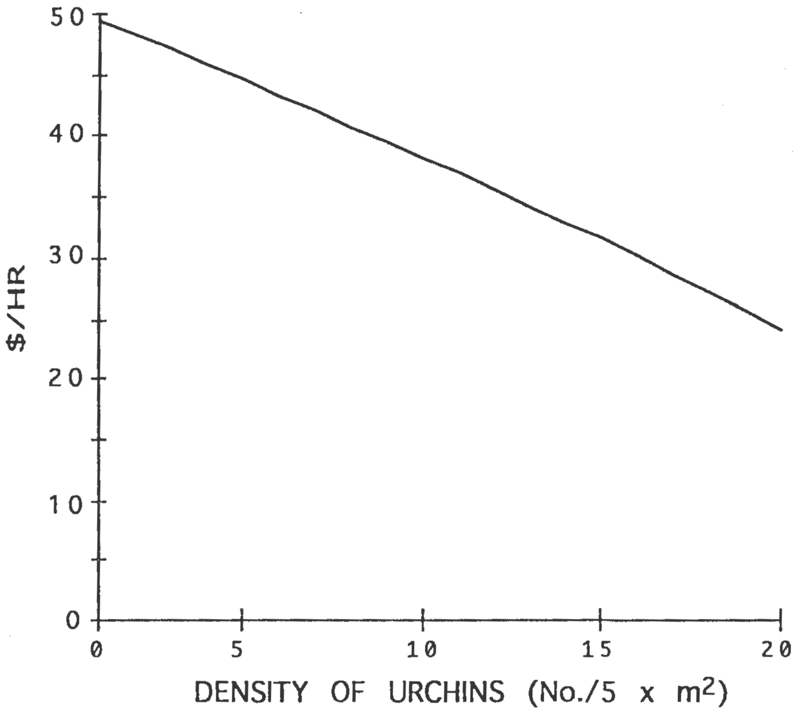


FIGURE 3.5

SAMPLED RECOVERIES (DEC 1995) AGAINST COMMERCIAL RECOVERIES (OCEANIA, JAN 1996).

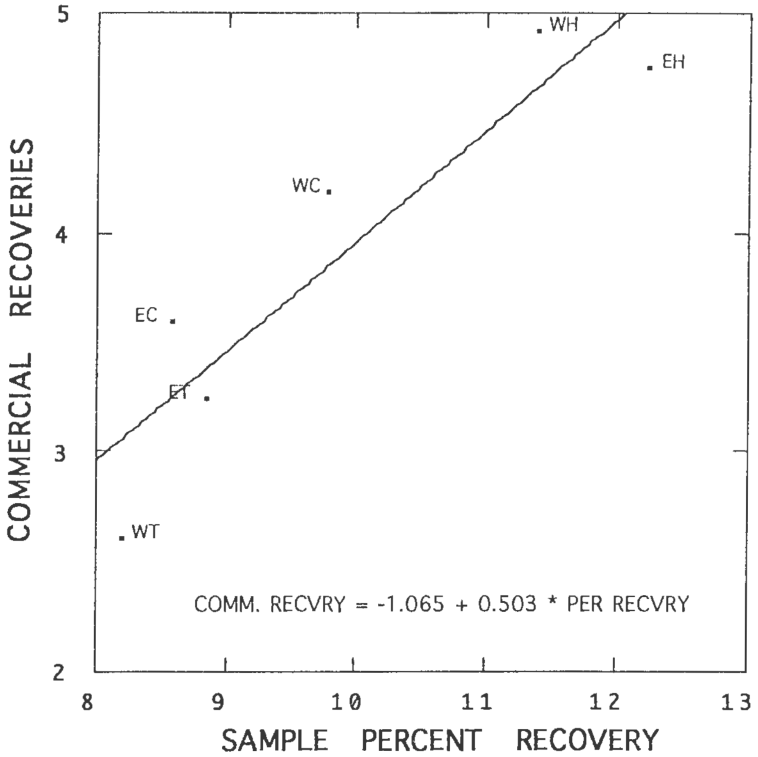


FIGURE 3.6 Colour grading of urchins from each of the treatment squares for each of the test sample dates Dec 93, Dec 94 and Nov 95.. Note that colours '1' and'2' have been merged as have '3' and '4'.

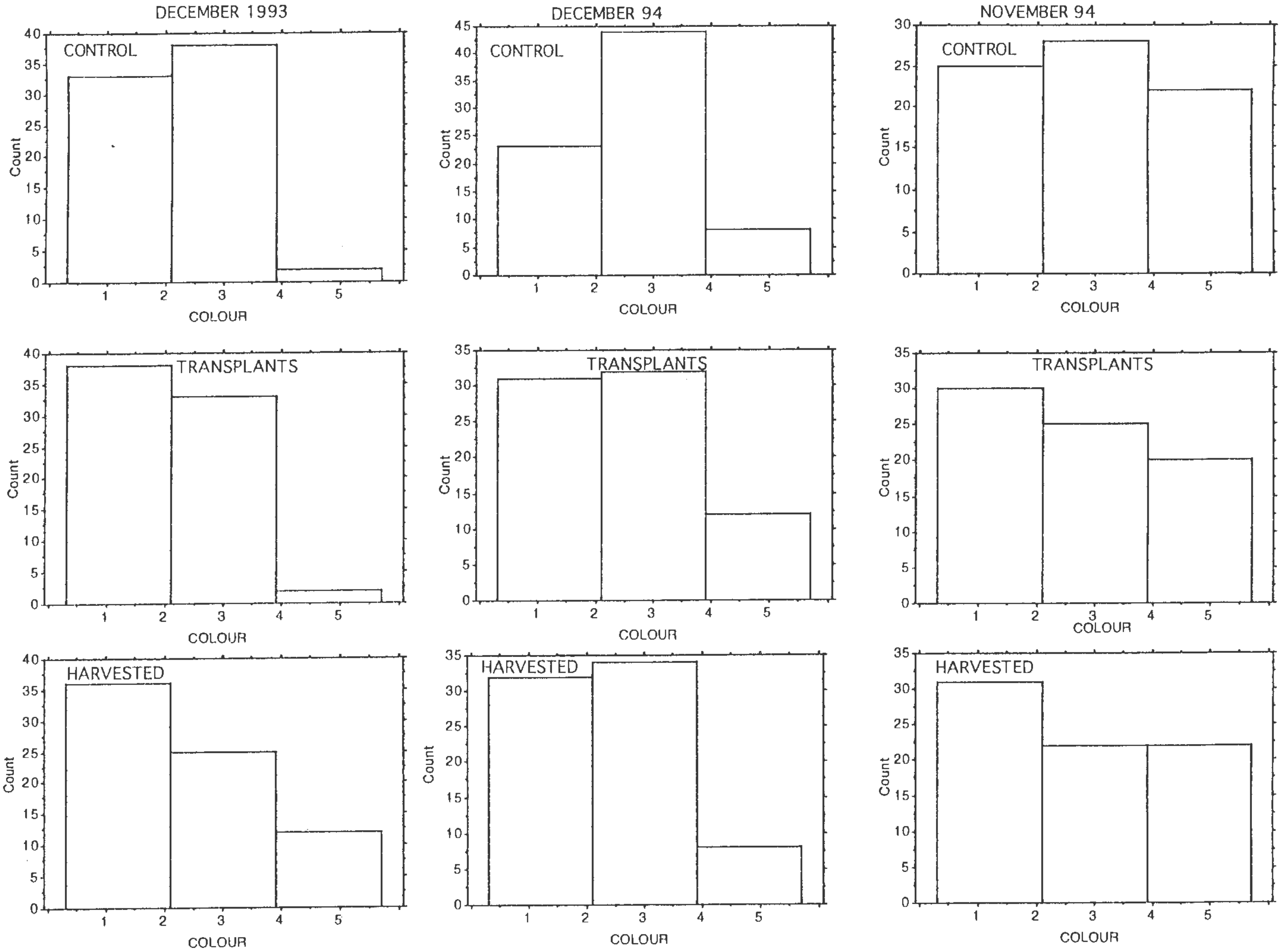
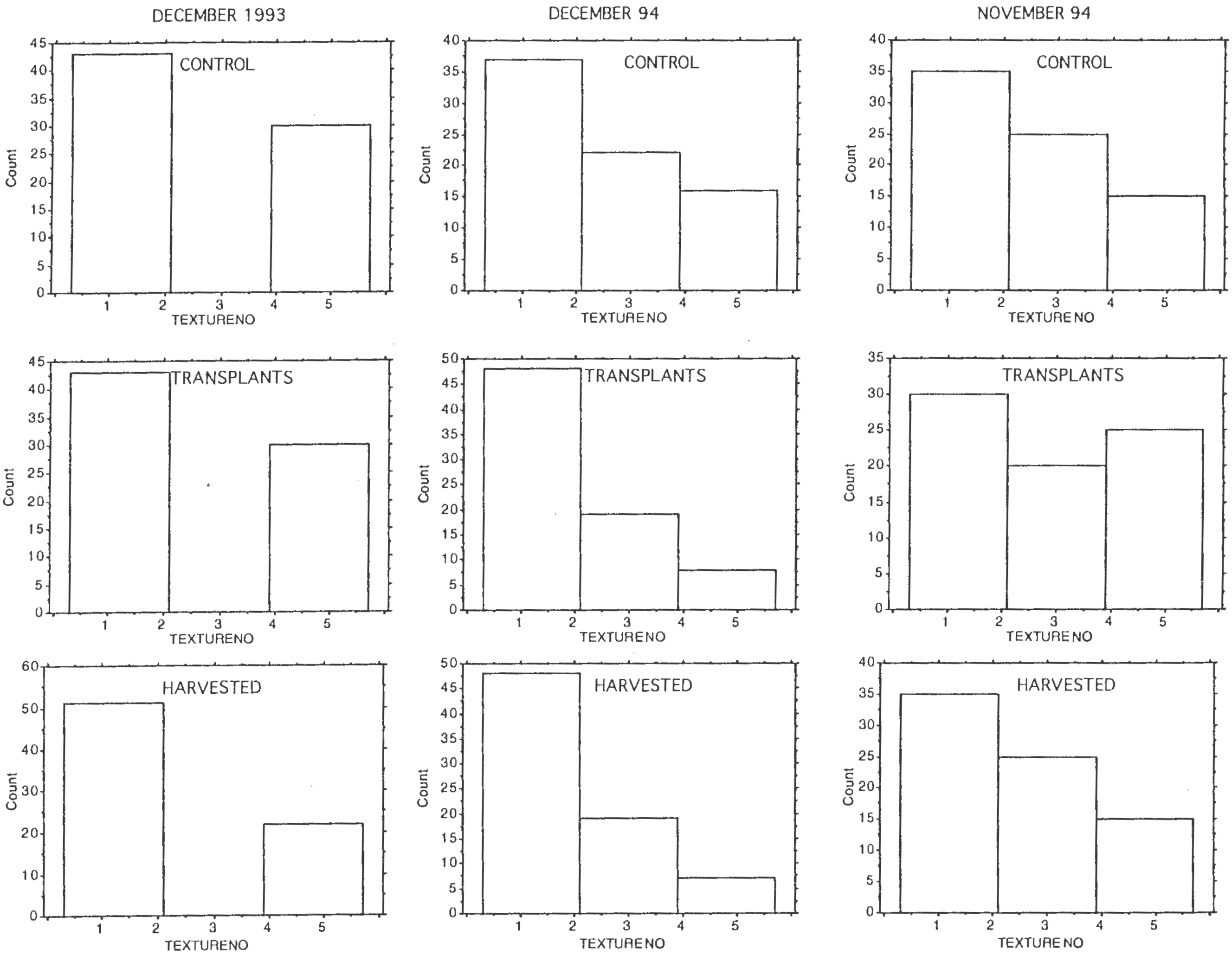


FIGURE 3.7 Texture grading of urchins from each of the treatment squares for each of the test sample dates, Dec 93, Dec 94 and Nov 95. Note that there was no middle rating for Dec 93. and 'VF' and 'F' (1 & 2) ratings have been merged, as well as 'C' and 'VC' (3 & 4).



SECTION 4:

HOPE ISLAND, URCHIN DENSITY MANIPULATIONS

INTRODUCTION

At Hope Is, preliminary short term trial clearings of urchin from barrens resulted in little recovery of macroalgal vegetation. This indicated that intended clearings of urchins at this site to improve roe quality would be unlikely to succeed as there was no subsequent increase in available food. It was postulated that limpets may be an additional herbivore controlling vegetation so the following experiment was conducted to determine if urchins were the principal herbivore at Hope Island.

METHOD

To determine the cause of the barrens on the island, four treatments were proposed. These were:

1. No urchins (U)
2. No urchins, abalone and limpets (UAL)
3. No abalone or limpets (AL)
4. Control (C)

These were done in quadruplicate for 16 squares divided off by approx. 50 cm high netting. The squares measure 10m x 7.5m. There are two blocks of four squares each on each side of the island with randomly allocated treatments.

Monitoring was conducted using 10 1 x 1m quadrats within each of the squares for counts of urchin, abalone and limpets. Quadrats were regularly arranged in the square: one at each of the corners, one at each of the mid points of the sides and two in the middle. Ten 0.5 x 0.5 m quadrats (50 point intercept) are used for the algae placed within the 1 x 1m quadrat used for urchin numbers.

In order to provide a source of spores, as spore availability may affect re-vegetation, *Macrocystis* plants were introduced to each of the squares. Ten plants were placed in each. Juvenile plants (0.2-1.0m high) were obtained from Dodges Ferry, kept moist under hessian sacks and within 24 hours of harvest, replanted at Hope Island in June 1994. Individual plants were attached to bricks using rubber bands over the haptera at the base of the plant. A further aspect of this experiment was to determine if urchins or limpets were controlling factors in *Macrocystis* populations at Hope Island. Urchin divers maintain that best roe recovery comes from urchins harvested from beds of *Macrocystis*.

Monitoring was conducted approximately once every four months after the pre-harvest survey. Minimal change was observed in re-vegetation for the first spring-summer period over which the experiment was conducted (1994) so it was run until spring-summer of the second year (1995). Clearing sessions were conducted at the beginning of the experiment (June 1994) and again in the autumn of 1995. The first monitoring session after the first clearing, showed abalone densities were not significantly different from the initial pre- first clearance survey. It was assumed that the nets were being transversed by the abalone and because density levels of these animals were low and thus likely of limited effect, abalone were not included in subsequent harvests.

RESULTS

Results for the manipulation experimants are depicted in Figs: 4:1 - 4:5. Limpets did not have a significant effect on the percentage cover of algae; filamentous, annual or perrenial recorded in the squares while urchins were highly significant. Time of monitoring is also highly significant. This is not surprising as there are seasonal differences in growth of the algae concerned.

TABLE 4.1

Analysis of variance on total algal cover on urchin cleared squares. Data for total algal cover was logged to normalise residual ditribution.

Dependent variable: Log Total algal cover, n: 16

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Block	4.305	3	1.435	8.932	0.006
Urchin treatment:	2.556	1	2.556	15.907	0.004
Block* Urchin treatment:	0.567	3	0.189	1.176	0.378
ERROR	1.285	8	0.161		

After four months, *Macrocystis* plant numbers were at significantly lower numbers in the squares with reduced levels of urchins (Fig. 4.5, Table 4.2). Later recruitment of *Macrocystis* plants was greater into the squares with reduced levels of urchins (Table 4.3).

TABLE 4.2 ANOVA on effect of urchin clearance on survival of transplanted Macrocystis plants four months after.

Dependent variable: Log No. Macrocystis plants in October 1994, n: 16

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Block	1.733	3	0.578	2.475	0.136
Urchin treatment:	5.696	1	5.696	24.403	0.001
Block * Urchin treatment:	0.715	3	0.238	1.021	0.433
ERROR	1.867	8	0.233		

TABLE 4.3 ANOVA on effect of urchin clearance on subsequent recruitment of *Macrocystis* plants into squares 23 months later.

Dependent variable: Log No. *Macrocystis* plants in May 1996, n: 16

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Block	0.921	3	0.307	0.473	0.710
Urchin treatment:	10.808	1	10.808	16.634	0.004
Block * Urchin treatment:	3.315	3	1.105	1.700	0.244
ERROR	5.198	8	0.650		

DISCUSSION

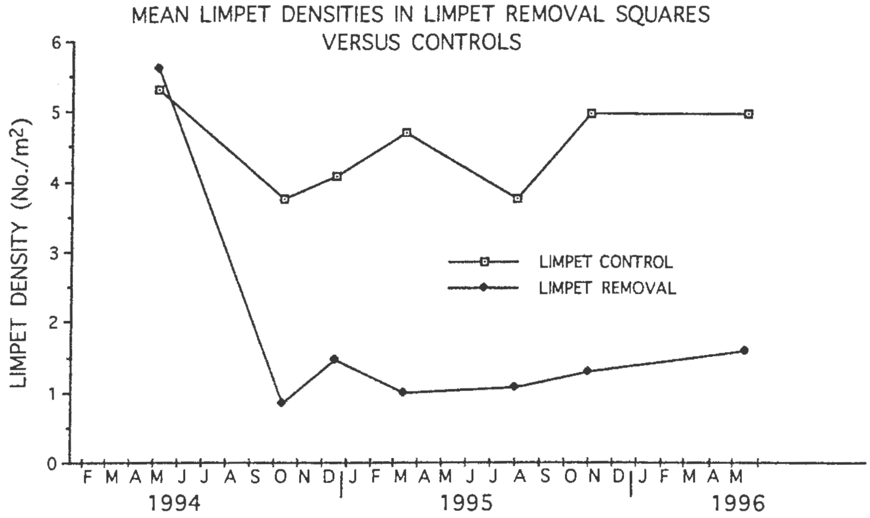
Two years later, an area that had been regularly cleared of urchin outside of treatment areas still did not have significant amounts of vegetation. It is thus quite likely that the reason for not becoming re-vegetated was due to a lack of a source of algal spores.

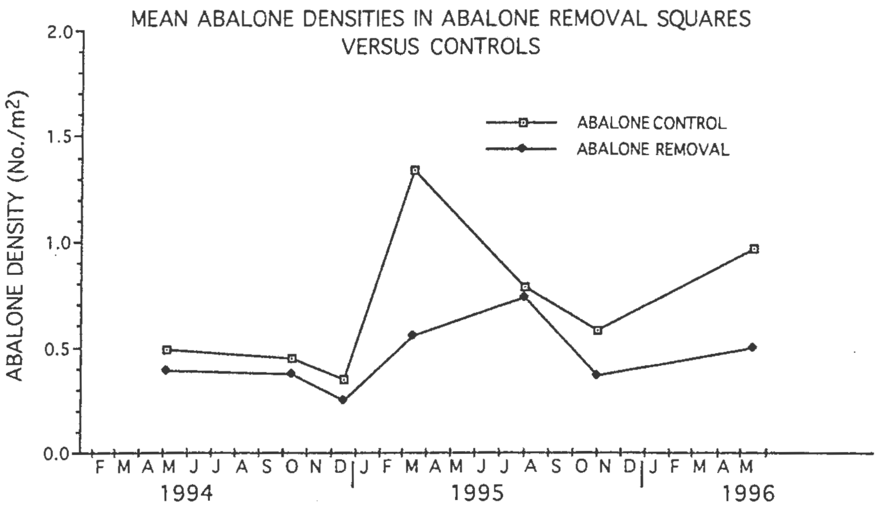
We have shown here that manipulations of urchin densities can result in increasing amounts of vegetation, and preferred species can be introduced. At these sites, while *Macrocystis* was a dominant algae that re-established itself in the cleared areas, a non-preferred alga also was evident namely: *Sargassum* sp. (*fallax*?, Fig. 4.6). *Sargassum* sp. are known to be high in polyphenolics (anti-herbivore secondary metabolites). This alga established itself in deeper waters with respect to *Macrocystis*. Urchin divers acknowledge that areas where *Sargassum* ('sticky weed') has established itself are poor recovery areas for urchin roe.

Unfortuneately, the experiment did not progress for sufficient time to determine the effect on roe of urchins associated with re-established *Macrocystis*, but it can be assumed from *Macrocystis* harvested urchins from nearby (Hope 5S) that they will improve.

FIGURE 4.1 Results of regular surveys within the squares at Hope Island.

LIMPET REMOVAL





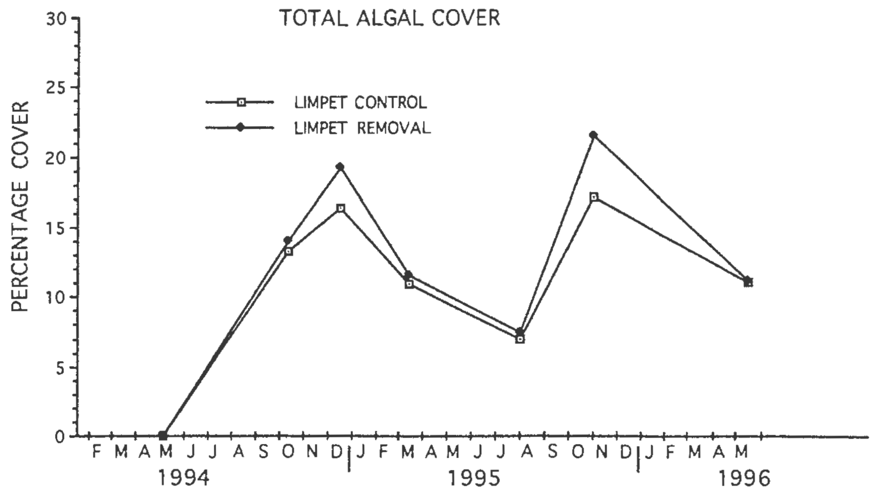


FIGURE 4.2 Results of regular surveys within the squares at Hope Island.

LIMPET REMOVAL

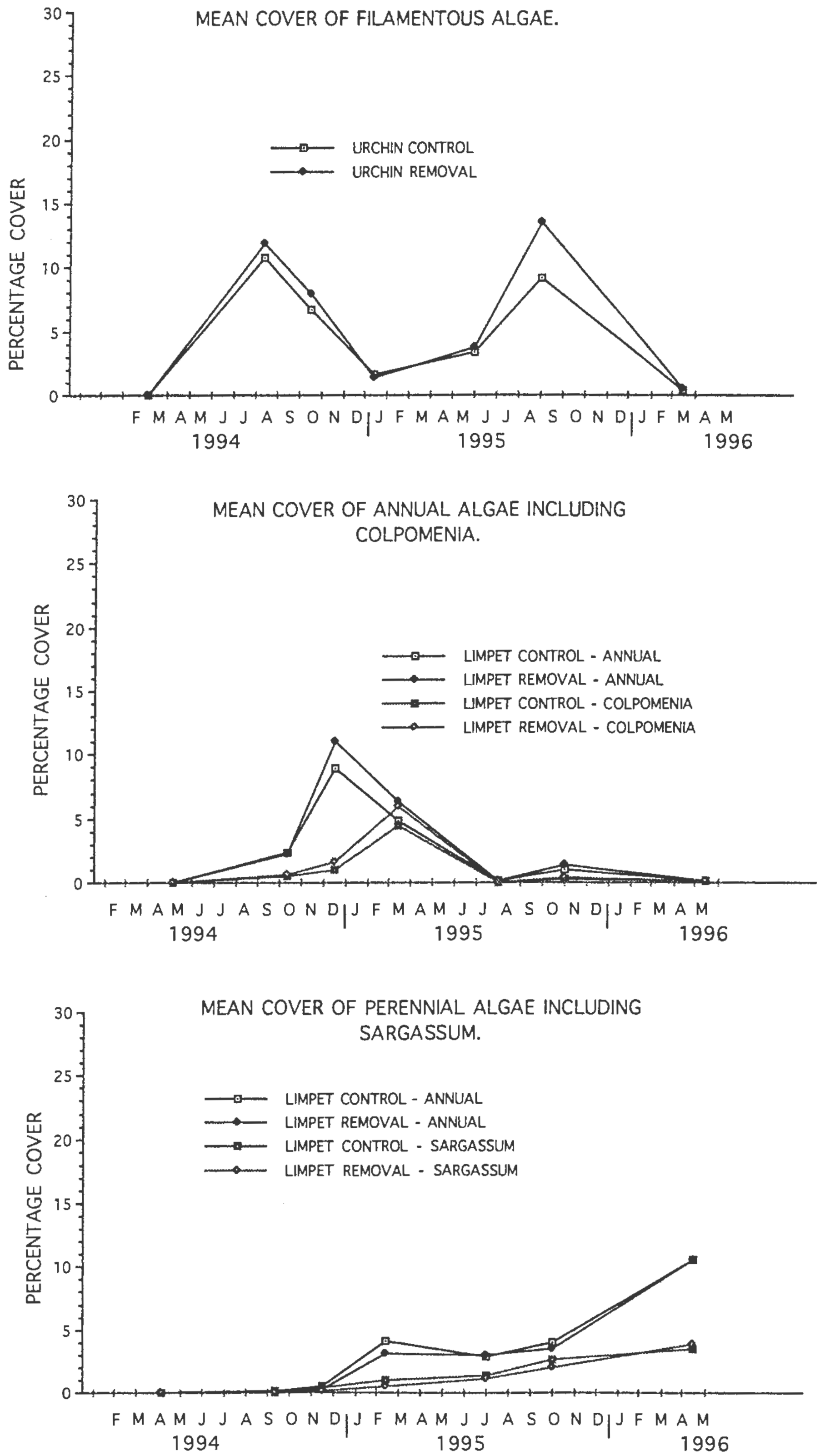
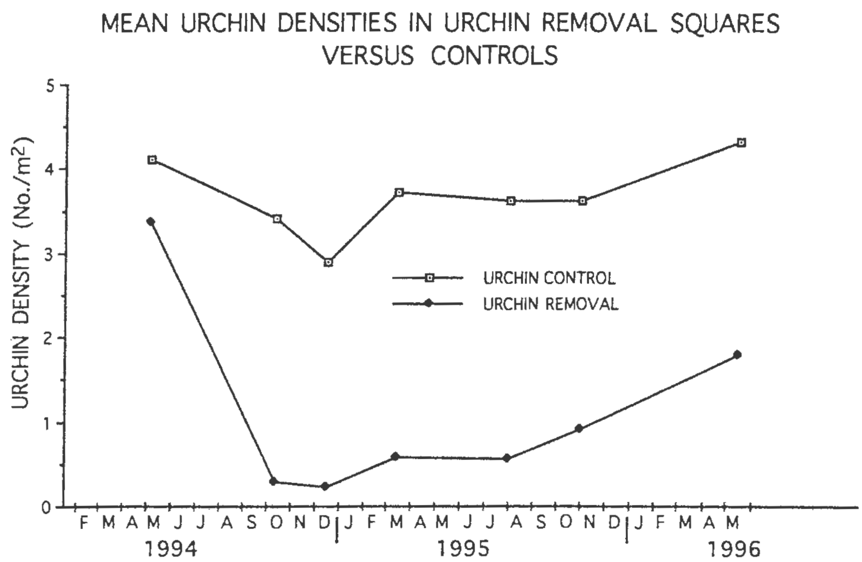


FIGURE 4.3 Results of regular surveys within the squares at Hope Island.

URCHIN REMOVAL



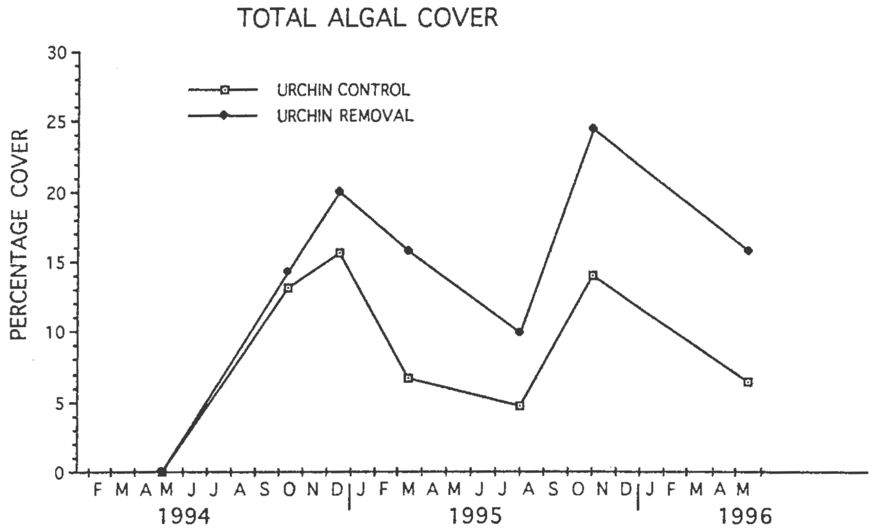


FIGURE 4.4 Results of regular surveys within the squares at Hope Island.

URCHIN REMOVAL

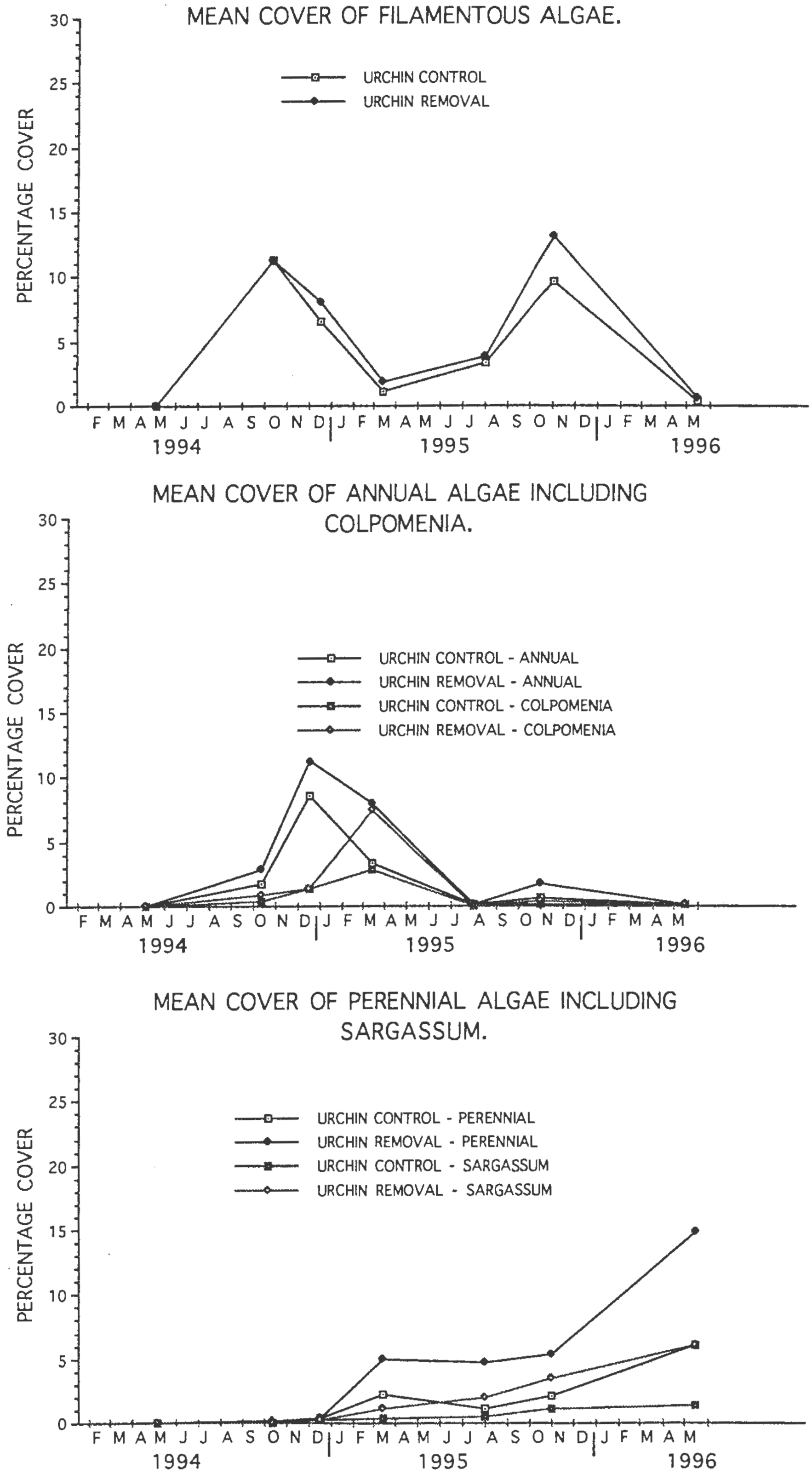
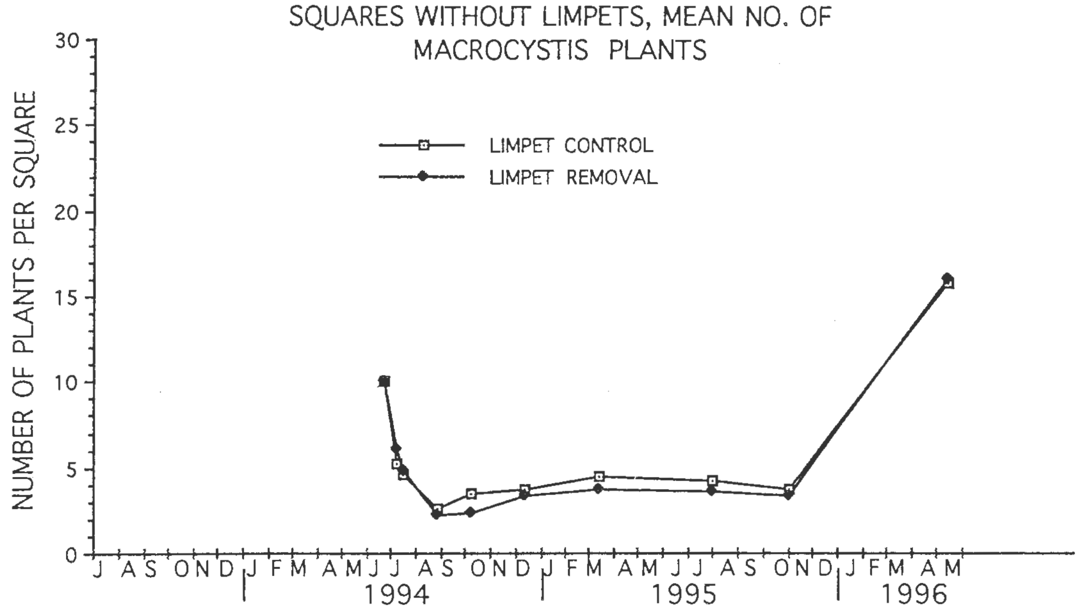


FIGURE 4.5 Results of regular surveys within the squares at Hope Island, *Macrocystis* transplants.



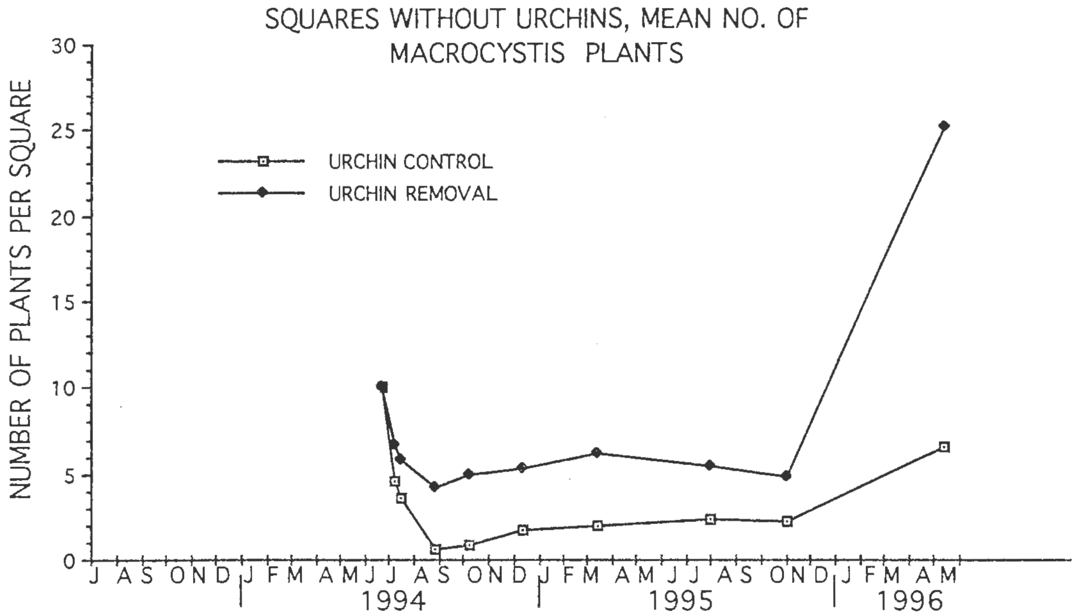
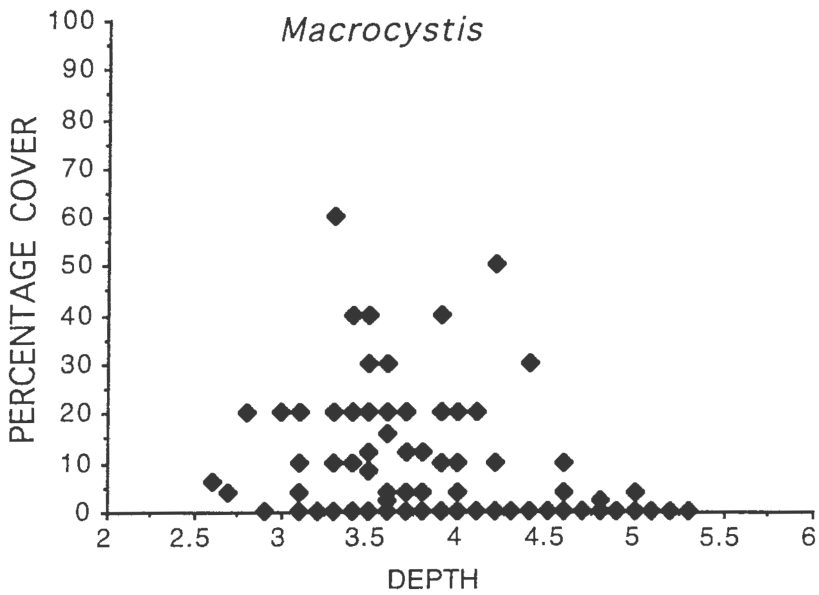
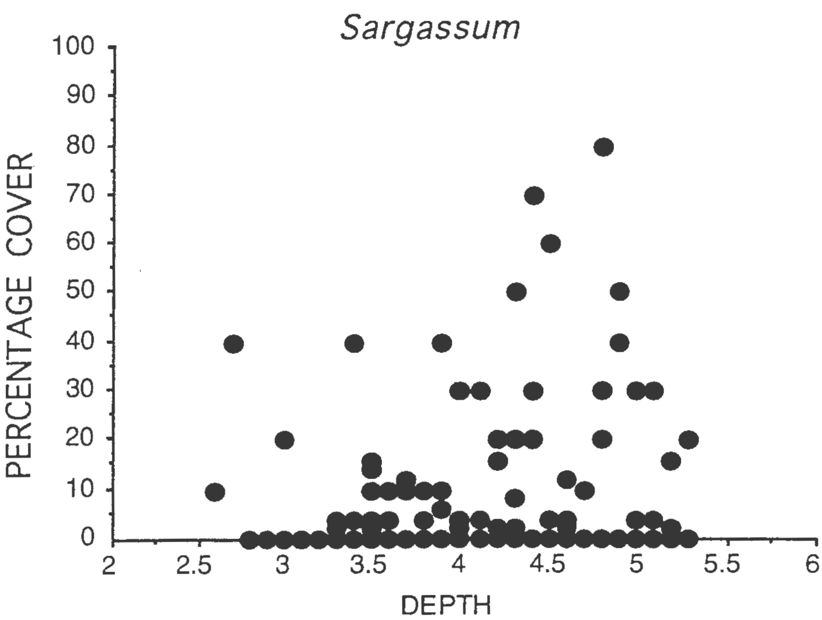


FIGURE 4.6 Diagrams showing variation in the distribution of *Macrocystis* and *Sargassum* with depth from survey results.





SECTION 5: *MACROCYSTIS PYRIFERA*

INTRODUCTION

Urchin divers claim that urchins with best quality and quantity roe come from *Macrocystis pyrifera* beds. If *Macrocystis* could be grown in barren areas where the urchins have been cleared, this would ensure optimal recoveries of urchin in the longer term.

Two methods were used to re-initiate *Macrocystis*, these were growth from spores and transplants.

METHOD

Spore release

Macrocystis plants have specialized fronds at the base of the plant that are the source of spores. These fronds are termed sporophylls. Sporophylls were collected from 5 - 10 plants and returned in seawater to the laboratory. To initiate spore release, sporophyll surfaces were wiped clean and placed in a 10% solution of the antiseptic Betadine in seawater for 10 minutes to surface sterilize, rinsed in sterilized seawater, wiped clean again and left in a cool place for 1.5 hours. They were then placed in seawater. Spore release was effected within 1-2 hours.

Spore densities in solution were determined using a graduated microscope slide (haemocytometer). Substrate for settlement were 5mm sections of 25mm PVC pipe. It was believed spores could most easily be transferred and attached in the field using these 'rings'. Spore numbers were calculated to give a density of approximately 1000 gametophytes per 6.25cm^2 of substrate and added to the container. Gametophytes arising from the settled spores were cultured on the 'rings' for one to four weeks before being transferred into the field. This was attempted on four occasions in the autumn-winter period of 1994 and again in 1995 at both Hope IS and Meredith Pt. Autumn-winter was the period of optimum growth of *Macrocystis* plants in SE Tasmania as determined by Sanderson (1990).

Transplants

Macrocystis plants were transplanted as part of this program on four occasions. First to Hope Is and Stapleton Pts. Plants were transplanted to Hope Island to provide a spore source and plants for the urchin/limpet manipulation experiment (see Section 2).

Plants were transplanted to Stapleton rather than Meredith Pt, to optimize the chances of success as a test of the method. Meredith Pt has much fine sediment on the reef surfaces and relatively little water movement, both conditions not usually associated with *Macrocystis* beds. Plants were obtained from Dodges Ferry as this was the site of many juvenile plants at the time; June 1994. Juvenile plants were used in preference to larger plants, as the smaller size made handling easier. Plants were attached to bricks using rubber bands and placed on the reef surface. Urchins were cleared from the immediate vicinity of transplants at Stapleton Pt to prevent possible herbivory from this source. After the success of these operations, tranplants were also later done to Meredith Pt and Oakhampton Bay in the winter of 1995. Plants for these sites came from Southerly Bottom.

RESULTS

Spore release

Results for raising *Macrocystis* plants from spores were mixed. PVC pipes transplanted into the field to Meredith Pt did not give rise to plants. At Hope Is, not all PVC pipes gave rise to plants and those that did, did so after a time lag of 1-3 months.

Transplants

Plants transplanted to Hope Island and Stapleton Pts have survived well. At Hope Is there was highly significantly better survival in squares that had been cleared of urchins (see Section 2). At both sites, the most marked change was observed the year after the transplants had been initiated. The plants that had been placed into the sites released spores resulting in many new plants in the following year.

The plants placed at Meredith Pt in 1995 have survived into 1996, but do not appear healthy with faded lamina, little growth and much fine silt on their surfaces. There has been high mortaility of the plants at Oakhampton, with only three survivors observed in early 1996. Loss of plants is believed to have been due to swells experienced in the area.

DISCUSSION

It was concluded that more research needs to be done into using spores to re-initiate plants. The mixed results experienced was most likely due to the conditions into which the cultivated spores had been placed and success will be seasonally determined.

Transplants were successful and also served as a good source for future plants.

SECTION 6: AGING

INTRODUCTION

Aging of the urchins is a valuable tool to enable calculation of growth rates, recruitment and mortality rates from population size structures and yield per recruit analysis.

Three methods of aging the urchins were attempted.

1/ counting of ridges on teeth and validation through marginal increment analysis

2/ Tetracycline tagging

3/ monitoring age classes through regular size frequency analysis.

RIDGES AND MARGINAL INCREMENT ANALYSIS

Method

If ridges are laid regularly, such as once per year, then the distance from the most recent ridge to the aboral end of the tooth should also vary regularly. Each month, as part of the gonad-sampling program, 25 (-50) urchins were collected from both sites. Distance from the most distal ridge to the end of the tooth was recorded, as well as the number of ridges, distances between successive ridges and length of the tooth (see Fig. 6.1).

Teeth were processed as follows:

- Aristotles Lantern was removed from harvested urchins and stored in numbered seedling trays.
- Lanterns were soaked for 24 to 78 hours in a 0.1 - 0.5 % (w/v) chlorine solution made using Olin HTH Granular Pool Chlorine (active ingredient 655g/kg CaOCl).
- Jawbones were separated and remnant soft tissue was removed by brushing with a soft bristled tooth brush. Washed jawbones were soaked in chlorine for another hour then rinsed with water and air dried.
- Observations of annual ridges on urchin jawbones were made using a Wild Heerbrugg M5 microscope at 12X magnification with a 0.3X adaptor lense attached. A Sony model DXC 151Ap colour video camera was used to capture images which were analysed on a Macintosh Quadra 650 computer using the National Institute of Health, USA image analysis package " NIH Image, version 1.57". Measurements were calibrated against a stage micrometer.

• Growth ridges were observed by projecting light at an oblique angle over the flat surface of the jaw from the oesophageal edge. This edge was favoured as ridges near the oral tip could be readily observed. Illumination from the the oral tip caused a shadow which obscured the first 2-4 mm of the jaw. however, where ridges were observed close to the oesophageal edge, the completion of the growth ridge was confirmed by reversing the jaw and projecting light from the oral tip as described by Constable (1989). A new ridge was counted only if a shadow was evident at the oesophageal edge. (The new image on camera could easily be compared with stored image on the computer monitor).

Number of tooth ridges was treated as a function of age; the tooth ridge-teste diameter data were fitted to the von Bertanlanffy growth equation using non-linear least squares regression with SYSTAT (Williamson 19).

RESULTS

Ridge data is presented in figs 6.2-6.4 for three sites and interpretation is equivocal. For Meredith Pt there seem to be three ridges laid down over the period monitored or at the rate of two per year. While this seems to be a definite pattern for the early part of the program , later it is not as clear. The results for Hope Is; 8S and 1D are even less clear. The results indicate that ridges are not deposited synchronously or that the number of ridges deposited each year is variable

The mean number of ridges per tooth for urchins from Meredith and the Hope 1D are also presented in these diagrams (e). The Meredith data shows an increase over the period of the monitoring. The Meredith populations were heavily fished in 1992 and the results support an increasingly aged population (assuming little recruitment). A linear regression of the Meredith Pt data indicates ridges laid at approximately 1.4 per year. The Hope populations on the other hand have had minimal fishing pressure and the mean number of ridges on the urchins from both sites does not change (the final measuremen is an outlier).

Calculation of growth rates by fitting Von Bertanlanffy growth curves for some of the sites are depicted in Fig 6.5. Fitted curves for all other populations examined have been calculated (see Table 1 for all results). Relative growth rates reflect what might be predicted ie. sites with urchins that may be expected to have better growth rates have higher K values and vice versa. Urchins from barrens eg. Stapleton Pt., Long Bay, Oakhampton have relatively low growth rates while sites that are expected to have high growth rates have high K values (eg. Dennes Pt (65'), Deep Hole, Meredith 5S). Note the tetracycline-labelled urchins from Hope Island have a relatively high K value using this method but came from a barren. These urchins also have a poor fit for the estimation. There was only a relatively narrow size range for these urchins which reduces the confidence of the fit.

TABLE 6.1 Estimation of growth parameters from fitted Von Bertanlanffy growth curves using one ridge as equivalent to one year's growth. K is the growth constant and L_∞ is the estimated maximum diameter.

SITE	K	LINF	r^2(raw)	r^2(corrected)	N
Deep Hole	0.552	71.757	0.984	0.163	89
Dennes Pt (20')	0.322	75.541	0.973	0.24	100
Dennes Pt (65')	0.704	73.294	0.983	0.304	50
Hope Is 1D	0.389	92.887	0.99	0.308	367
Hope Is 8S	0.358	77.432	0.986	0.298	216
Hope - tetracycline	0.614	64.412	0.993	0.057	59
Horseshoe Reef	0.222	50.587	0.977	0.202	16
Huon Pt	0.441	102.753	0.987	0.108	80
King Is (Chris Is)	0.519	81.506	0.988	0.095	28
King Is (Counc Is)	0.481	78.207	0.993	0.299	48
King Is 2.1	0.468	78.349	0.987	0.048	25
King Is, Grassy 1	0.466	82.229	0.997	0.275	27
King Is, Grassy 2	0.226	100.892	0.991	0.461	24
Long Bay	0.284	85.133	0.96	0.237	97
Meredith 5S	0.553	74.786	0.988	0.348	389
Meredith - tetracycline	0.359	82.561	0.986	0.382	85
Oakhampton	0.268	84.96	0.986	0.525	100
Safety Cove	0.509	75.97	0.993	0.408	74
Stapleton	0.182	85.985	0.966	0.449	83
MEAN	0.42	79.96			1957

TETRACYCLINE

Method

At both Meredith and Hope Island, four concrete-filled tyres were used to mark out the corners of a 10 X 10 m^2 square. All urchins within these squares were injected in-situ with a lg Tetracycline HCl (Sigma) per 100 ml filtered seawater solution at the rate of 0.1 ml per 10 g body weight (converted to diameter equivalent) in February 1994 (as per Ebert 1982). In February 1996 all urchins were harvested from within the square and their teeth processed as above. Use of a UV light showed which urchin teeth had taken up the tetracycline tag. These teeth were analysed using image analysis apparatus (as above). Colour scanning gave an image that coould be split into blue, green and red components. Examination of the blue section of the image revealed the tetracyline markings as per Fig. 6.6. The distance was measured from the aboral end of the tooth to the tetracycline mark and other measurements taken as above. Von Bertanlanffy growth curve parameters were calculated from Walford plots as per Ebert (1980a).

Results

At Meredith Pt, 41 of the 164 urchins collected had the tetracycline tag (25%), while at Hope Island, 59 of 300 collected were tagged (20%). Fig 6.7 shows Walford plots for the data and resulting Von Bertanlanffy growth curves with confidence intervals. In 6.10 c the different methods have been compared on the one graph. The tetracycline results estimate consistantly slower growth than if using the ridges at either one per year or two per year.

Table 6.2

Growth rate parameters estimated using Walford plots as per Ebert (1980a).

SITE	K	LINF
Meredith Pt	0.20	84.99
Hope Is	0.21	64.09

SIZE FREQUENCY ANALYSIS

Method

Modal progression anlysis was conducted within the squares at Meredith with size frequencies measured every six months. There were no clear progression of nodes (Appendix 2). In the summer of 1993, the heaviest rainfall experienced for 25 years occurred on the east coast of Tasmania (Fig. 2.10). Many mortalities were noted on the Meredith site in water less than 1.8m deep. Nearby in the port of Triabunna, a reef called Horseshoe Reef by the divers experienced mass mortality of urchins. Two years later, we sampled urchins from this reef, believing them to be the Dec-Jan 1993/4 cohort. Size frequencies were sampled regularly.

Results

Size frequencies of urchins from Horseshoe Reef, are presented in Fig 6.8. They show growth of the cohort from approximately 27.5 mm at estimated18 months of age to approximately 39 mm at 30 months. For teeth from urchins sampled at Horseshoe Reef sampled 11 Jan 96, a Von Bertanlanffy growth curve was fitted to ridge-test diameter data assuming one ridge per year The gave a slower growth rate of: 1.5 yr; 14mm, 2.5 yr; 21.5mm. Median number of ridges per tooth was between four and six for the 11 Jan 96 sample. These urchins were believed to be 24 months old. Again results indicate that ridges are not deposited synchronously or that the number of ridges deposited each year is variable making interpretation of ridge data tenuous and complex.

Tooth length to test-diameter ratio

Urchins have shown an ability to shrink their tests at times of low food availability while tooth length stays the same (Constable 1989). The relationship between tooth length and test diameter was examined for a number of populations and is nearly linear (see Fig 6.9). By comparing how each of the populations tooth length to diameter ratio compared to a grand mean;

$$\text{Diameter (mm)} = -1.16 + 5.525 * \text{tooth length (mm)}$$

we can make inferences about food availability to the populations. In fig 6.10 are presented the mean residuals for each of those populations. Sites that are barrens consistantly have a higher tooth length to diameter ratio. Urchins that come from sites that are known to be good recovery areas for urchin roe have lower tooth length to diameter ratios. This opens the possibility that this relationship may be used to determine the potential for roe recovery of populations where conventional sampling is difficult. In Fig 6.11, is the variation in this ratio for the one site over a number of months. As is evident, the ratio remains consistant. the variation that is evident indicates some shrinking of the test while the urchin roes are developing (Fig.s 2.3-2.7).

The tetracyclene labelled urchins gave slow growth rates for both sites. Comparison of the tooth length to diameter ratio for the tetracycle labelled urchins from both sites shows high values (starved) for Hope Island urchins and low for the Meredith teeth indicating good growth. This indicates that the tetracycline results are reasonably representative. Is both samples were starved or vice versa then we might consider the results as extraordinary.

DISCUSSION

Use of ridges would be the most time effecient method of age determination and only requires one visit to a site whereas the other two methods used here require at least two. Interpretation of aging results using ridges however appears equivocal. There seemed reasonable evidence that the urchins may be forming up to two ridges per year, but the results are not born out by the tetracycline method. The tetracycline results appear representative and show that the urchins are taking a long time to reach maturity. At both the sites, this may be 5-10 years. Further growth rate work needs to be done to clarify this further. Oxygen isotope analysis or microchemistry of the teeth may also be of some help in aging. Monitoring rate of growth of caged urchins, where individuals may be distiguished may be the most direct.

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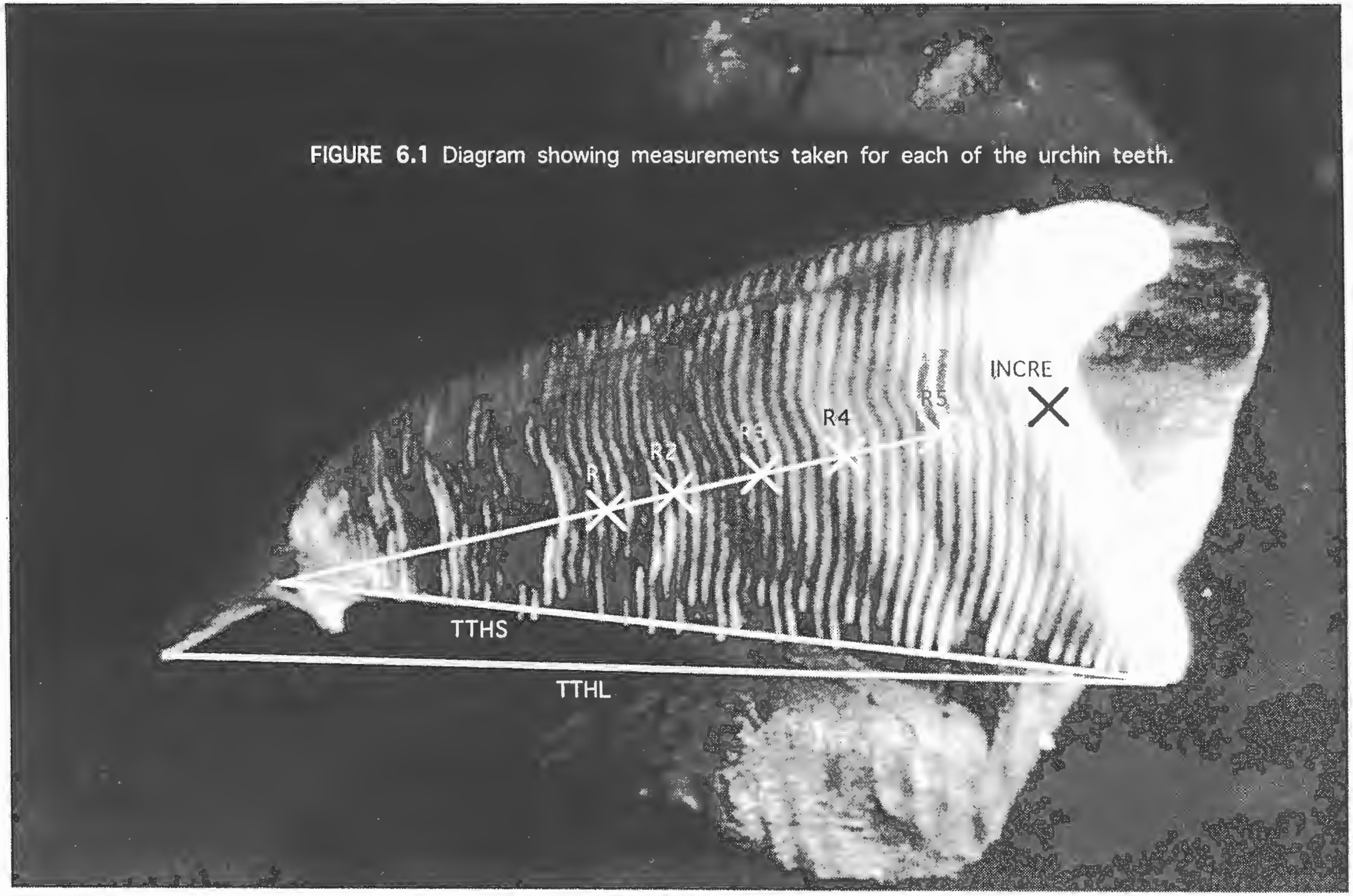
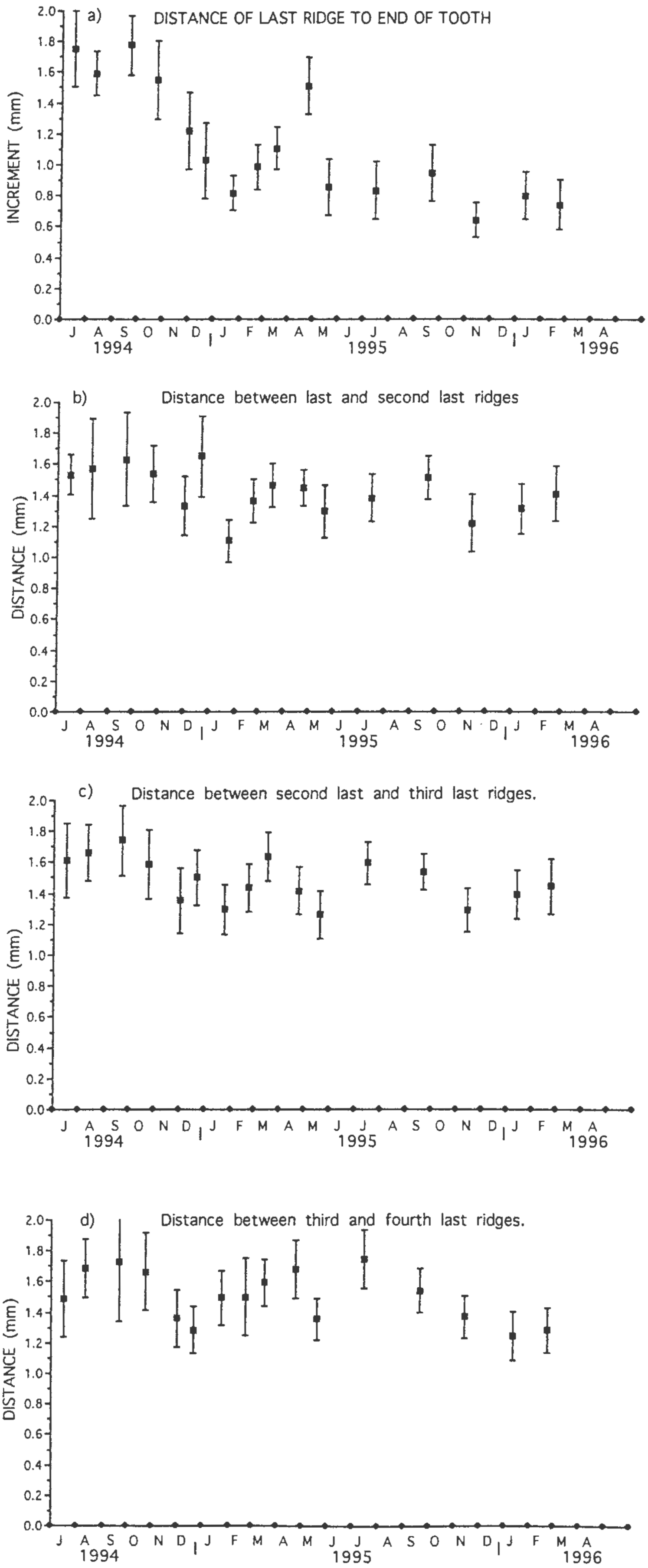


FIGURE 6.1 Diagram showing measurements taken for each of the urchin teeth.

TTHL - Total tooth length
TTHS - Length to 'knuckle'
R1 - Distance to first ridge
R2 - Distance to second ridge
R3 - Distance to third ridge
R4 - Distance to fourth ridge
R5 - Distance to fifth ridge
Rx - Distance to xth ridge
where x is the last ridge.
INCRE - distance to tooth edge.
The length difference between
Rx and INCRE is the 'marginal increment'.

FIGURE 6.2 details of teeth from Meredith 5S



MEREDITH 5S

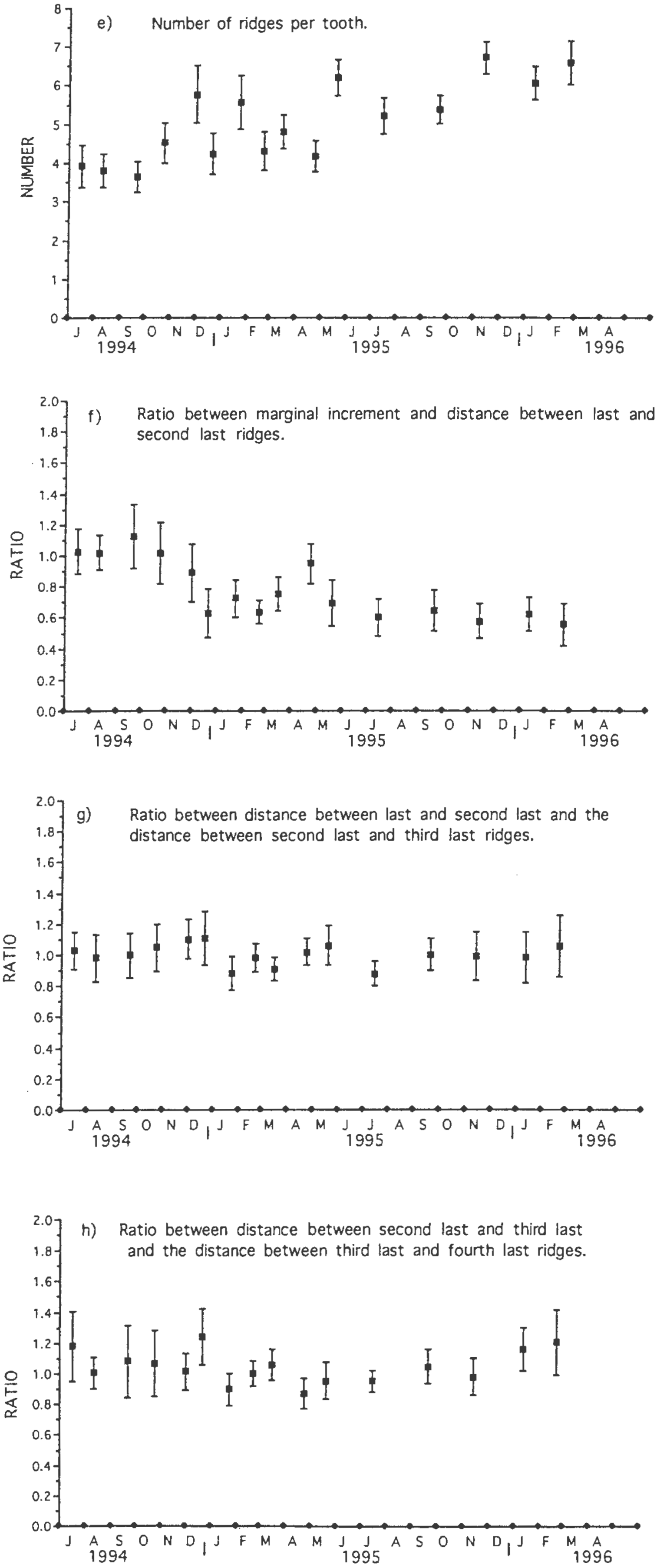
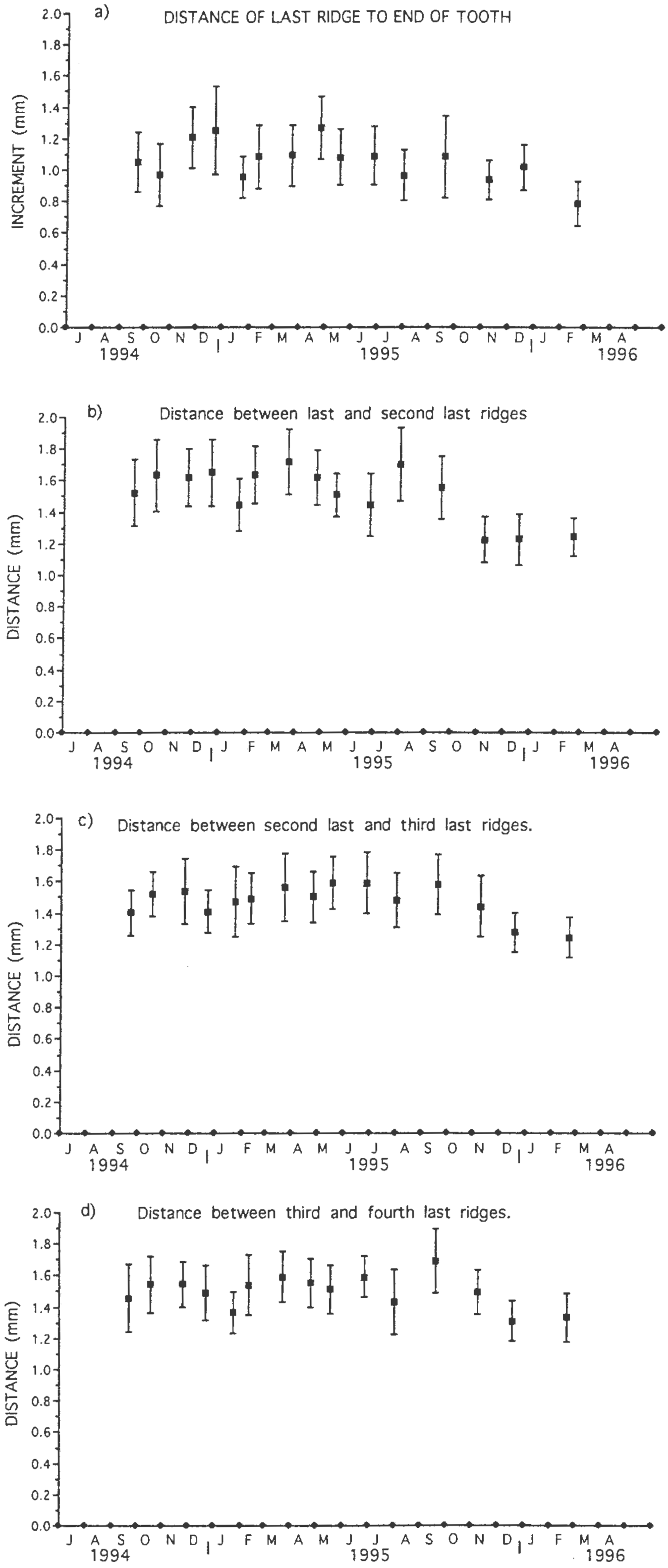
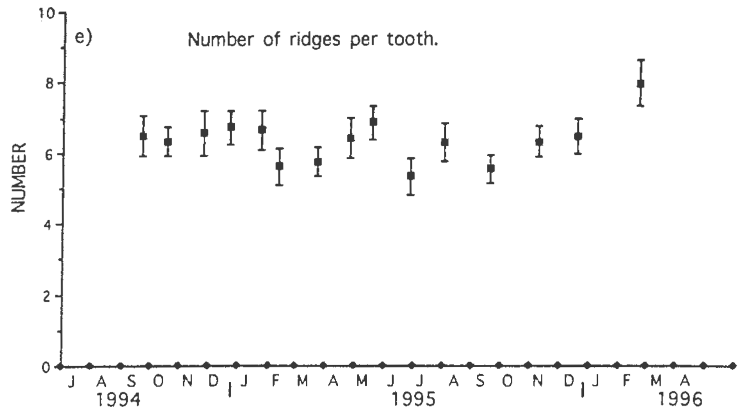
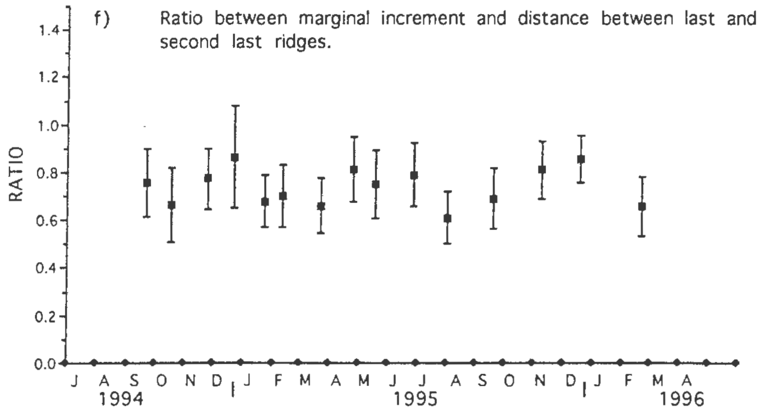

e) Number of ridges per tooth.
NUMBER
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996
f) Ratio between marginal increment and distance between last and second last ridges.
RATIO
g) Ratio between distance between last and second last and the distance between second last and third last ridges.
RATIO
h) Ratio between distance between second last and third last and the distance between third last and fourth last ridges.
RATIO

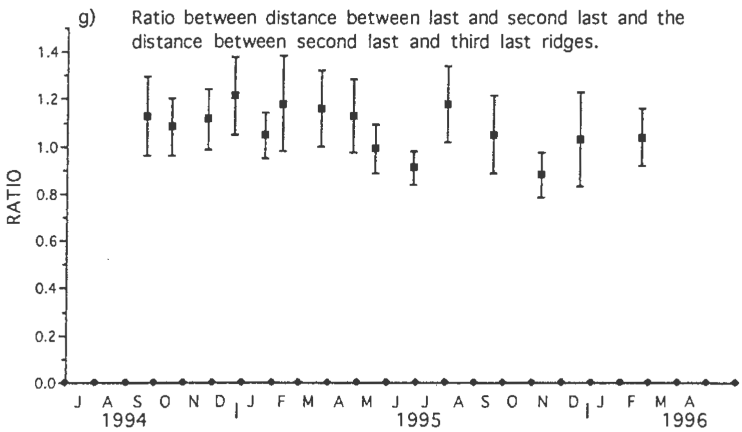
FIGURE 6.3 details of teeth from Hope 1D.



HOPE 1D


e)
Number of ridges per tooth.
NUMBER
0
2
4
6
8
10
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996


f)
Ratio between marginal increment and distance between last and second last ridges.
RATIO
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996


g)
Ratio between distance between last and second last and the distance between second last and third last ridges.
RATIO
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996

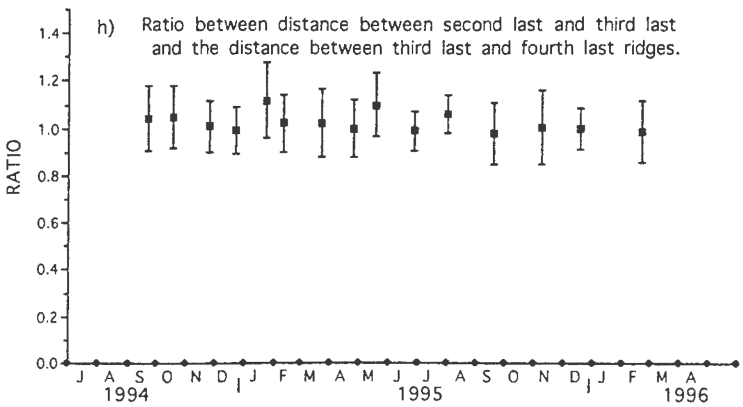
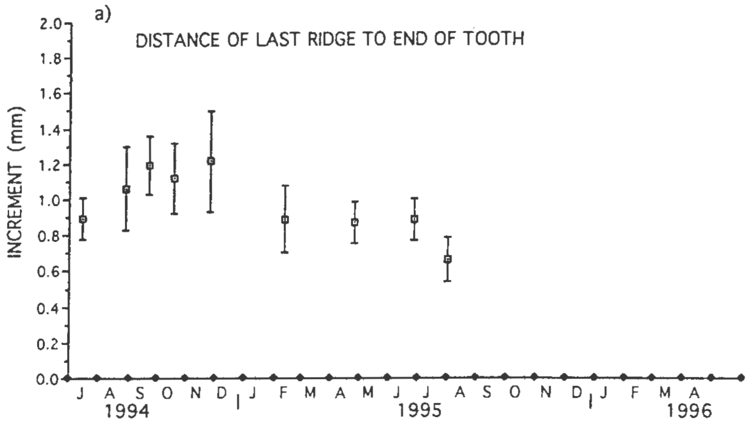
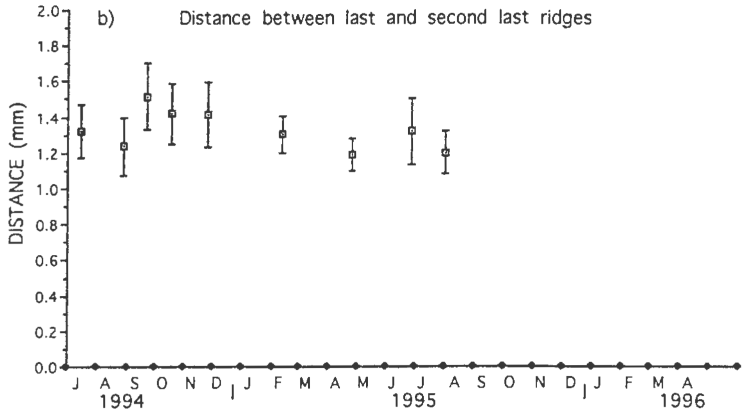
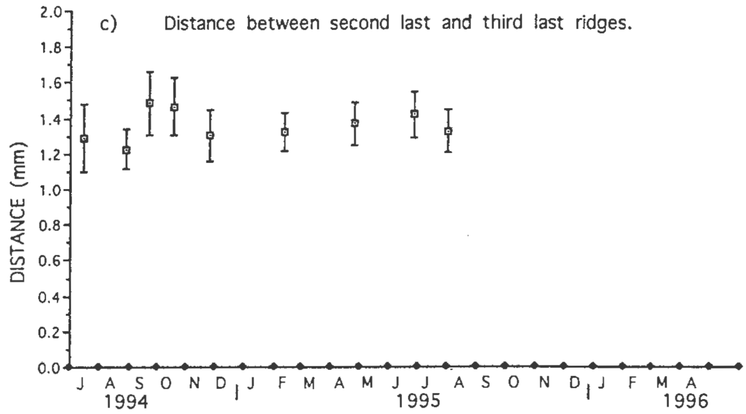
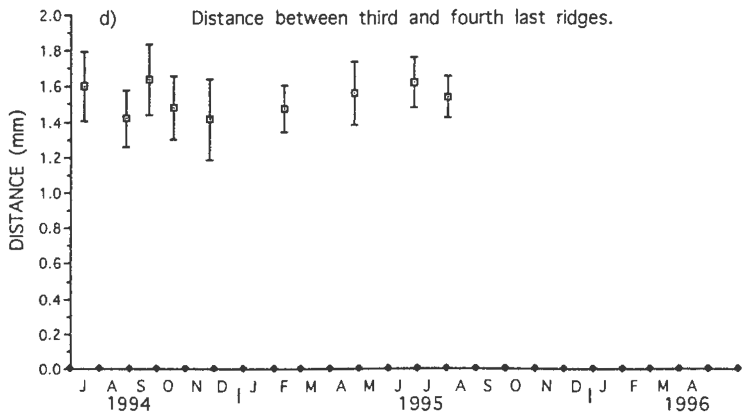

h)
Ratio between distance between second last and third last and the distance between third last and fourth last ridges.
RATIO
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996

FIGURE 6.4 details of teeth from Hope 8S.

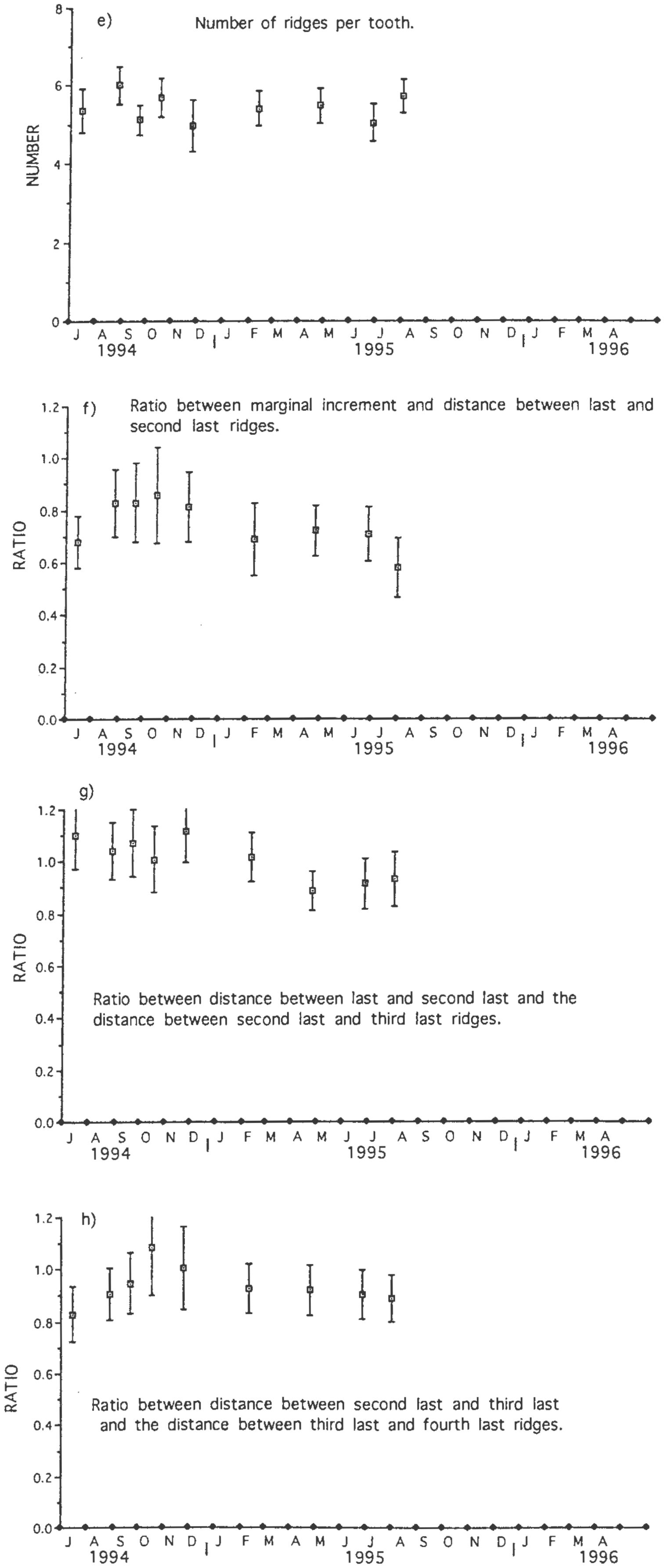








HOPE 8S



e)
Number of ridges per tooth.
NUMBER
0
2
4
6
8
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996
f)
Ratio between marginal increment and distance between last and second last ridges.
RATIO
0.0
0.2
0.4
0.6
0.8
1.0
1.2
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996
g)
Ratio between distance between last and second last and the distance between second last and third last ridges.
RATIO
0.0
0.2
0.4
0.6
0.8
1.0
1.2
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996
h)
Ratio between distance between second last and third last and the distance between third last and fourth last ridges.
RATIO
0.0
0.2
0.4
0.6
0.8
1.0
1.2
J A S O N D J F M A M J J A S O N D J F M A
1994
1995
1996

FIGURE 6.5 Fitted Brody-Bertanlanfy curves to data assuming one ridge/per year except for top right diagram (two ridges/year).

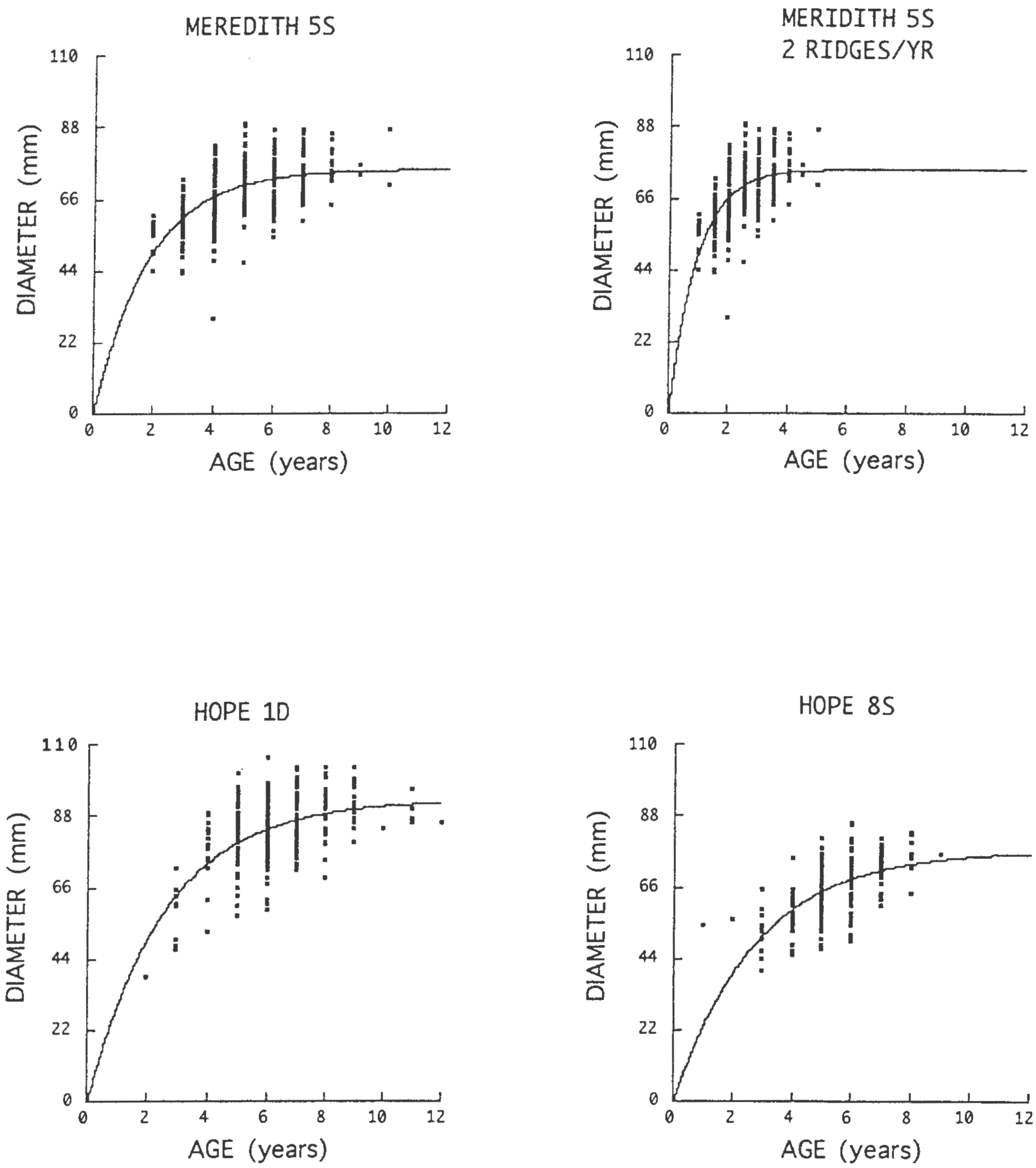


FIGURE 6.9 Tetracycline bands on urchin teeth as evidenced using blue light filters through image analysis apparatus.

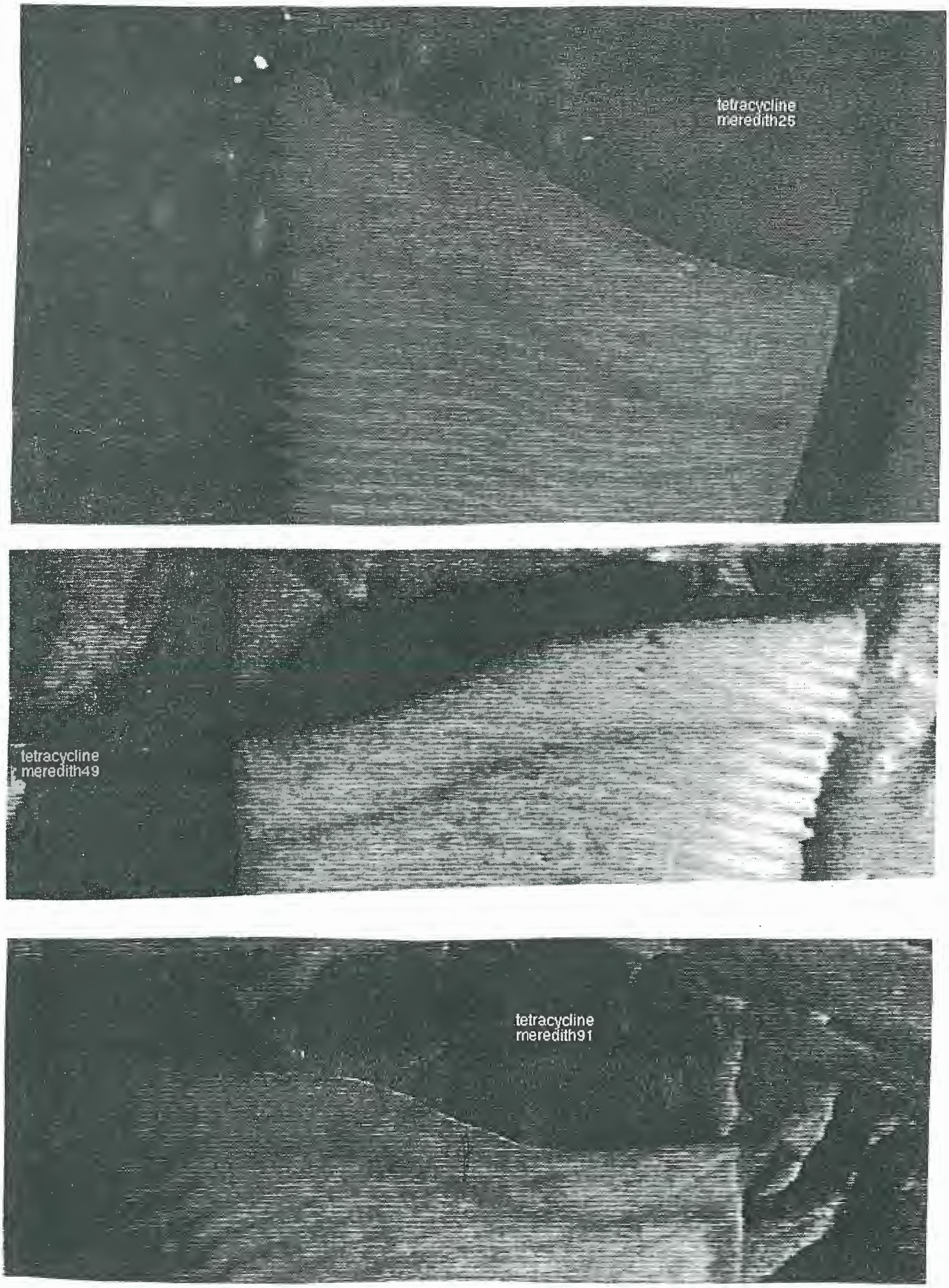
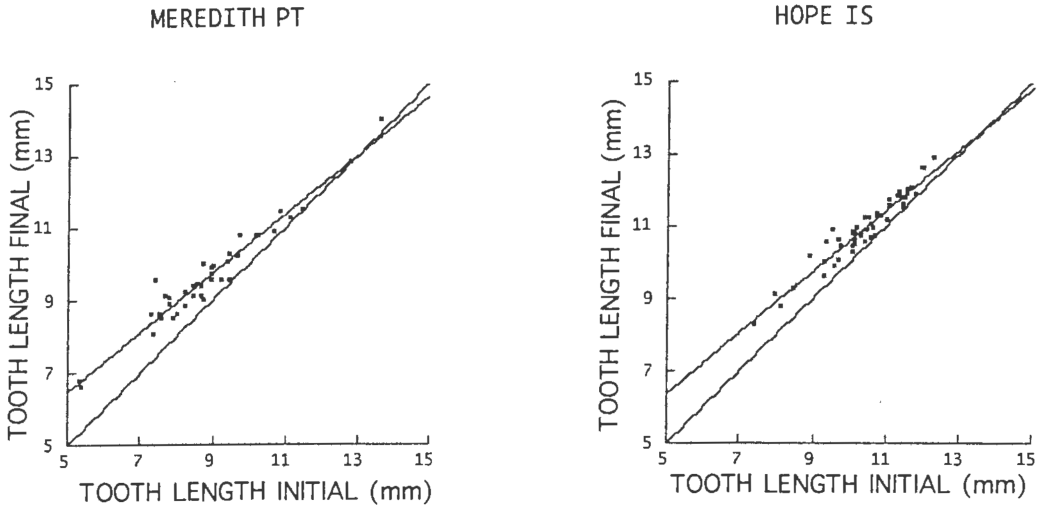
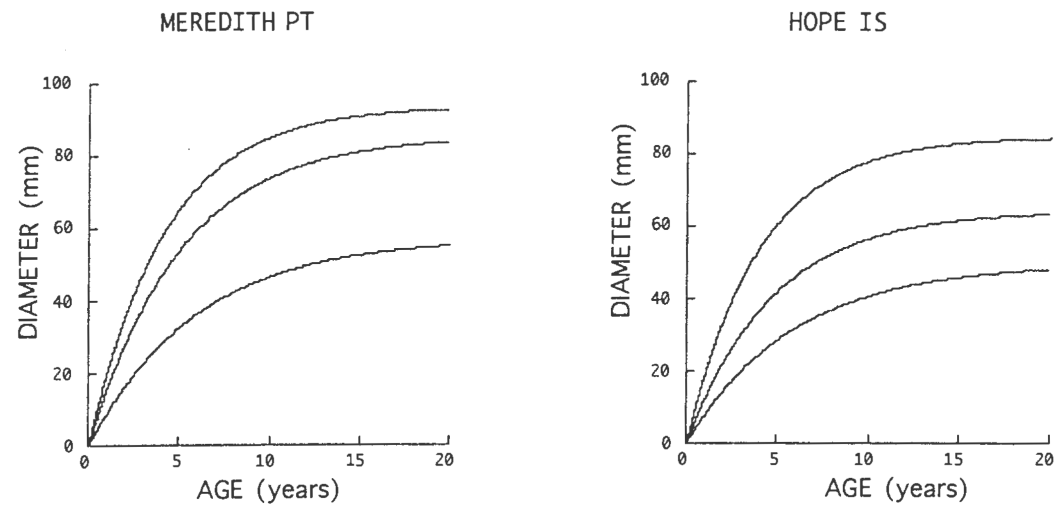


FIGURE 6.7 **a)** Walford plots for Meredith Point and Hope Island tetracycline labelled urchins



b) Von Bertanlanfy growth curves based on values from Walford plots (+/-se).



c) Comparison of aging estimates on the same teeth, using two and one ridge per year and the tetracycline method.

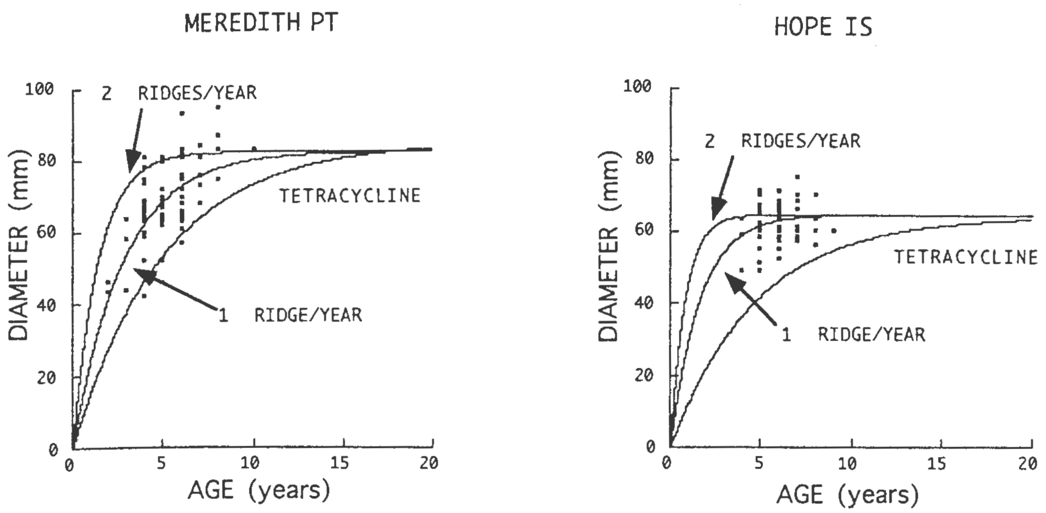


FIGURE 6.8 **a-d)** Size frequencies of urchins sampled from Horseshoe Reef and **e)** age (?) frequency of urchins sampled 11/1/96.

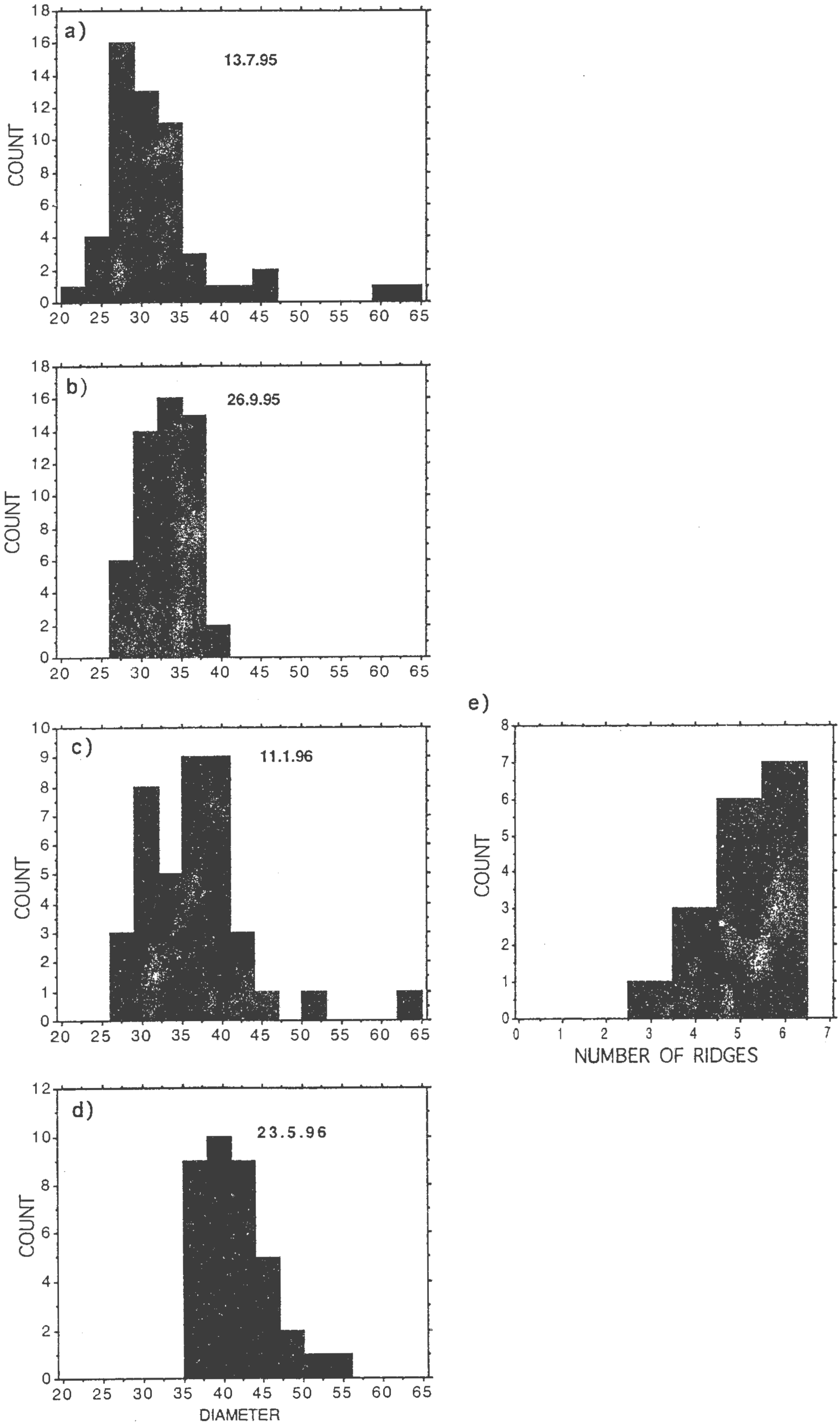
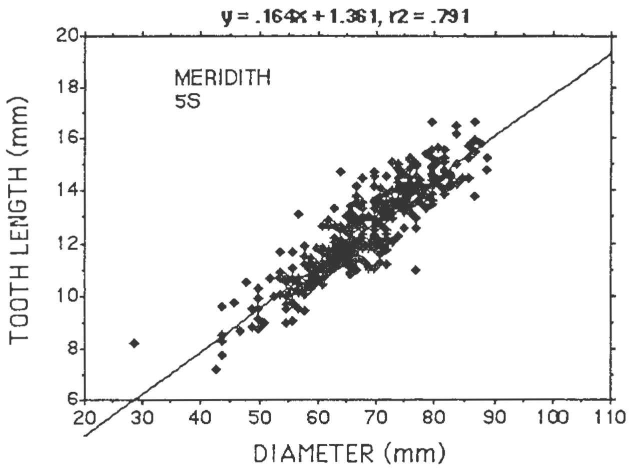
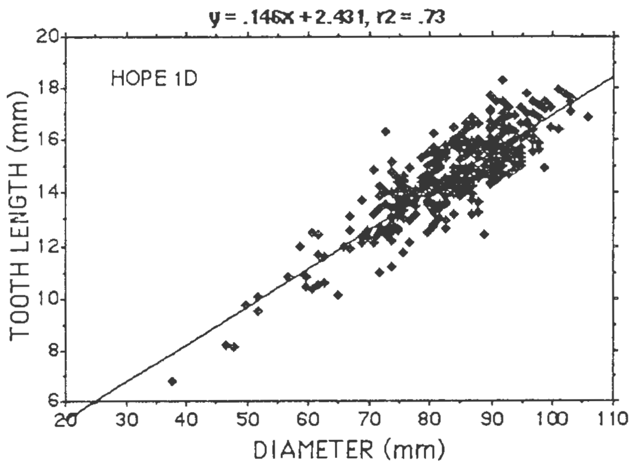


FIGURE 6.9 Relationship between tooth length and test diameter for three sites.





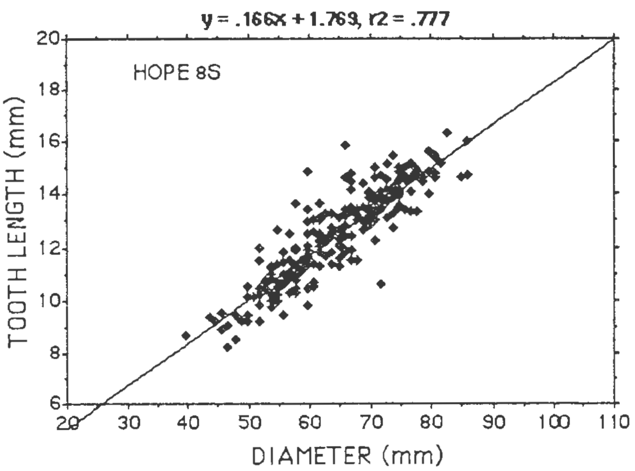
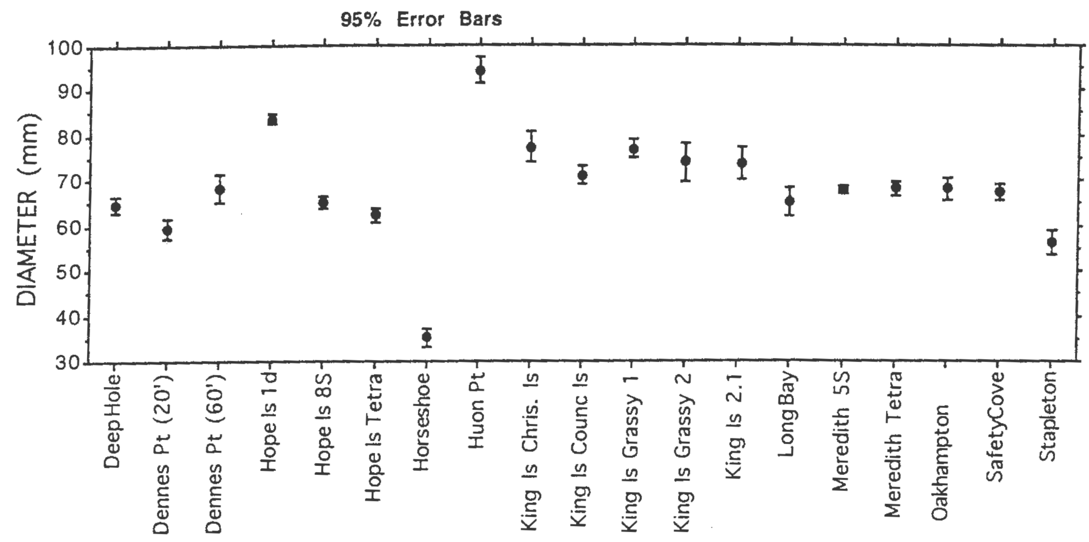


FIGURE 6.10 Mean diameters of aged urchins (above) and mean deviation from overall fitted relationship between tooth length and diameter for each of those populations (* samples from 'barrens').



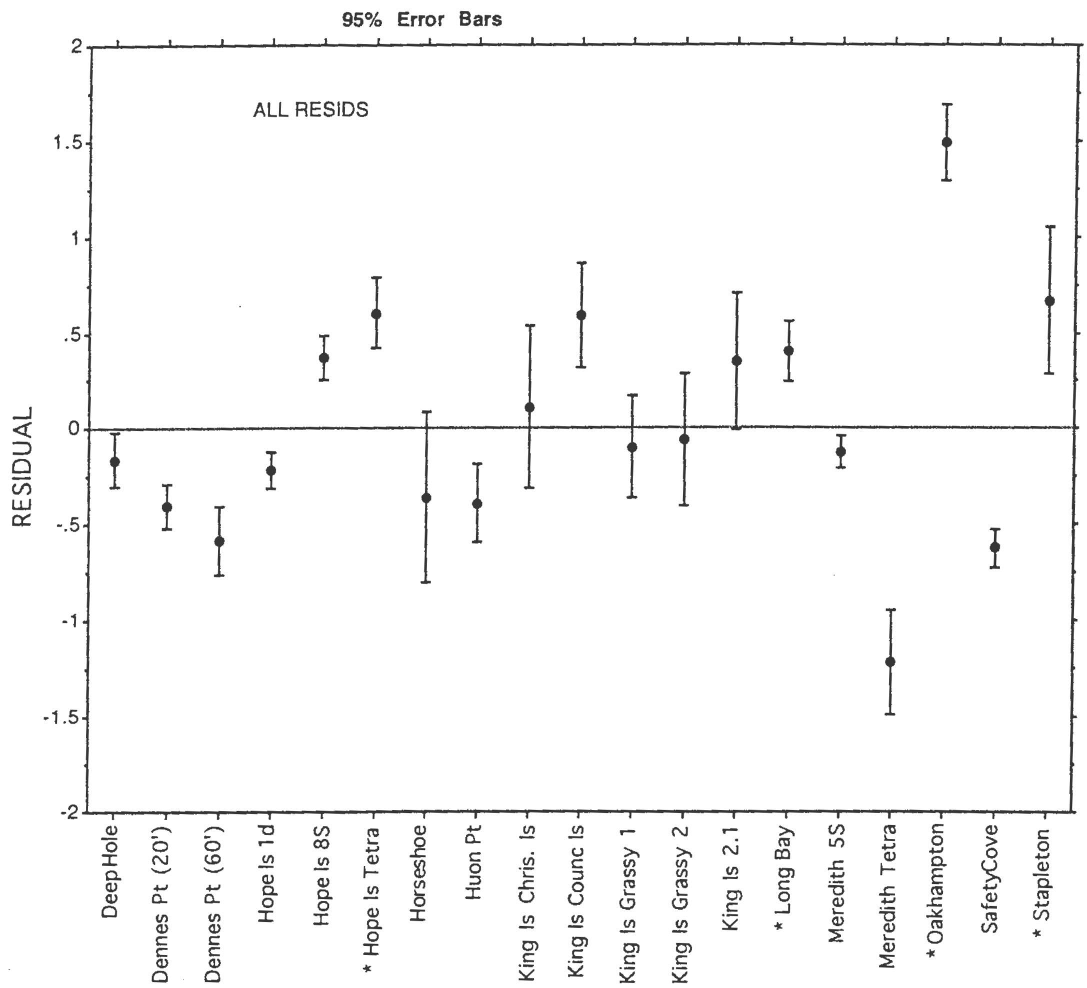
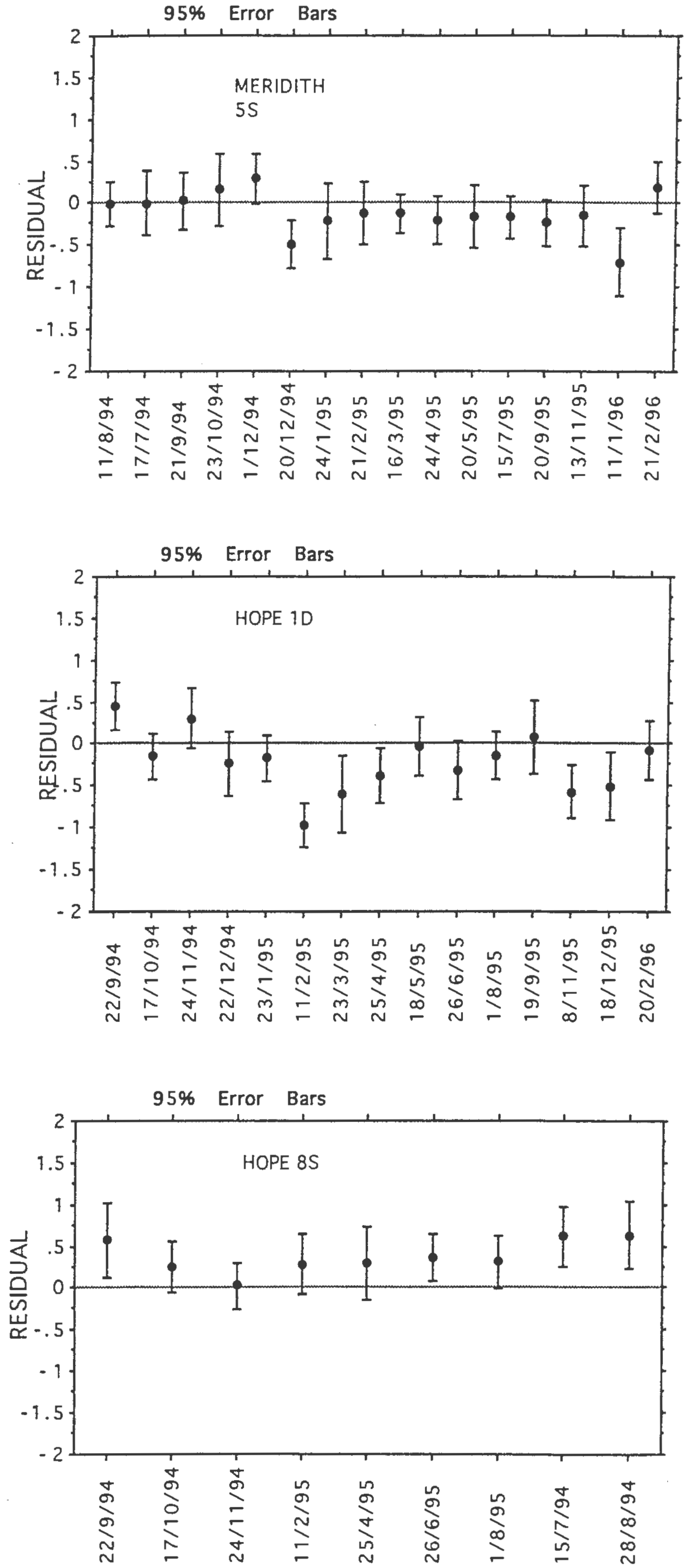


FIGURE 6.11 Mean deviation from overall fitted relationship between tooth length and diameter for each of the three sites: Meredith (5S), Hope Is (1D) and Hope IS (8S) for each sample session.



SECTION 7: MOVEMENT

INTRODUCTION

Movement of the urchins needs to be ascertained to answer one of the assumptions of the manipulation experiments at Meredith Pt. ie. as there are no physical barriers between squares - is there much movement of urchins in or out of these squares - do we need a buffer zone, if so how much? Knowledge of movement of urchins is also necessary in determining how far urchins are likely to move after given time periods for tranplantation and re-seeding exercises. Long term movement of urchins is difficult to determine as they cannot be tagged. The following experiment was designed to circumvent these difficulties.

METHOD

The movement studies were done in two parts. The first examined seasonal changes in movement by checking on movement on a one - two month basis. In the second part, urchin movement was examined over a period of a year.

Part 1

A 10 m x 10 m square was set up at both sites which was cleared regularly (approx. once/month at Hope and once/2 months at Meredith). The corners of the 10 meter square were marked with concrete filled tyres and for each clearing session, a rope grid was set up as per the diagrams in Figs 7.1 and 7.2. At each clearing session, which of the minor partitions within the larger square the urchins came from was noted. The number of urchins within a meter of the perimeter was also noted as movement into the square may be affected by outside concentrations. It was necessary to determine if on-going harvesting might be affecting movement into the square.

This means of estimating movement rate has the advantage of not being directionally biased but as the measurement area becomes smaller towards the inner square, there is likely to be an overestimate of movement as any urchins moving in are concentrated in the middle and this should be taken into account.

Part 2

Early in 1995, the above two squares were not cleared but monitored regularly, approximately once every 3-4 months. An extra square at the two sites was also cleared to improve estimates of overall rates. At the end of one year, all four squares were cleared again and position and size of urchins harvested noted.

Monitoring was conducted by laying the rope grid as above and using a meter stick, numbers of urchins were counted within one meter of the ropes (see Fig 7.5). This gave finer resolution for urchin movement and ensured that fewer urchins were missed.

RESULTS

Part 1

In Figs 7.1-7.2, the size frequency of cleared urchins from the "outer-outer", "outer" and "inner" areas of the squares demonstrate obvious differences. The "inner" square at Hope Is has a much greater proportion of urchins below 50mm, while at Meredith, there is a higher proportion of urchins below 60mm in the "inner" square. Interestingly, these sizes are those of sexual maturity for these sites (see fig 2.1). It is postulated that the smaller urchins may be the new recruits. Consequently in figs 7.3-7.4 they have been considered seperately in the analyses. An alternative explanation may be that the smaller urchins move a lot more than the larger urchins, this is unlikely, but should be proved/disproved experimentally.

From the graphs it is apparent that there is seasonal movement of the urchins with more movement occurring from March to August at Hope Is and December to June at Meredith.

Part 2

The densities of urchins as determined from the interim surveys and the final clearance for the four squares are shown in Fig 7.5. These results agree with the results of Part 1 ie. that most movement occurs in the first few months of the year. The change in density from the "outer-outer" to the inner square are represented well by a linear relation (Fig 7.6) . The mean of these linear relationships is significantly different for the two sites with lower movement at Meredith Pt. This agrees with the topography of the two sites as at Hope Is, there is largely a homogeneous reef bottom consisting of small boulders and rocks overlaying a reef base. At Meredith Pt, sand is dispersed around rock outcrops.

Size frequency of the cleared urchins do not show much difference for the Hope Is squares (Fig 7.7) between inner and outer areas as might be expeced from the greater recorded movement and consequent mixing. At Meredith (Fig 7.8), where movement was not as great, there is a higher proportion of the smaller urchins in the inner squares.

DISCUSSION

Relatively little movement was demonstrated over the period of a year at the Meredith Pt site. Our assumption of minimal movement for the manipulations at Meredith was thus met. Topography and homogeniety of the reef bottom may be a significant factor in determining the amount of movement when comparing movement between sites. Movement at Hope Island was much greater than at Meredith and the above assumption could not have been met at this site. Further evidence of minimal movement was the obvious increase in vegetation right up to the border's edge in plots that had been cleared of urchins one-two years after clearance and the localized barrens patches that occurred around tranplanted urchins that had been dumped at the Meredith Pt site after similar periods of time.

TABLE 7.1 Recruitment of urchins believed to be new to the fishery based on the number of smaller urchins harvested from inner squares at both sites.

MEREDITH POINT (<63mm diam.)

	Feb 94 - Feb 95	May 94- May 95	May 95 - Apr 96
Square 1	64	38	24
Square 2			4

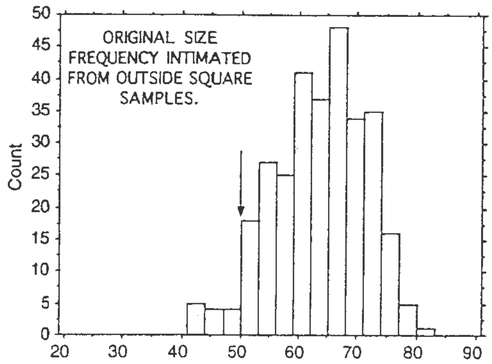
HOPE ISLAND (<51mm diam.)

	Jan 94 - Jan 95	May 94 - May 95	May 95 - Apr 96
Square 1	48	37	14
Square 2			2
Year Averages:	56	37.5	11
Overall Average (/36m^2)			34.8
Overall Average (/m^2)		0.97	

FIGURE 7.1

HOPE ISLAND

Size breakdown of all urchins harvested from the Hope is square after initial two clearances (two clearances were required initially to ensure proper eradication of urchins).



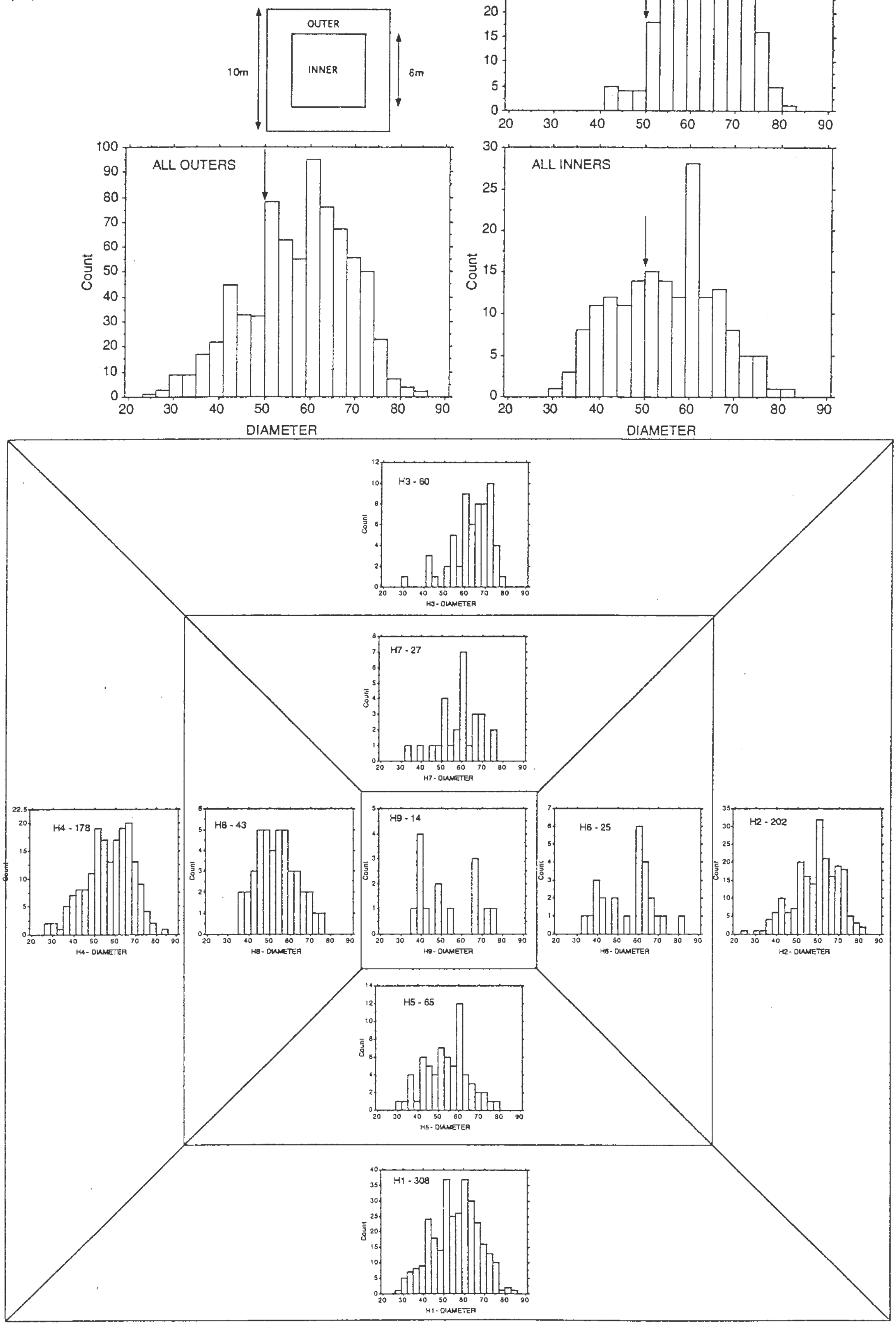
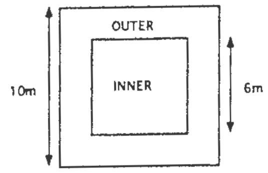
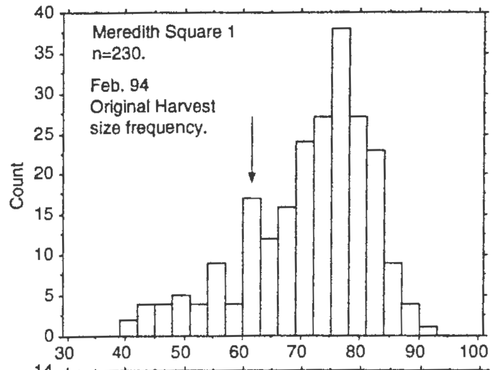


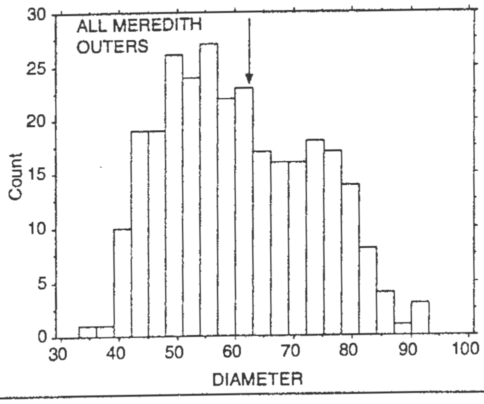
FIGURE 7.2

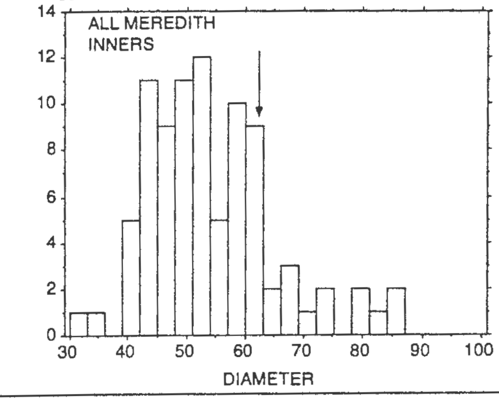
MEREDITH PT

Size breakdown of <u>all</u> urchins harvested from the Meredith Pt square after initial two clearances (two clearances were required initially to ensure proper eradication of urchins).









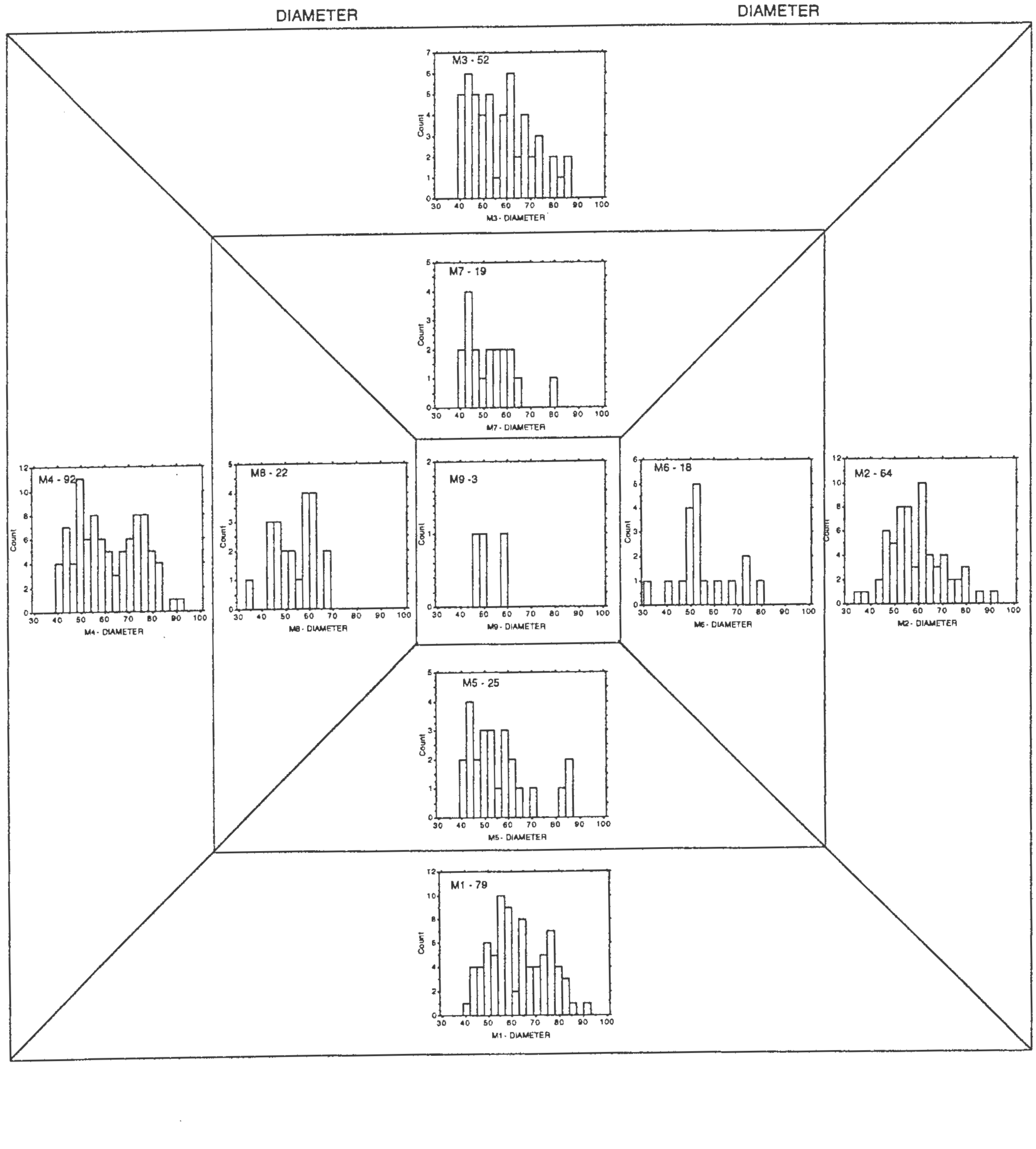
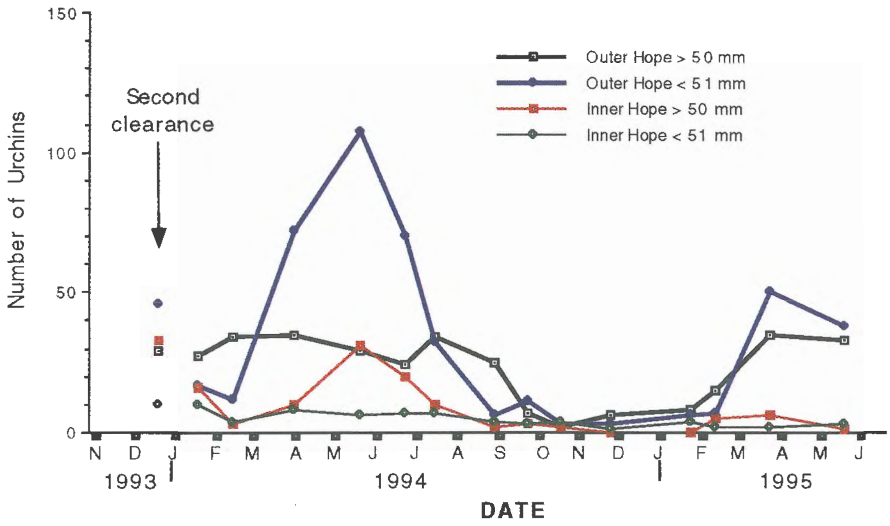


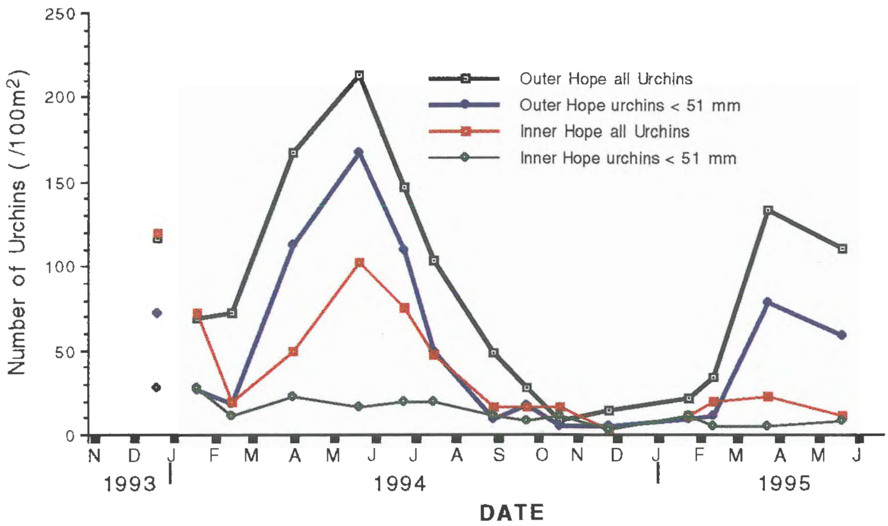
FIGURE 7.3

HOPE ISLAND (50 mm limit)

Urchins harvested from inner and outer square, Hope Is.



Urchin densities in inner and outer square at each harvesting session.



Rate of change in urchin desities at each harvesting session.

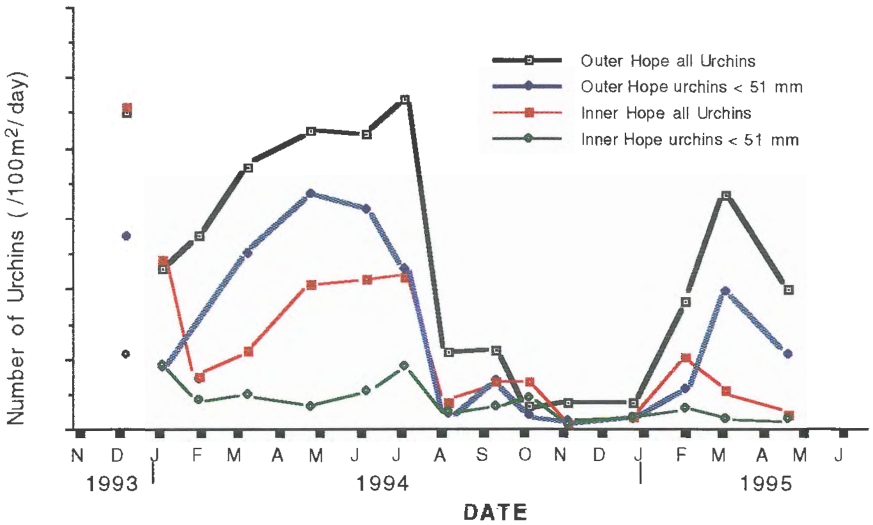
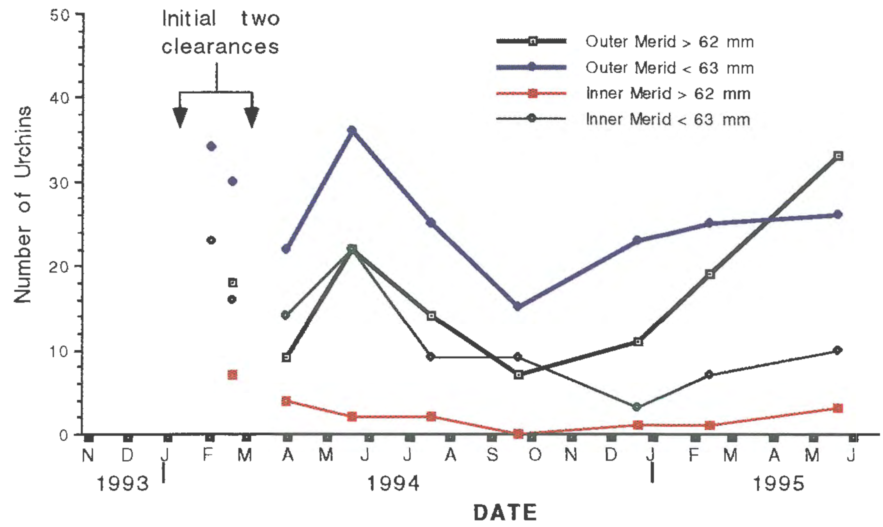


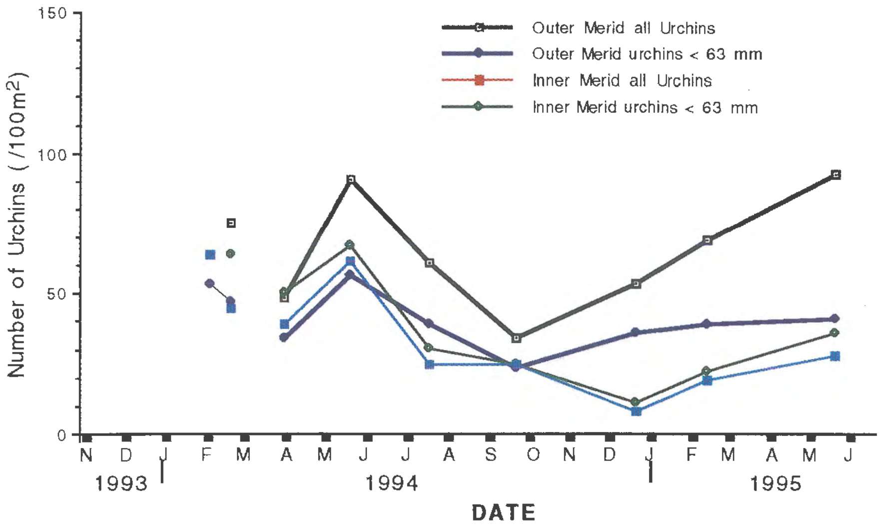
FIGURE 7.4

MEREDITH PT (62 mm limit)

Urchins harvested from inner and outer square, Meredith Pt.



Urchin densities in inner and outer square at each harvesting session.



Rate of change in urchin desities at each harvesting session.

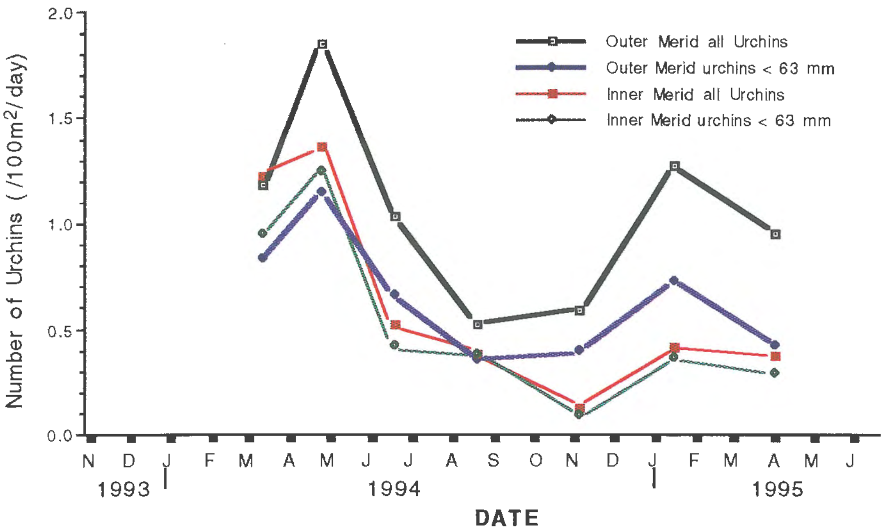


FIGURE 7.5 Density of urchins at differing distances from the edge of the square for the surveys at the end of each quarter of the year, all squares combined.

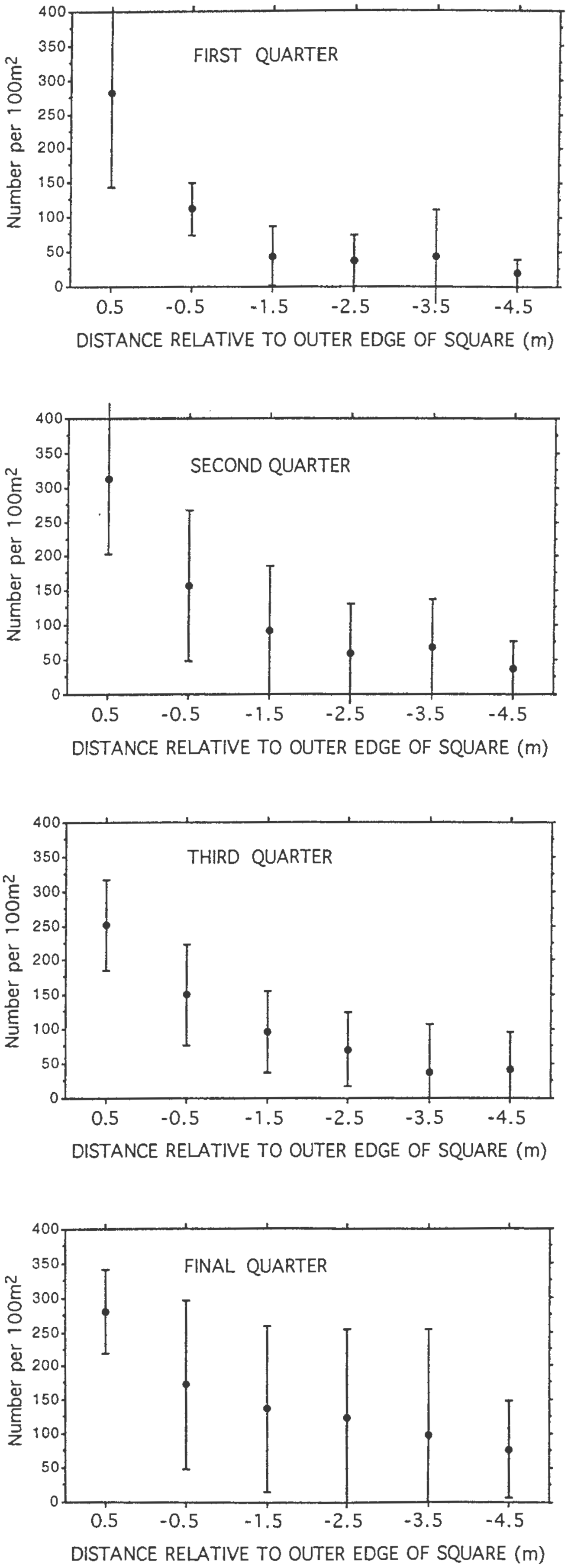


FIGURE 7.6 Decrease in density towards the inside of the square (as a percentage of outside densities) one year after clearance for both squares at both sites.

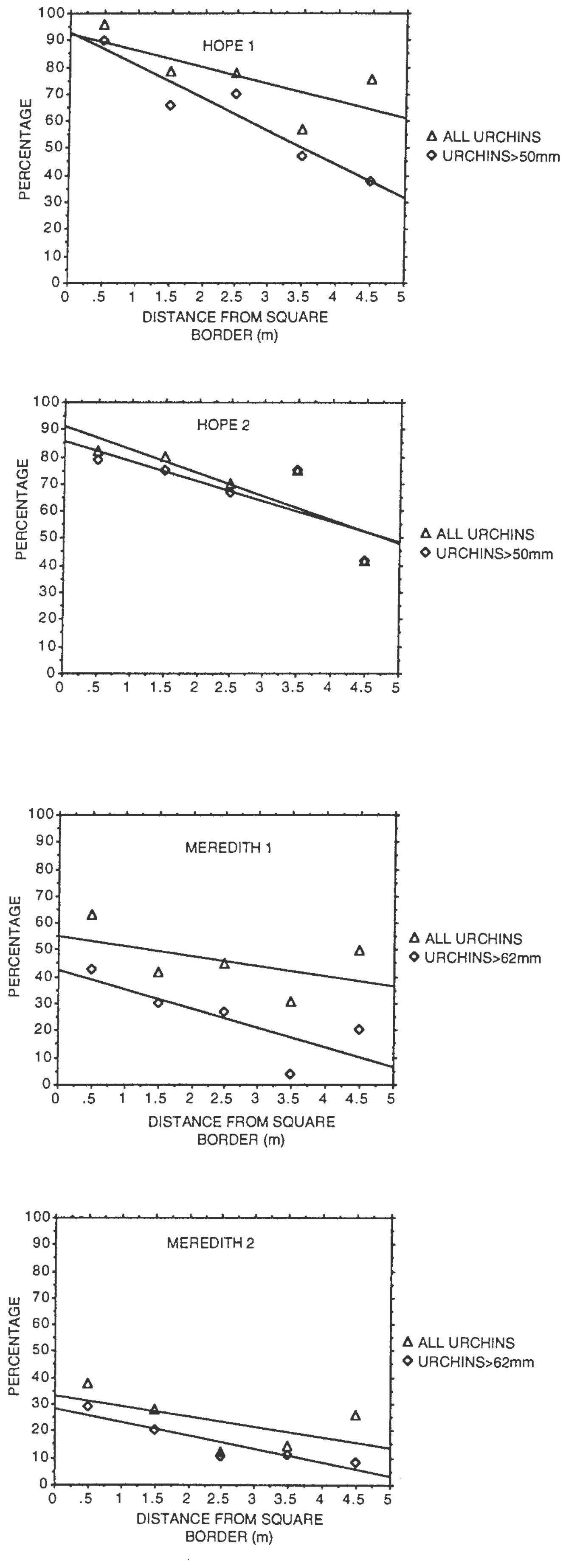


FIGURE 7.7 Size frequency of urchins found before clearances and immediately outside, in the 'outer' and 'inner' one year after clearances for both squares at Hope Is.

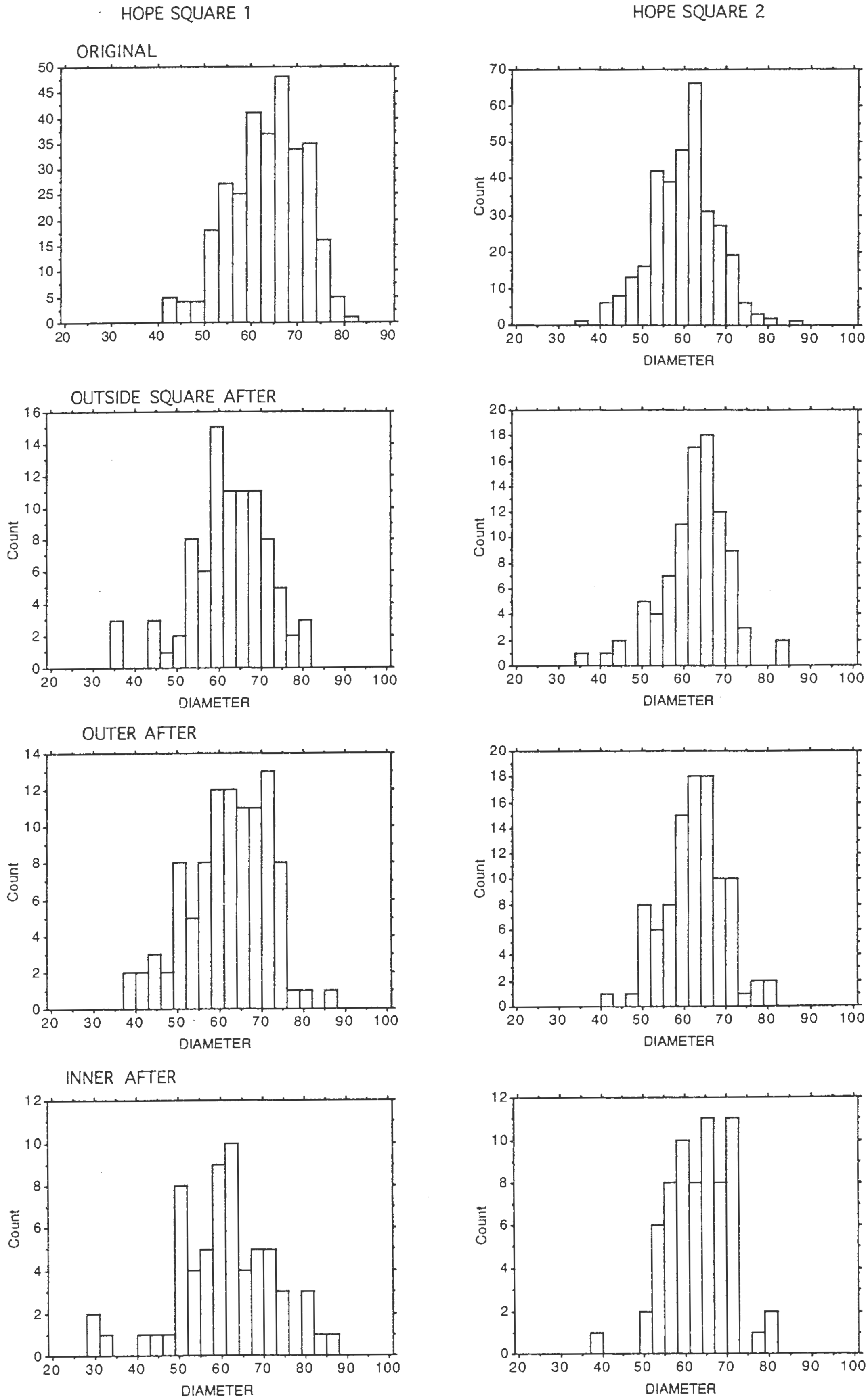


FIGURE 7.8 Size frequency of for both squares at Meredith Pt.

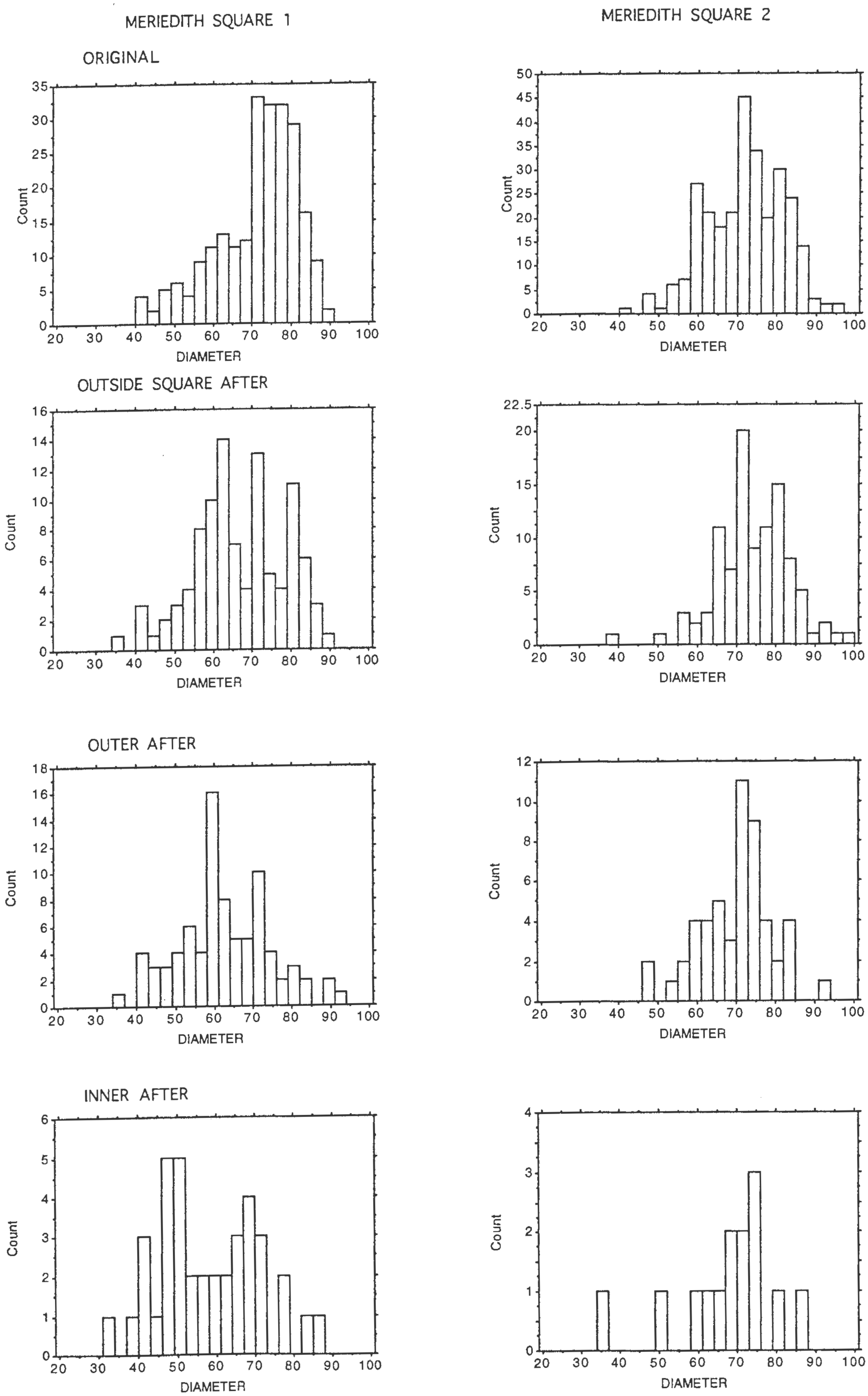
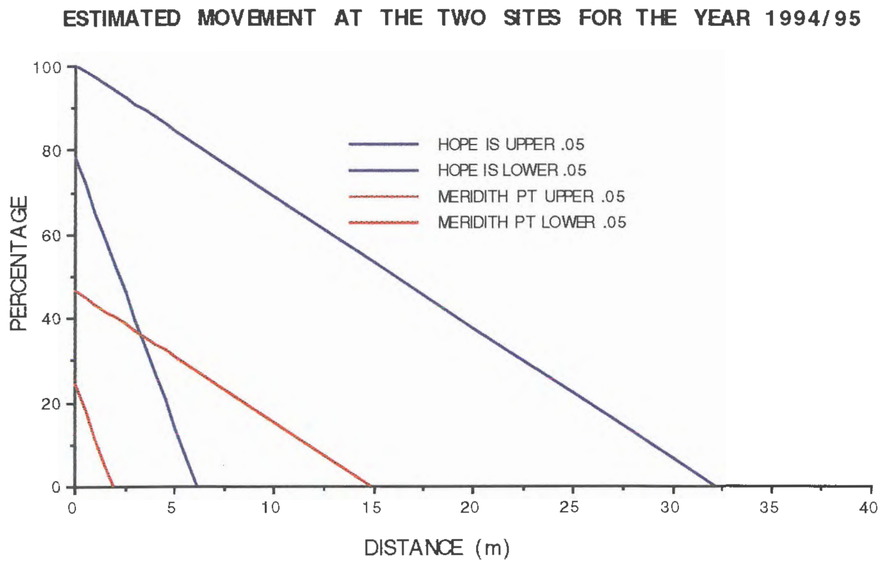
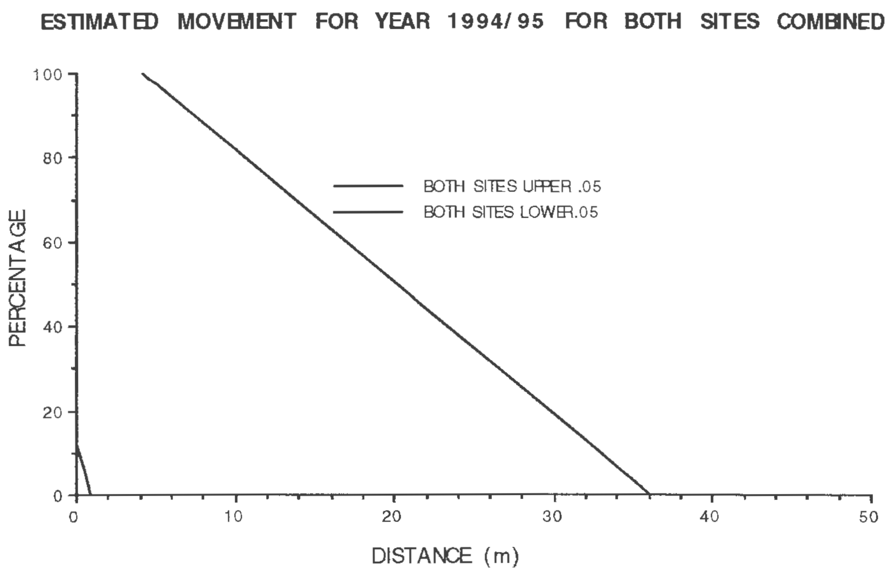


FIGURE 7.9 Estimated movement for both sites (top) and for both sites combined (bottom). Densities expressed as a percentage of outside square densities.





SECTION 8: KING ISLAND

INTRODUCTION

One of the factors limiting expansion of the urchin fishery is the lack of knowledge of condition of urchins outside the south eastern part of Tasmania. As part of this program some exploartory work was done at remote sites. This section shows results for King Is.

METHOD

In July of 1995, urchins from King Is were sampled for roe quality and quantity. To quicken the sampling process to get as many sites sampled as possible within the time on the island, for each of the sites, 25 urchins were collected, diameters measured , roe extracted and combined roe weight recorded. Individual weights of urchins were extrapolated from a diameter/weight relationship obtained from sites in SE Tasmania, a relationship which is conservative. At two of the sites, size frequency of 1-200 urchins was also determined. At one of the sites, a 100m transect was deployed and urchins were counted in 20 contiguous 5 x 1 m quadrats on either side of the transect.

Figure 8.1 shows where the sites were located on the island.

RESULTS

Day 1 Naracoopa

Site 1 (1/1)

Dominant algae: Caulerpa obscura (?), Caulerpa pentaflexa (?), Caulerpa flexilis, Macrocystis angustifolia with Caulocystis in shallow

Site 2

Exposed: Cystophora moniliformis, Ecklonia radiata, Phyllospora comosa, Macrocystis angustifolia, Acrocarpia panniculata in shallow (no sample).

Site 3 (1/2)

Acrocarpia pannculata, Cystophora moniliformis, Cystophora grevillaea (?), Caulerpa obscura, Ecklonia radiata and Sargassum sp.

Site 4

Ecklonia radiata, Macrocystis angustifolia, Sierococcus axillaris, Cystophora platylobium (no sample).

Site 5

Phyllospora comosa, Durvillaea potatorum, Macrocystis angustifolia (no sample).

Day 2 Christmas/New Years Island

Site 1 (2/1): **Reef between islands and mainland King Is**

Site 2 (2/2): **Inside Christmas Island**

Site 3 (2/3): **Approx 200m inside Christmas IS**

Day 3 (3/1) **Councillor Is**

Day 4 Grassy

Site 1 (4/1): **Reef between islands and mainland King Is**

Site 2 (4/2): **Inside Christmas Island**

Site 3 (4/3): **Approx 200m inside Christmas IS**

TABLE 1 Percent recoveries, for sampled urchins for King Is, July 95.

	SITE NO.									
	1.1	1.2	2.1	2.2	2.3	3.1	4.1	4.2	4.3	AV.
Roe Grade										
A	0.75	1.36	1.46	2.63	1.63	1.48	1.05	1.44	3.40	1.69
B	2.52	3.57	4.18	1.69	4.50	3.70	5.37	3.06	3.40	3.55
C	2.84	2.64	0.78	2.12	0.92	1.83	1.82	0.98	2.13	1.78
A+B	3.27	4.93	5.64	4.32	6.13	5.18	6.42	4.50	6.80	5.24

See Table 2 for results of transect undertaken at Councillor Is.

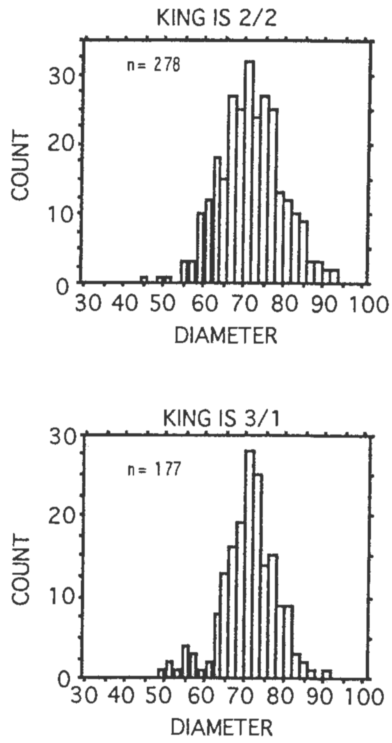
DISCUSSION

Overall, considering the samples were taken out of season, roe recoveries were reasonable, enough to warrant further investigation of King Is.

COUNCILLOR IS 8/7/95																								
QUADRAT		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Urchins		26	7	5	15	26	15	21	1	15	3	11	13	22	6	24	19	6	12	5	40	29	12	15.1
Depth (feet)		27	24	24	26	24	26	27	25	25	28	22	24	22	25	26	28	30	31	28	31	25	24	2.11
Rock		100	100	100	100	100	50	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Cobble							50																	
Caulerpa brownii	C	15	40		5		2				2	2	2	5	2	5					2	2	2	
Caulerpa geminata	C	80	40	30	60	50	40	30	15	40	30	15	20	20	30	50	30	15	15	20	20	20	20	
Caulerpa obscura	C												1		15		15	10	10	5	2		5	
Caulerpa simpliciuscula	C			5	10		2	5			10	1			2	5	2	2		5	5	2	2	
Codium	C	1									1							1						
Acrocarpia panniculata	P													1	1		1	1	1					
Caulocystis (uvifera)	P						1																	
Cystophora moniliformis	P	5	4	2	2		2		5	5	2	15	10	5	5	5	2	2		5	2	5	2	
Ecklonia radiata	P													1									1	
Perithalia caudata	P														1									
Sargassum (heteromorphum?)	P	1				1	1		2	2	5	2		5		5				2	5	5		
Xiphophora gladiata	P	1		1					5			5	2	10	10	5	2	2	5	5	5	5	5	
Zonaria	P																					1		
Corallina	R							1																
Reds	R					1							1											

FIGURE 8.1 Sites sampled for roe recovery, king Island, july 1995.

FIGURE 8.2 Size frequencies for urchins at two sites on King Is.



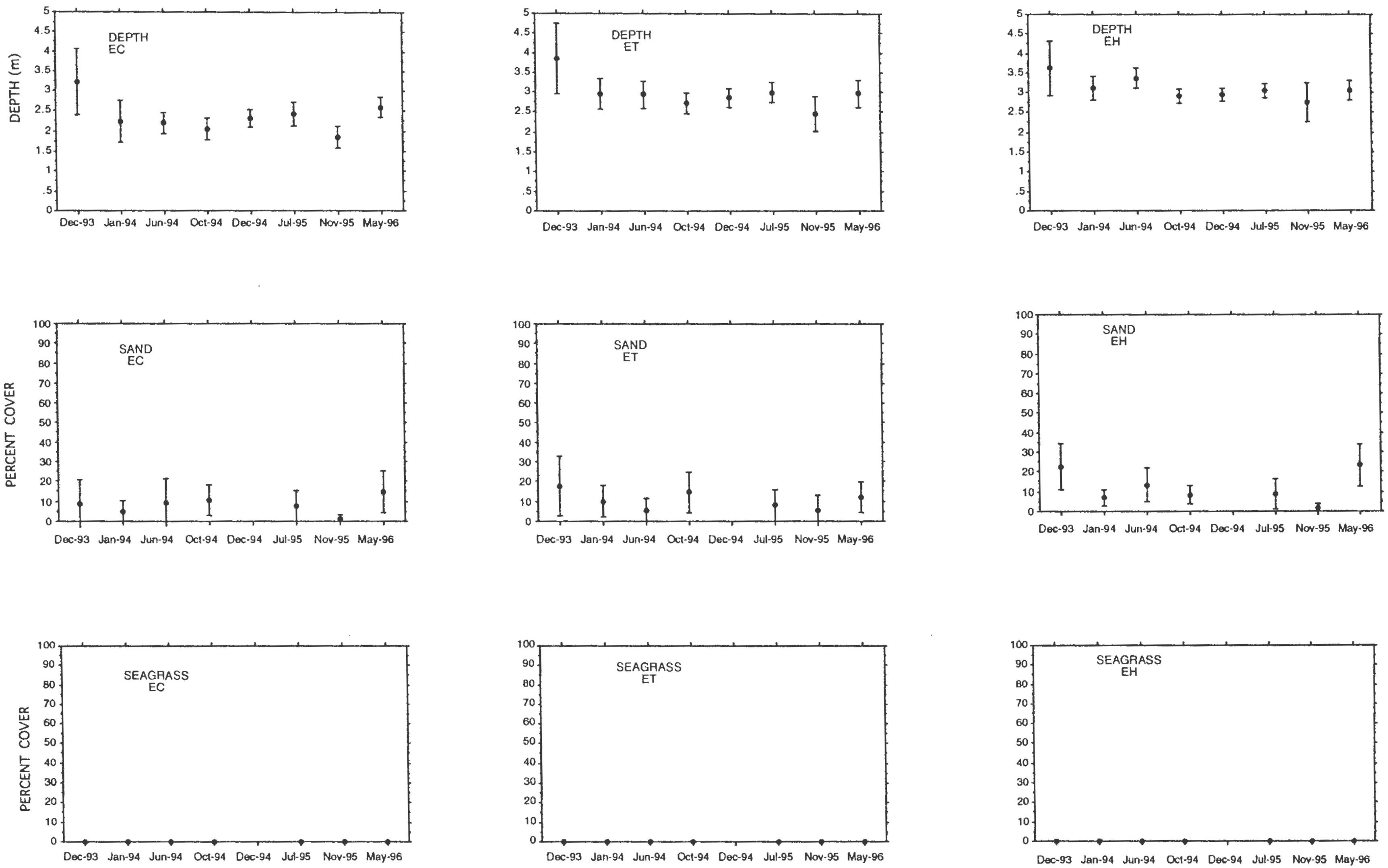
APPENDIX 1

Transect results for each of the squares at Meredith Point.

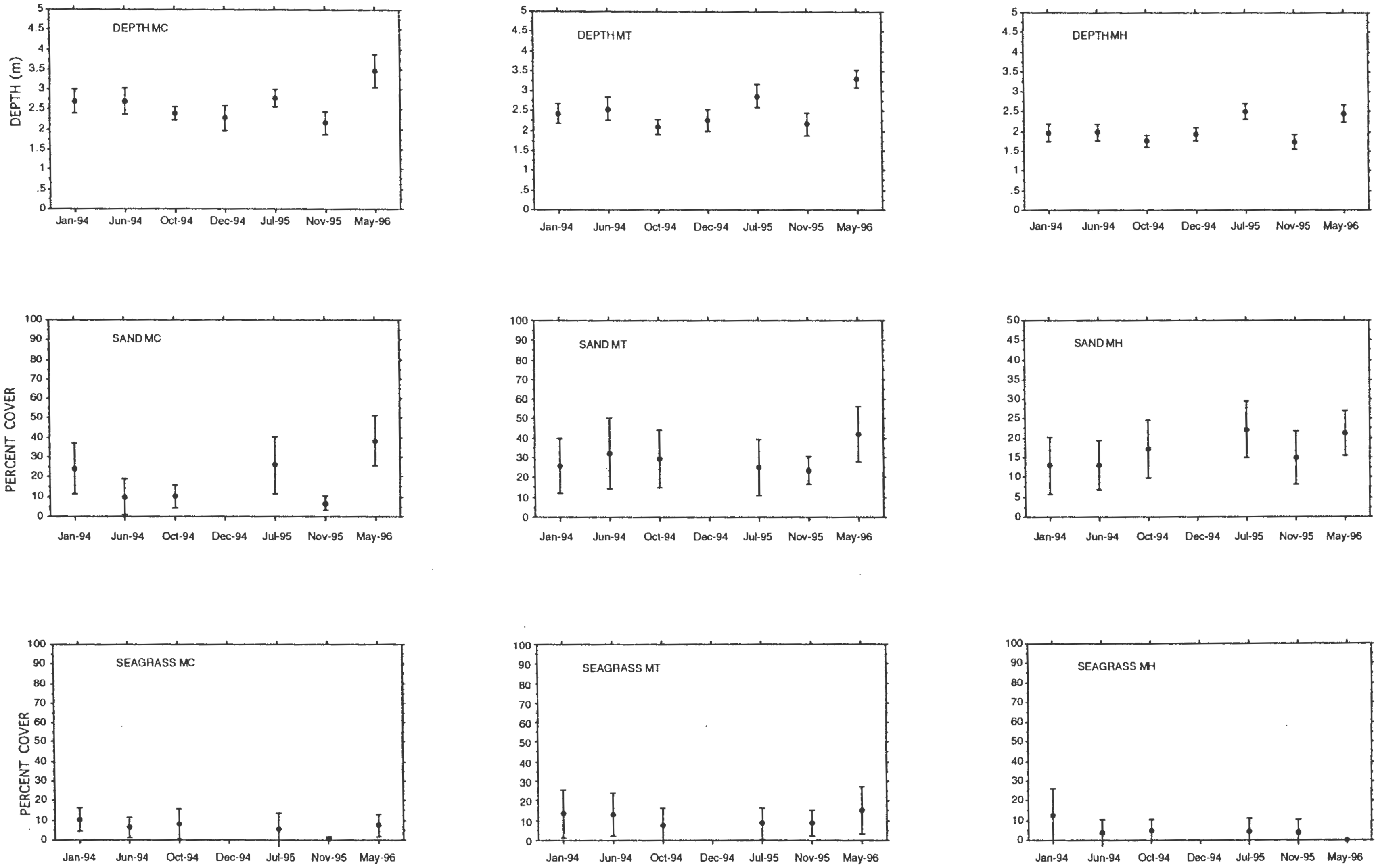
Note in particular the results for the eastern squares. Here EH was a barren before clearance. Vegetation has returned to this square over the period of two years.

Fucales (predominantly *Sargassum* and *Caulocystis*) were lumped together for June 94 survey.

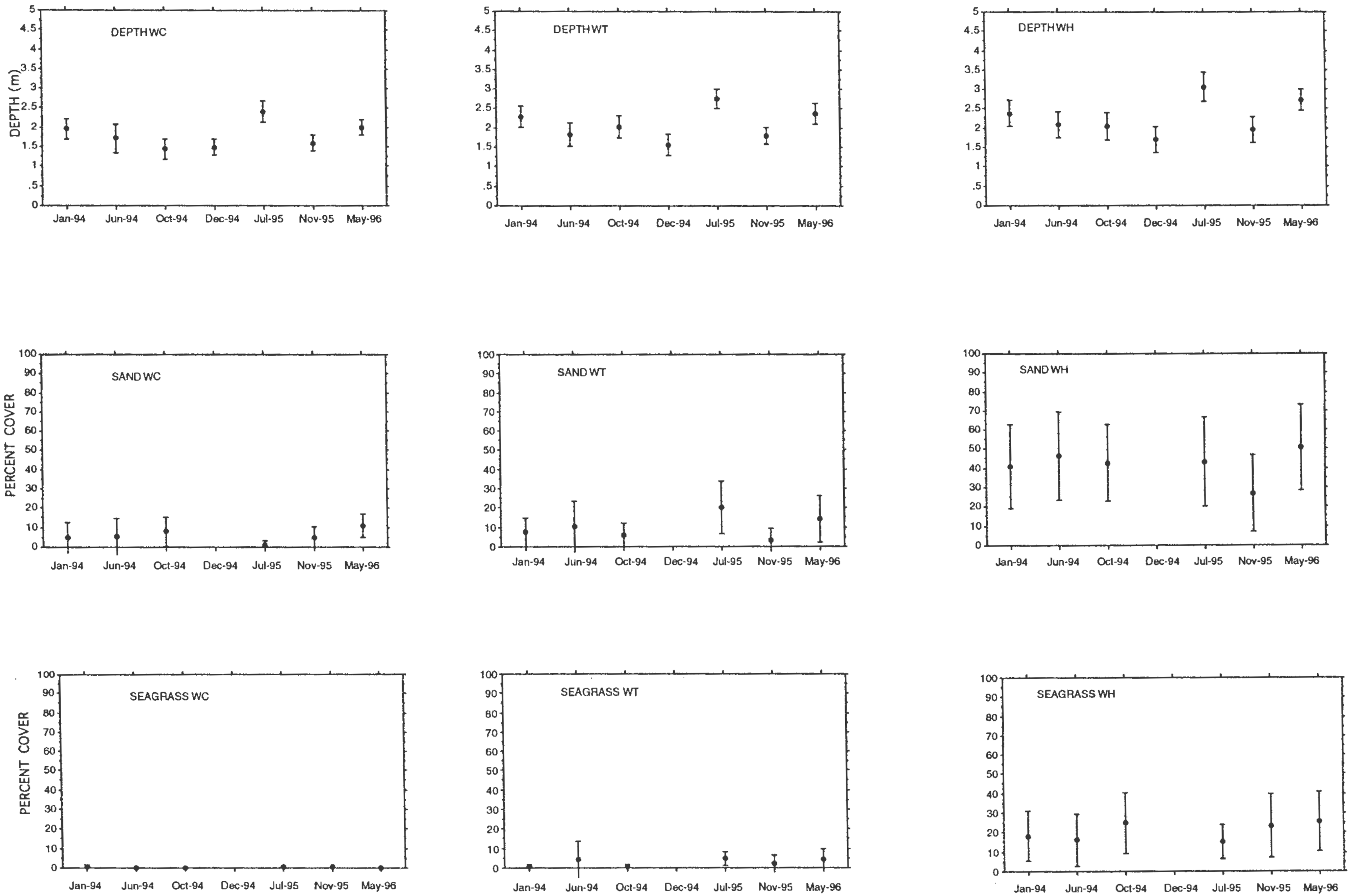
APPENDIX 1 Transect results for the eastern block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



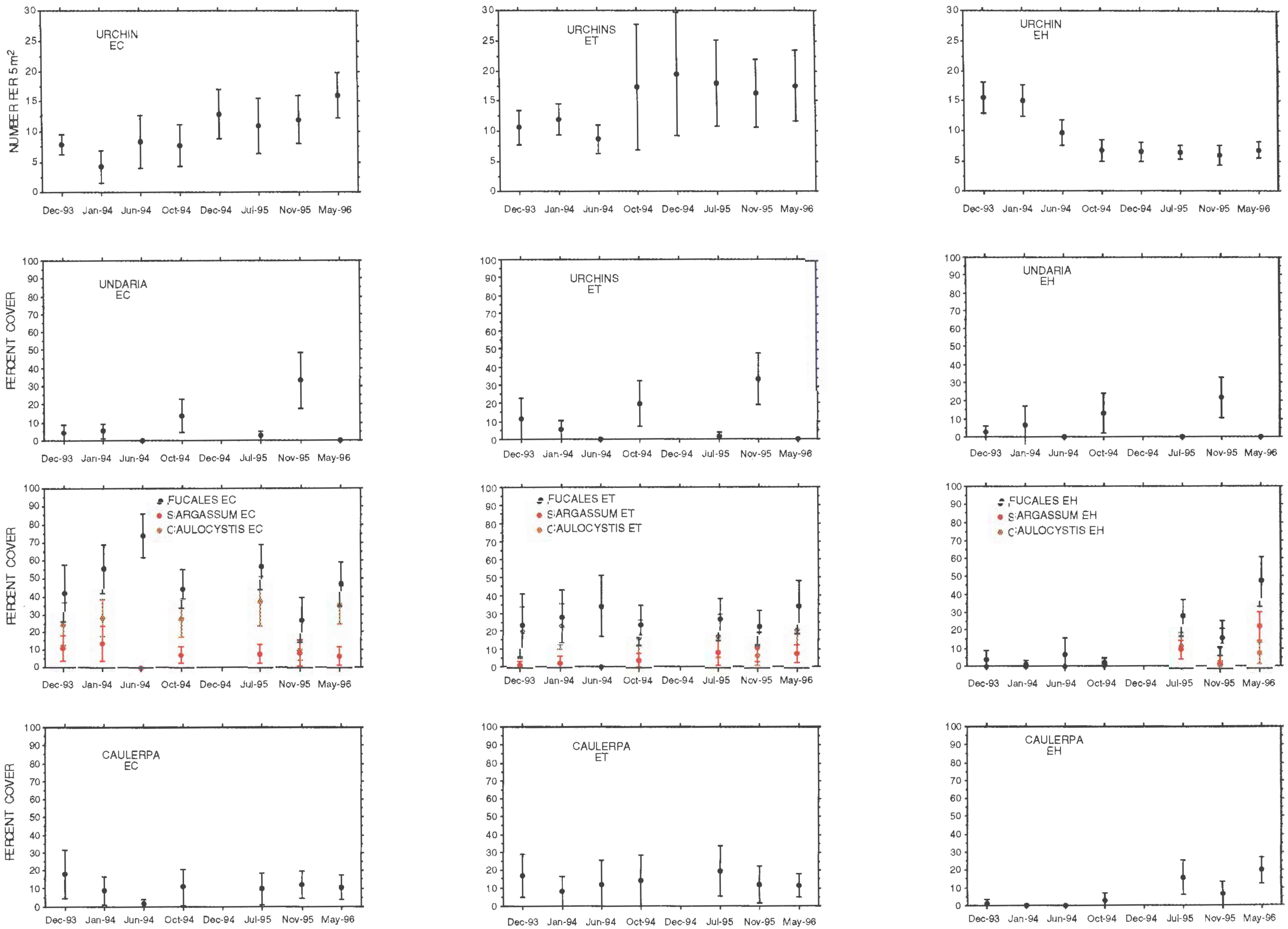
APPENDIX 1 Transect results for the middle block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



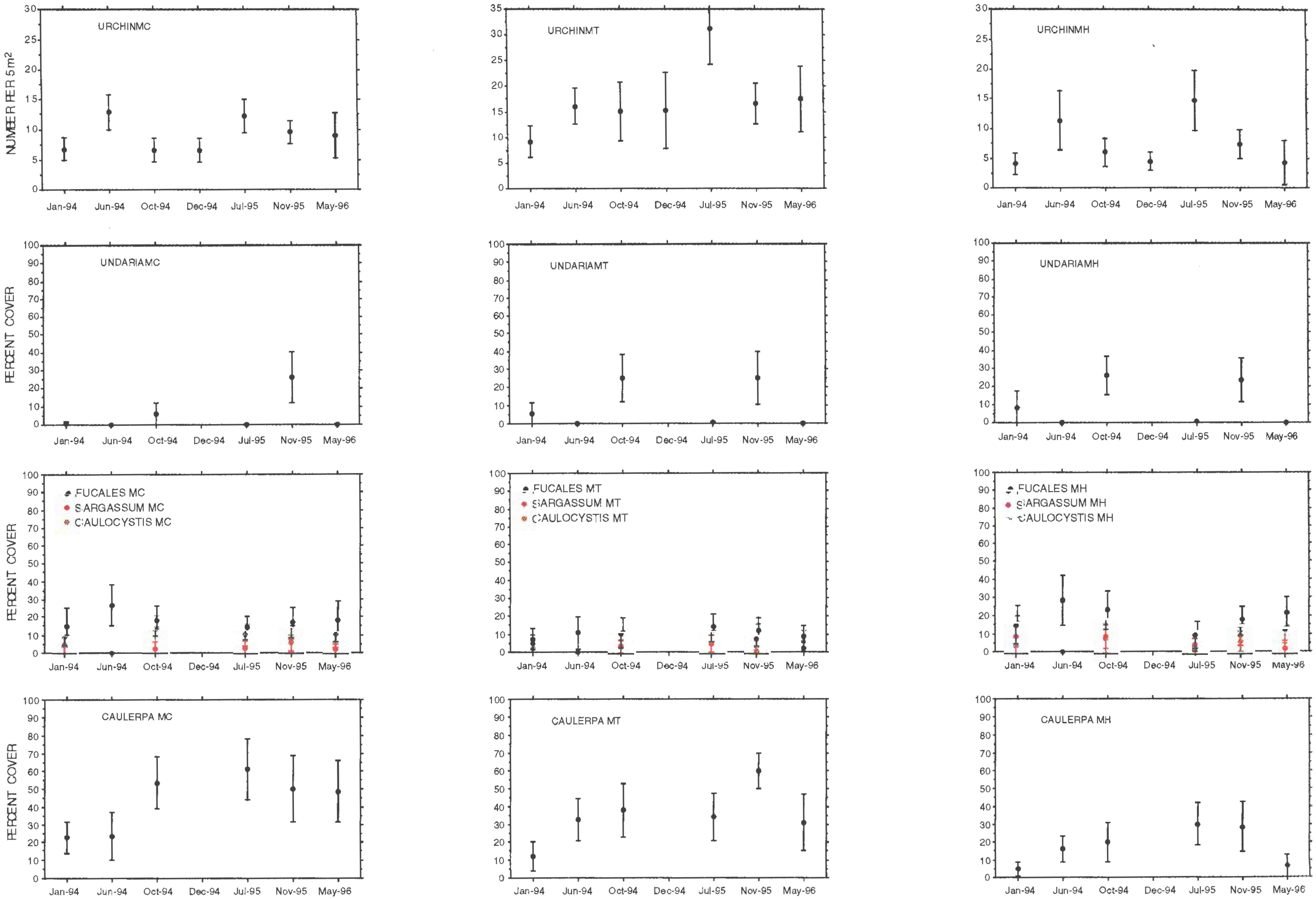
APPENDIX 1 Transect results for the western block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



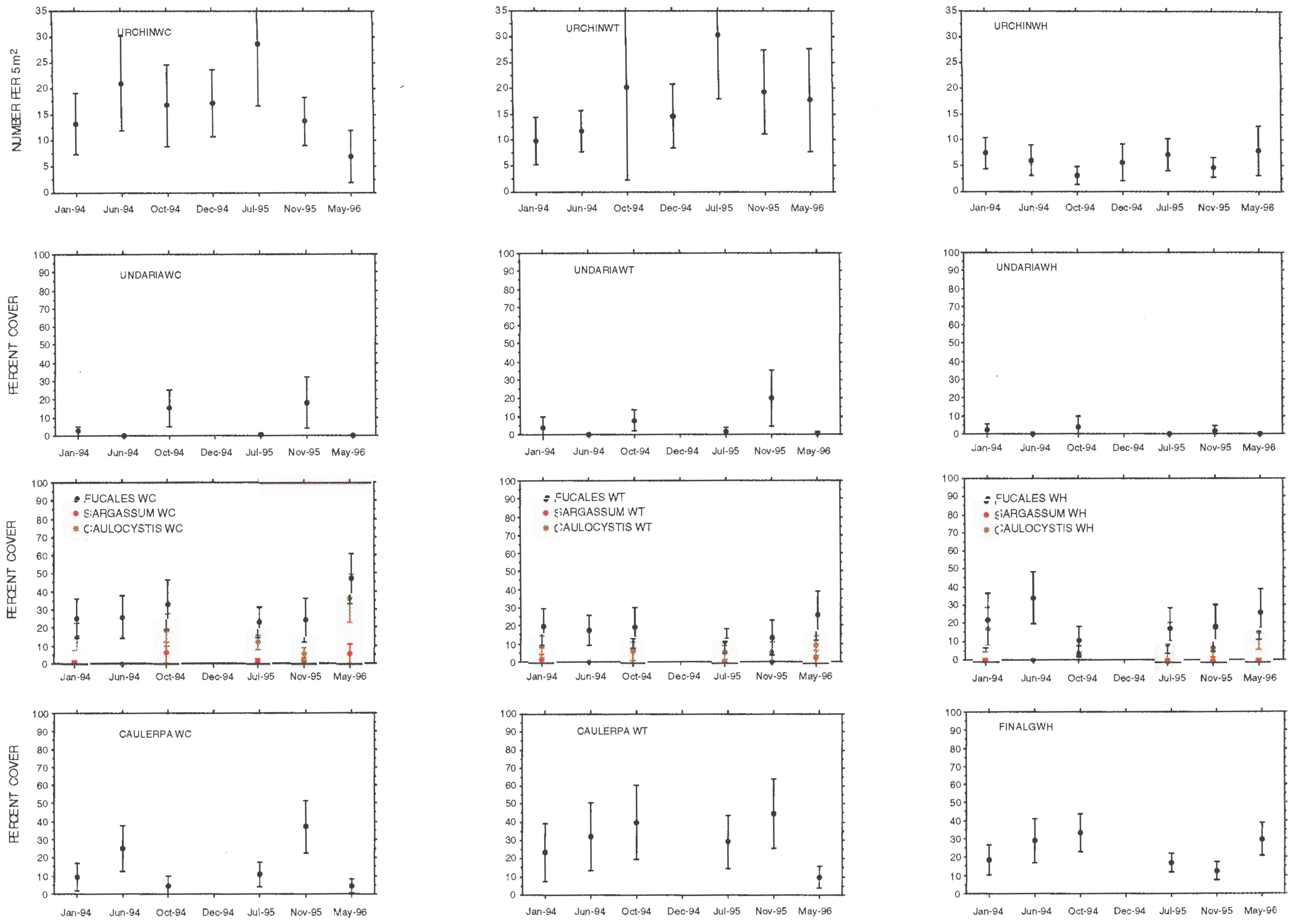
APPENDIX 1 Transect results for the eastern block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



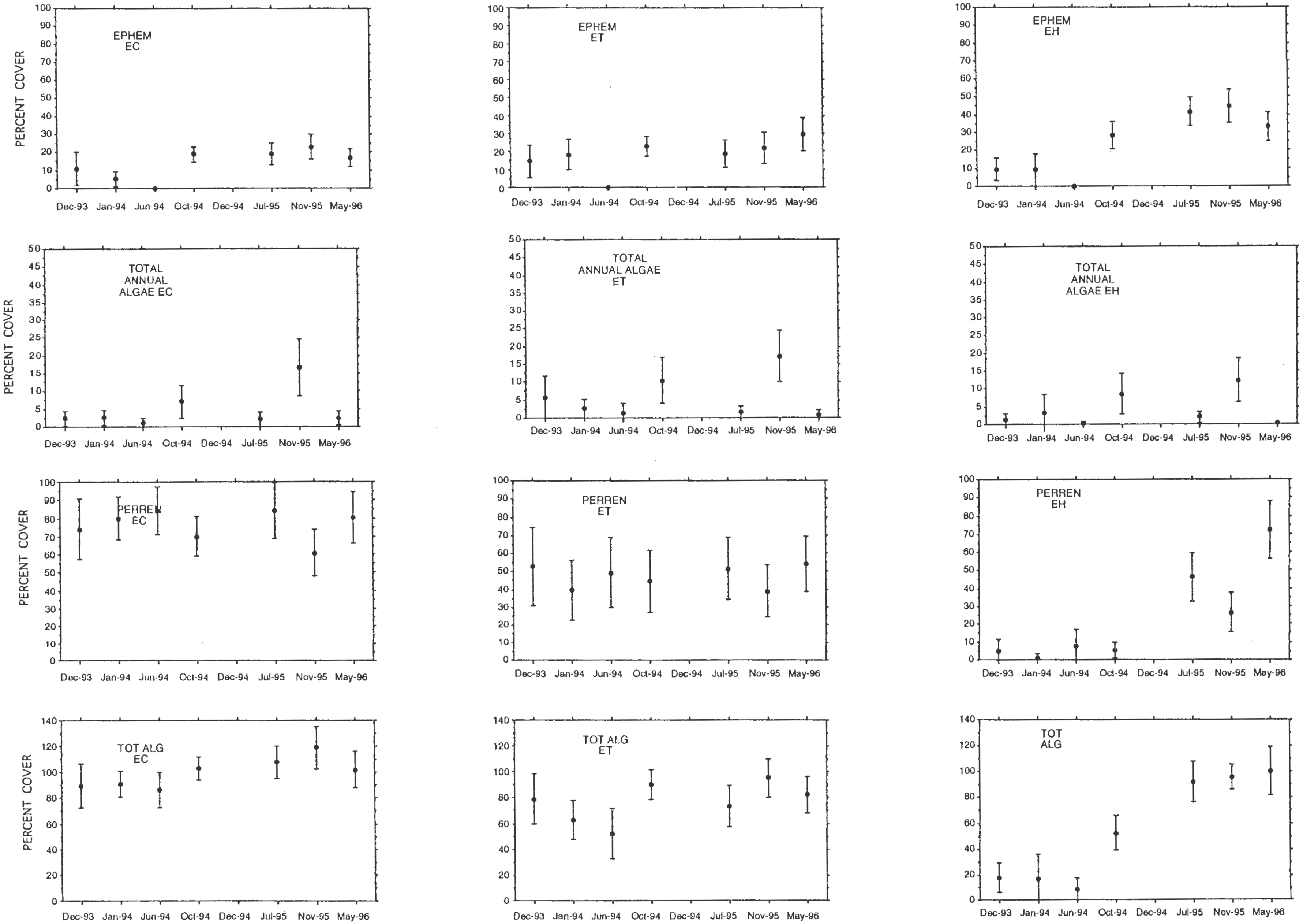
APPENDIX 1 Transect results for the middle block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



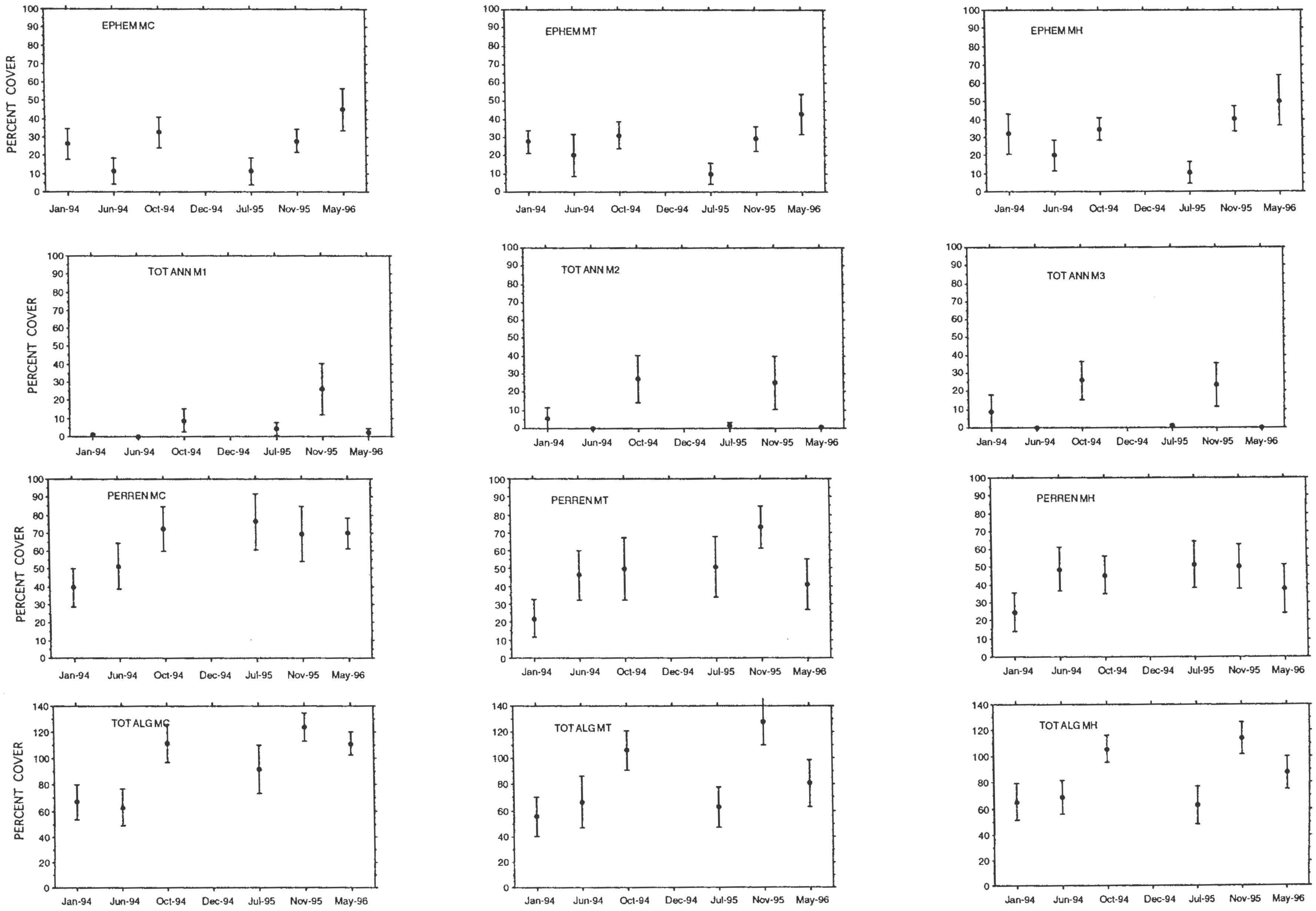
APPENDIX 1 Transect results for the western block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



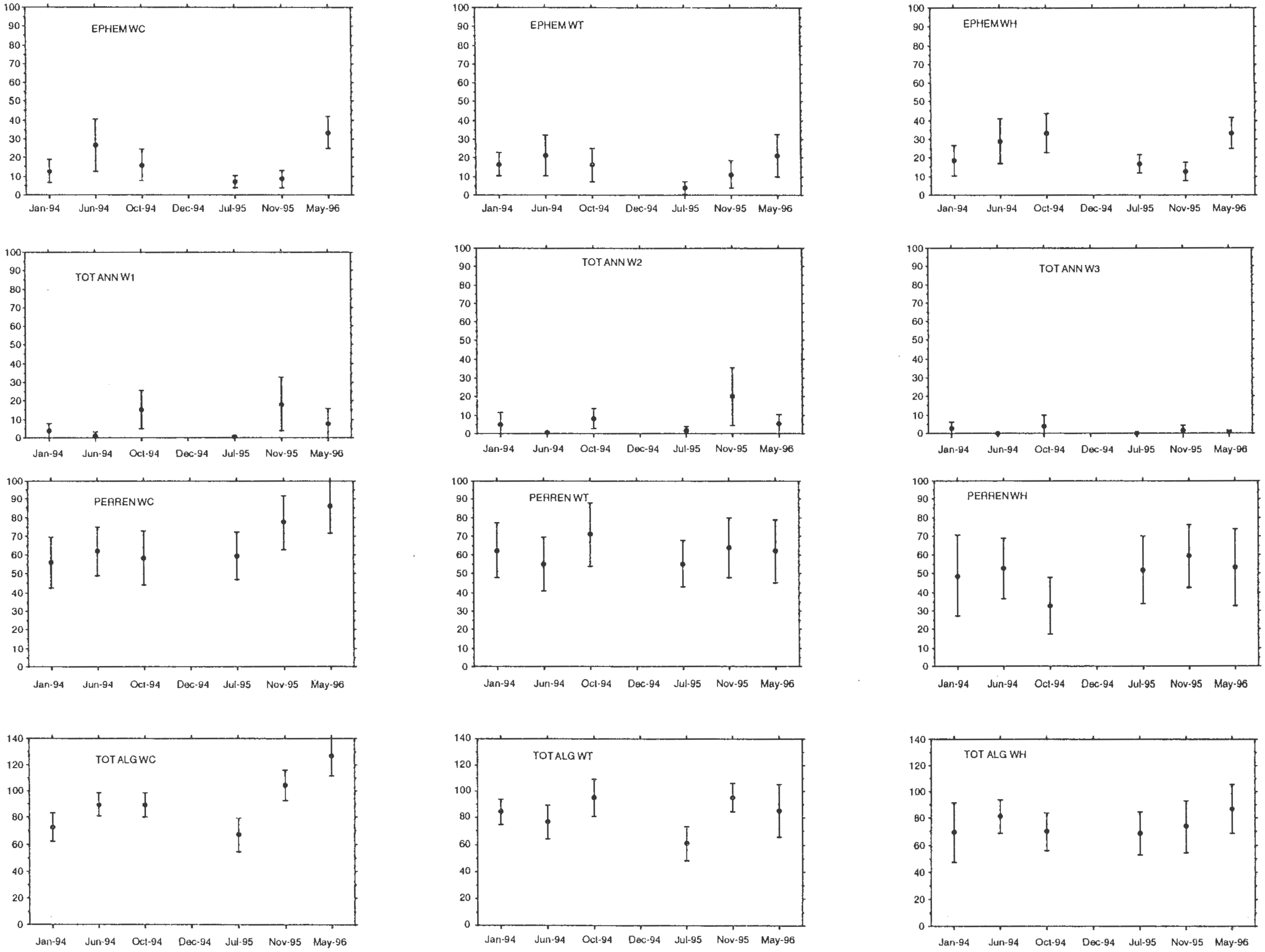
APPENDIX 1 Transect results for the eastern block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



APPENDIX 1 Transect results for the middle block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



APPENDIX 1 Transect results for the western block at Meredith Pt. E - Eastern block, M - Middle block and W - Western Block, C - Controls, T - Transplants and H - Harvested..



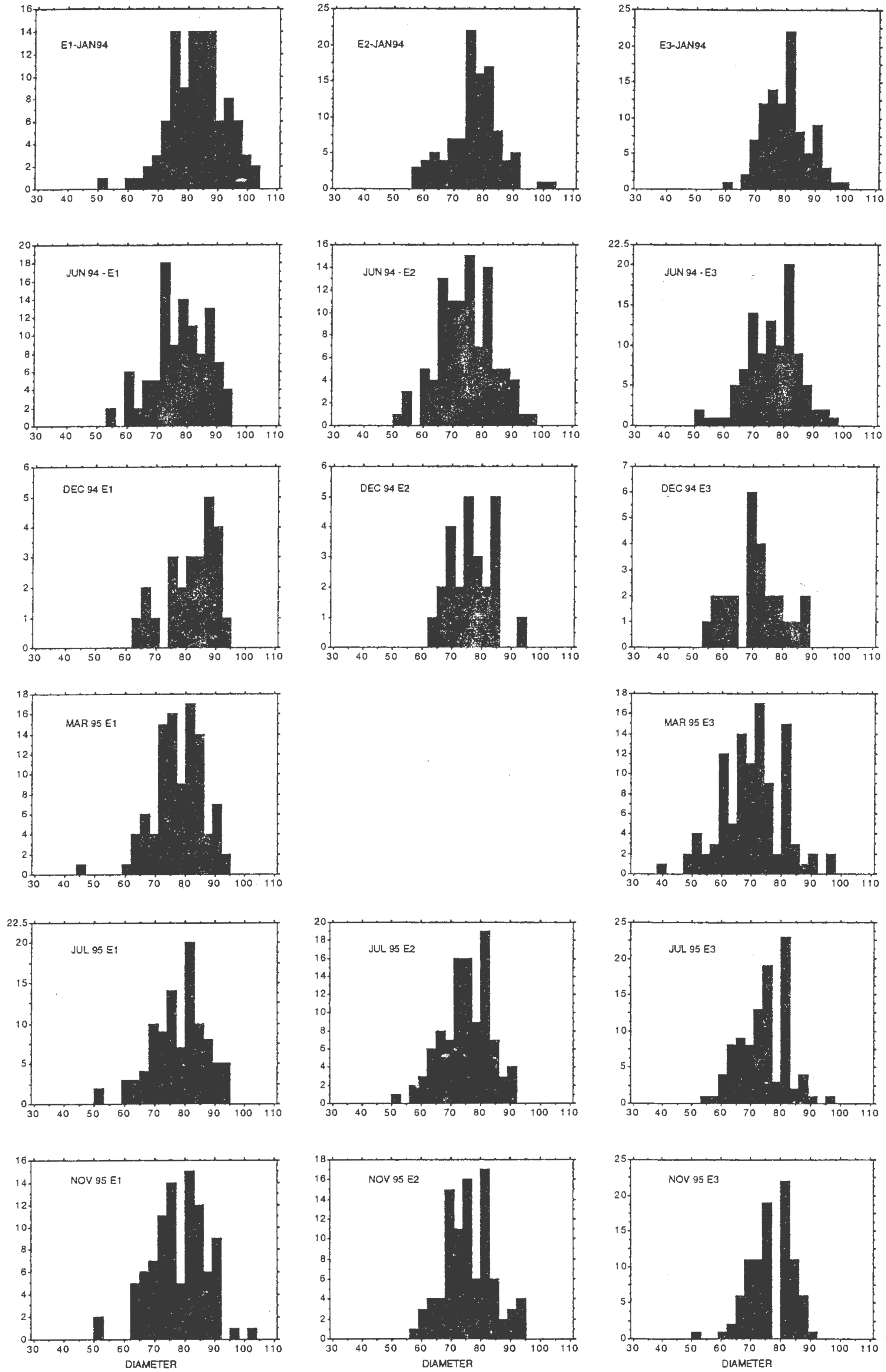
APPENDIX 2

Size frequency results for urchins from square surveys at Meredith Point.

Results were largely in-conclusive.

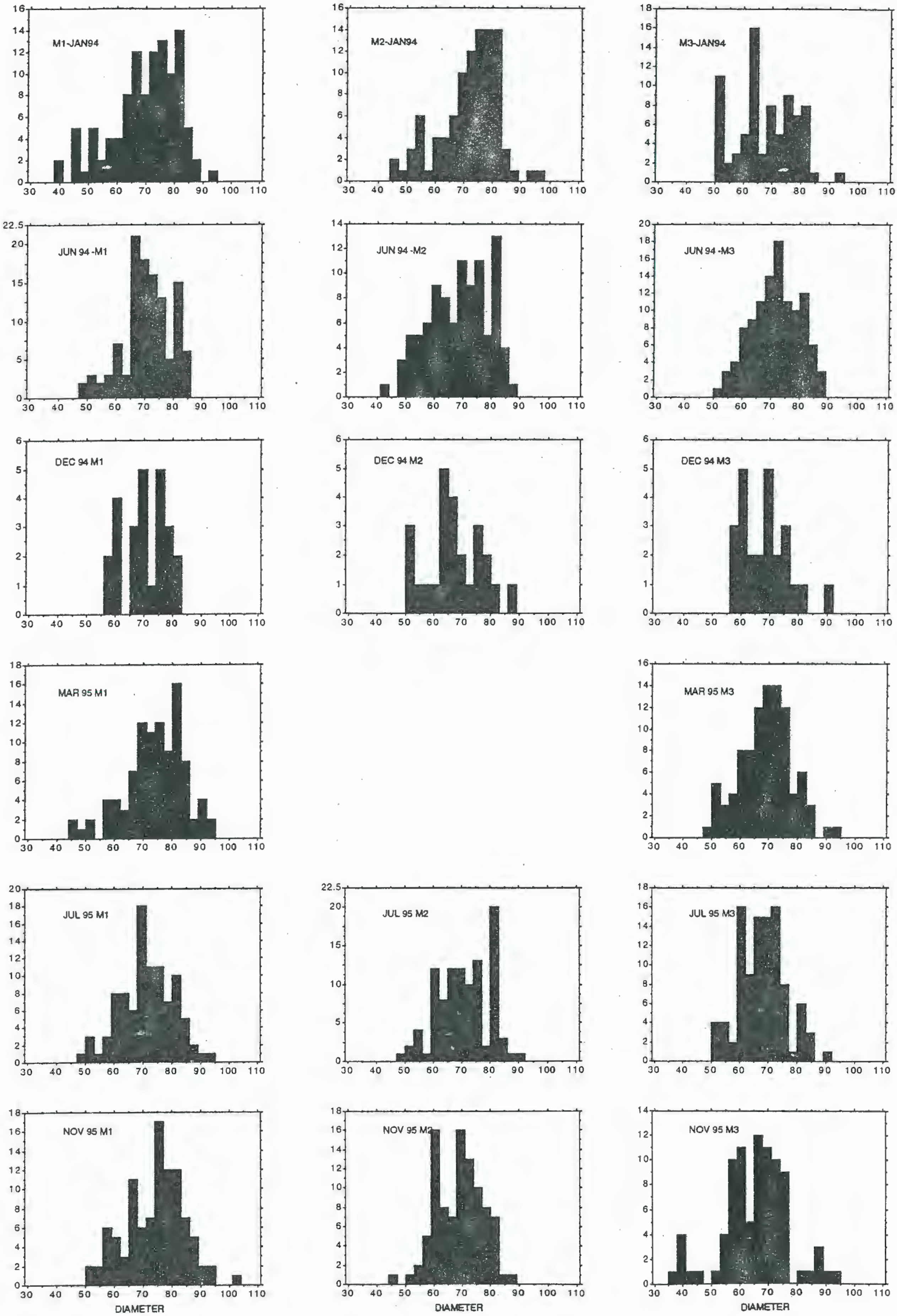
EAST

CONTROLS | TRANPLANTS | HARVESTED

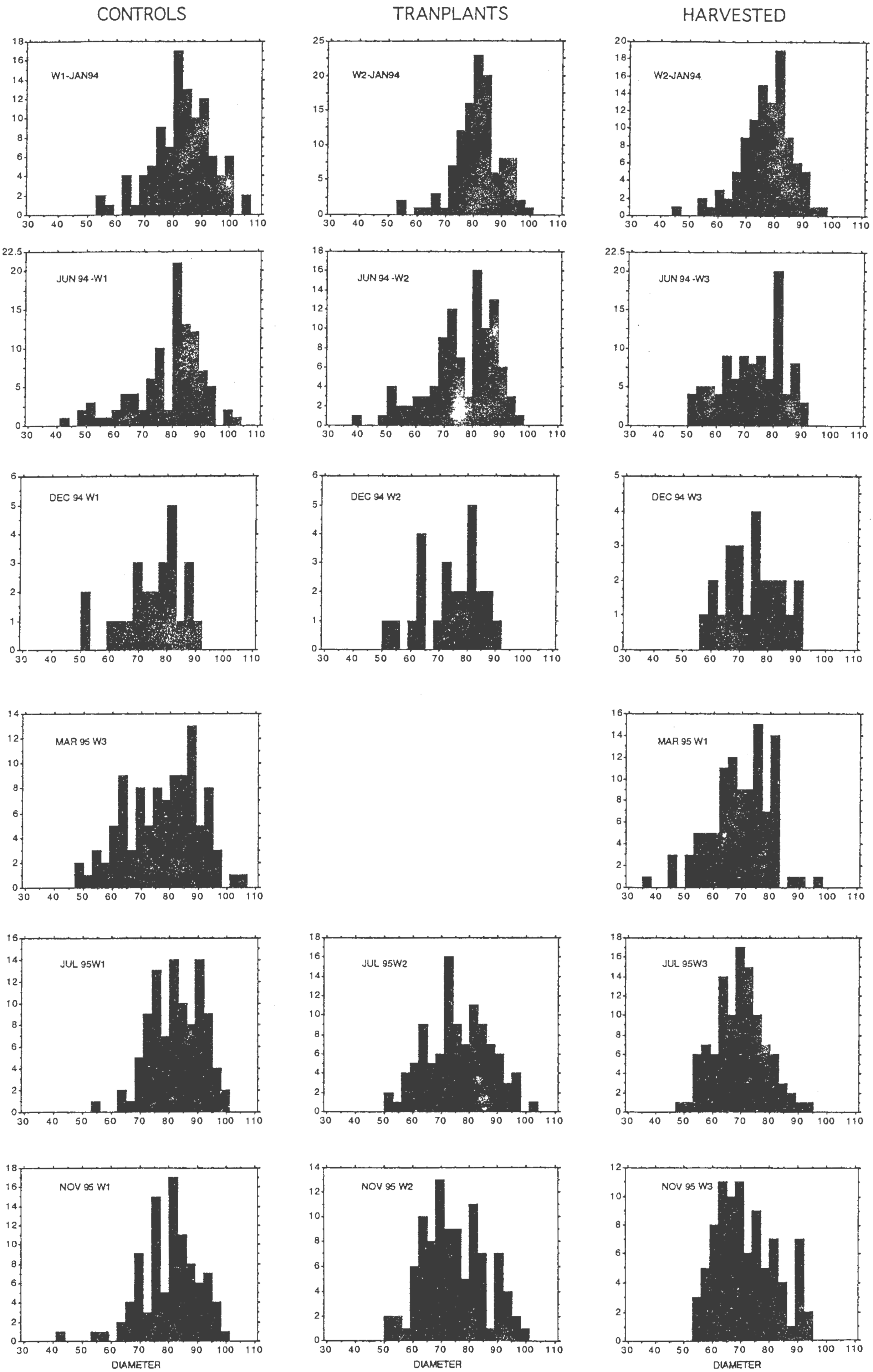


MID

CONTROLS TRANPLANTS HARVESTED

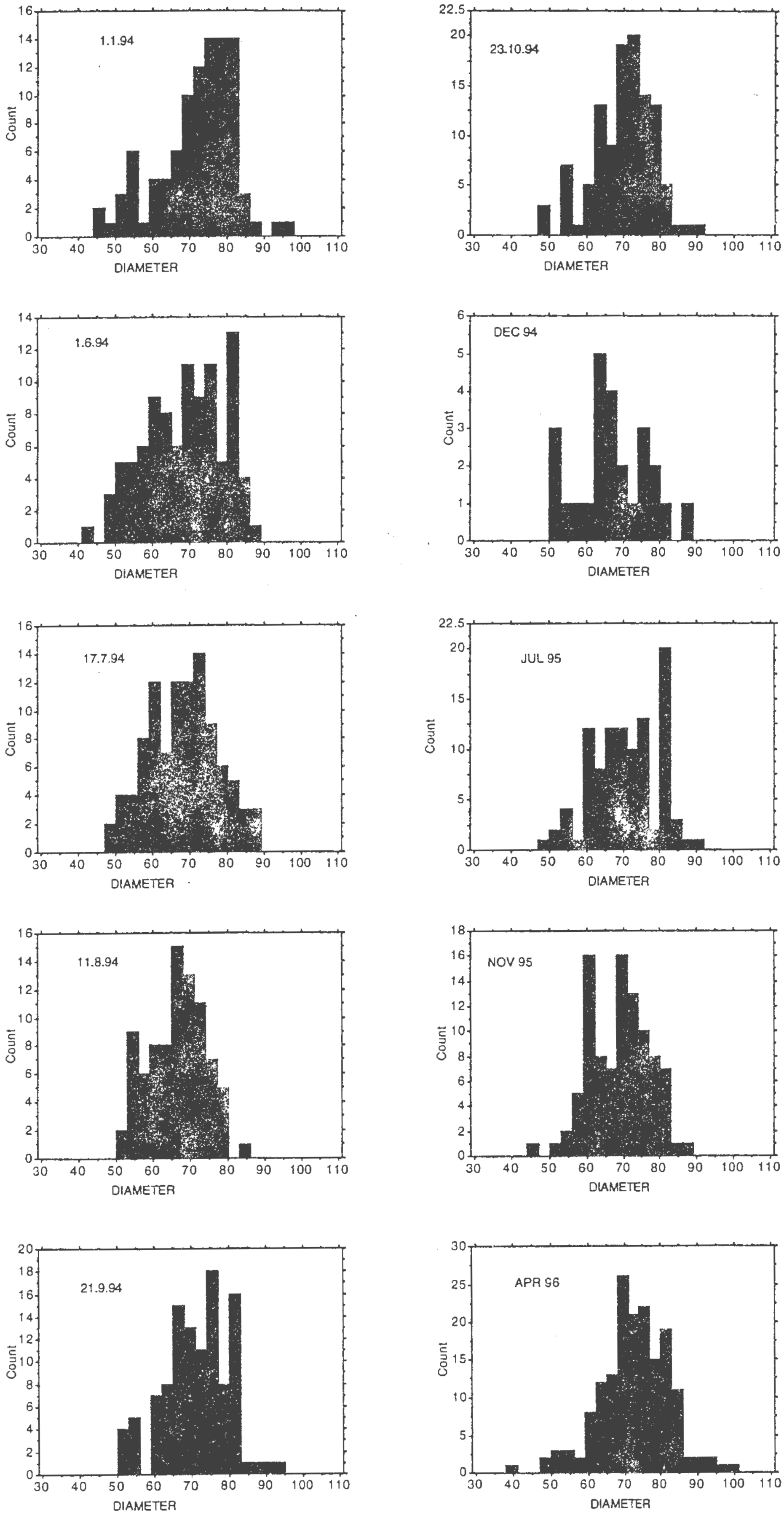


WEST

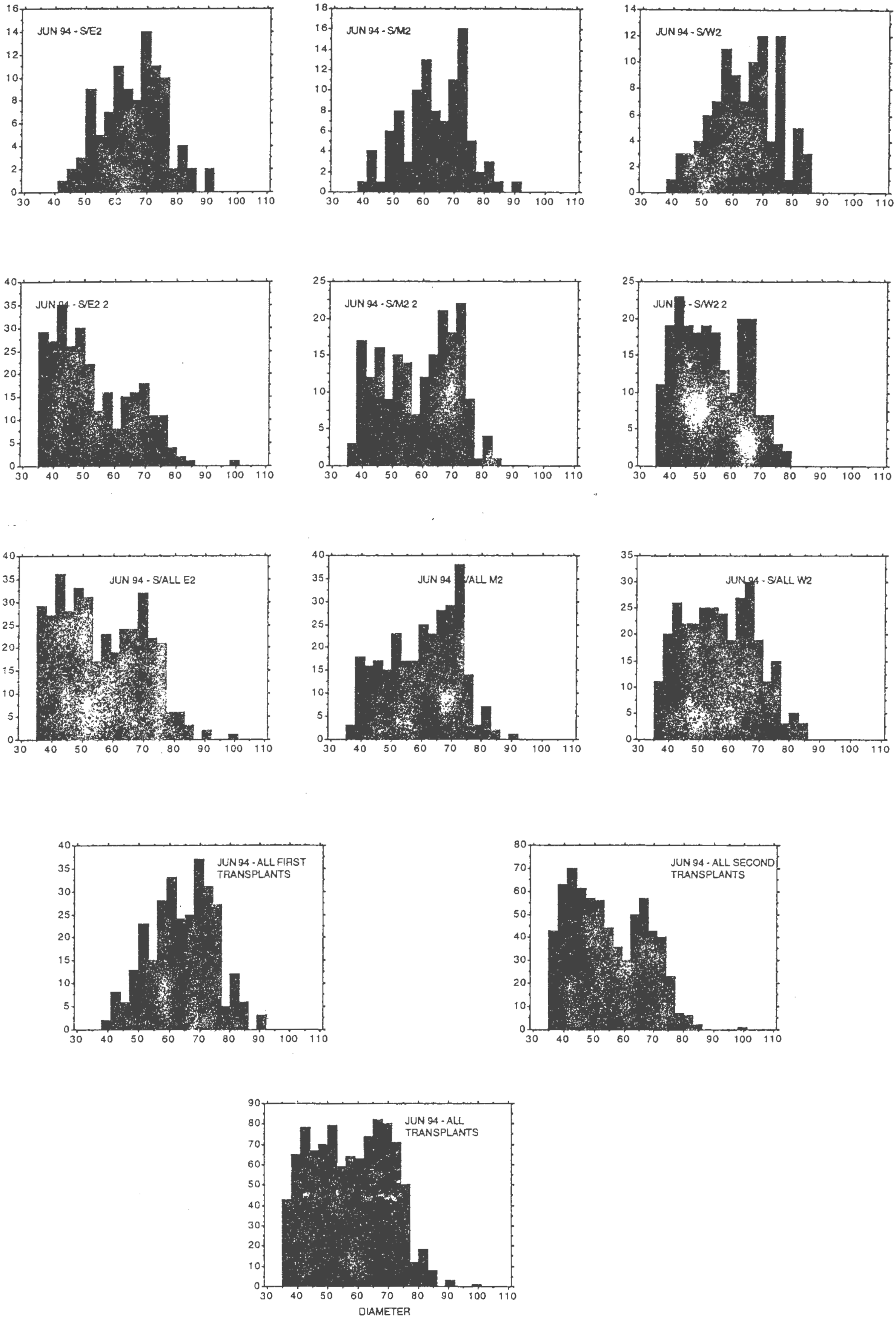


CONTROLS
TRANPLANTS
HARVESTED
W1-JAN94
W2-JAN94
W2-JAN94
JUN 94 -W1
JUN 94 -W2
JUN 94 -W3
DEC 94 W1
DEC 94 W2
DEC 94 W3
MAR 95 W3
MAR 95 W1
JUL 95W1
JUL 95W2
JUL 95W3
NOV 95 W1
NOV 95 W2
NOV 95 W3
DIAMETER
DIAMETER
DIAMETER

Size frequencies of urchins for the middle site square that received transplanted urchins (transplanted: June 1994).



Size frequency of tranplanted urchins, Stapleton Point - Meredith Point, June 1994
(S - Stapleton, E - East block, M - Middle block, W - West block).



Mean diameters of urchins sampled for size frequencies from each of the squares at Meredith (1 - Control, 2 - Transplants, 3 - Harvested).