FINAL REPORT - FIRTA GRANT 86/92

Investigation of the impact of the seastar *Coscinasterias calamaria* on commercial mollusc fisheries.

Dr R. W. Day,
Zoology Department, University of Melbourne,
PARKVILLE, VIC. 3052.

The large starfish,*Coscinasterias calamaria* is known to feed on commercially exploited molluscs, including blacklip abalone (*Haliotis rubra*),mussels (*Mytilus edulis*) and scallops (*Pecten irradians*). This study investigated the abundance of the seastar on reefs in Port Phillip Bay (Fig. 1), and the extent to which it reduces stocks of the blacklip abalone on these reefs. It is recommended that abalone divers note when there appear to be very few small mussels on offshore reefs early in the year, as this may provide a warning of possible depletion of abalone stocks later. Preventative measures could then be taken.

INTRODUCTION

Previous reports revealed a puzzling contrast in what the starfish eats on different reefs. Local abalone divers have reported that this starfish feeds extensively on abalone, and McShane and Smith (Australian Fisheries, April 1986) reported that at Sticks Reef, off Altona, the density of blacklip abalone was severely reduced by the starfish, which occur there in very high densities (up to 15 m^{-2}). We have observed large numbers of abalone eaten on an offshore reef off Point Cook. In contrast, studies on abalone at Beaumaris and Kirk's Point Reefs (see Fig. 1) have noted very little predation on abalone by the starfish, and at Point Cook Reef the starfish appeared to eat prey in proportion to their abundance. In fact abalone and chitons, which retreat into crevices, were less often eaten than might be expected from a random selection of prey, perhaps because they are less easily caught.

McShane and Smith suggested that once the starfish had depleted the mussels on the reef, they began to eat the abalone. We therefore set out to discover what *Coscinasterias* usually eat, what they prefer to eat, and the rate at which they feed on mussels and abalone; and under which conditions abalone fall prey to the starfish.

Juvenile *Coscinasterias* have been found on large foliose algae at Point Cook Reef, and they eat very small animals available on the algae, especially small molluscs. Juveniles have also been found under rocks and amongst mussels in this study, but have not been observed feeding on abalone. Only large starfish (> 150 mm diameter) are considered in this report.

To determine the sizes, densities and diet of large *Coscinasterias*, belt transects were laid out perpendicular to shore on each reef,spaced approximately 75 meters apart. The transect lines extended to the outer edge of the reef,and areas within 1 meter of the line were searched. Two diameters between opposing ray tips of all starfish encountered were

measured, to give a mean diameter. Each starfish was checked to see if it was eating any prey, and if so what species and its size. To discover which types of prey were chosen and which were avoided, all possible prey items were counted and measured in a 10 meter belt on the part of the reef where the highest density of starfish was encountered. The relative abundances of potential prey could then be compared to the percentages of these prey in the diet.

In aquaria, large starfish (19-31 cm diameter) were offered mussels and abalone of known length, and monitored every 60 minutes to determine the time spent feeding. To determine food preferences, a starfish was offered one 70mm mussel and one 50mm abalone and the preference was determined by which animal was taken first. The sizes of prey were chosen so that their wet weights were similar. We observed how the starfish caught abalone in various situations to help determine why abalone are eaten only on some reefs.

RESULTS

At most sites densities increased offshore (Fig. 2). The overall densities of the starfish in the belt transects at each site are shown in Figure 3, but the starfish occured in patches: the density varied greatly between transects at each reef. By far the highest densities occured at Sticks Reef, which lies offshore. The mean diameter of the starfish lay between 25 and 30 cm on most reefs, but the animals at Williamstown were significantly larger than at any other site.

Mussels were the most common item in the diet at most sites (Fig. 4), followed by other bivalves, and gastropods, including abalone. The abundances of prey groups on the reefs is shown in Figure 5 A and B. On most reefs bivalves were the most abundant prey (Fig. 5A), but they were absent in the transects on Point Cook outer reef (labelled PtC.O in the figures) and Beaumaris, where abalone (*Haliotis rubra*) were the most abundant prey available at the time of the surveys. Yet scarcely any abalone were recorded in the diet at any of these sites.

Sticks Reef was surveyed in December 1986, June 1987, and four times per year in 1988 and 1989. In December 1986, there were very high densities of seastars. The centre of the reef appeared devoid of molluscs of any kind, except for patches of recently settled mussels, 2-3mm long. A more wide ranging search for abalone revealed some were present on scattered rocks at the edge of the reef. Very few of the starfish were feeding, and the prey items were very small, including a 15mm juvenile abalone, and a few of the tiny mussels. Arms were removed from some starfish to determine the size of internal organs, and these animals were immediately attacked by larger animals, which inserted their stomach folds into the wounds. The digestive glands and gonads were very small. Clearly these starfish were starving, due to the lack of mussels, abalone or any other prey left on the reef.

By 1987 the densities of starfish were much lower, the 1986 mussel juveniles were large enough to be eaten, and more of the starfish were feeding, almost entirely on mussels. A BSc. honours research project by C. Shaw showed that *Coscinasterias* avoids very small mussels, presumably

because they contain very little nutrition. Good recruitment of mussels apparently occured again in 1987 and 1988, so that mussels have remained abundant, although feeding rates were low from January to May in 1989 (Fig. 6). Feeding rates increase by September, which may be due to protein requirements associated with egg and sperm production. Although abalone have become fairly common we did not find any being eaten. It appears likely that in most years the previous year's recruitment of mussels is sufficient to sustain the starfish until the next year's recruits grow large enough, especially as feeding may be reduced in the first half of the year.

The results from Beaumaris and other reefs show that *Coscinasterias* do not simply start feeding on abalone whenever there are no mussels available, as suggested by McShane and Smith. They may feed on a wide variety of other prey. Furthermore in aquarium choice experiments *Coscinasterias* do not exhibit a clear preference for mussels over abalone of about the same size. If anything they tend to prefer abalone. Large numbers of abalone have been eaten only among dense aggregations of the starfish, which appear to occur on offshore reefs that receive a good recruitment of mussels in most years, such as Sticks Reef. Yet our observations at Sticks Reef and another offshore reef off Point Cook suggest that on reefs with dense aggregations of *Coscinasterias* few abalone are eaten while there are large mussels available. It seems that both dense aggregations of starfish and a lack of mussels may trigger feeding on abalone.

In aquarium experiments, we found that the times taken for *Coscinasterias* to consume both mussels and abalone increase exponentially with the length of the prey, and the fitted lines are very similar for each (Fig. 7). Laboratory experiments indicate that digestion of prey continues during the night, but field observations suggest that the starfish do not forage for new prey during the night. Thus it is difficult to estimate the rate at which mussels are consumed on a daily or weekly basis. However, the data suggest that during the day mussels were eaten at Sticks Reef at a rate of 0.157 mussels m^{-2} hr^{-1} in late 1988. If the starfish switched to feeding on abalone, juvenile abalone could be eaten at similar rates, but adult abalone would be consumed much more slowly. At Williamstown, where most of the mussels were large, the calculated rate was 0.022 mussels m^{-2} hr^{-1}. The fact that mussels on a reef are eaten more slowly as they grow larger reduces the chance that the starfish will "run out of mussels" before a new set of recruits becomes available.

Aquarium observations suggest when abalone may become vulnerable to being eaten in large numbers. Blacklip abalone exhibit an escape response when attacked by starfish. As the starfish approaches, the mantle tentacles are expanded fully, and when the tube feet attach to the shell the abalone quickly twists the shell through 90 degrees in each direction, then moves rapidly away. However if the foot is not firmly attached to the rock, the twisting response will detach the foot, and it is then unlikely to escape. This occurs if the abalone is caught while moving rapidly, as only part of the foot is attached during movement. If it loses its contact with the rock, the abalone folds the sides of the foot tightly together, leaving only the dark sides of the foot exposed, and exudes copious quantities of mucus. The starfish turns the abalone over to consume it.

In small aquaria the abalone were often unable to escape from the starfish, because they soon encountered a corner of the tank, and this allowed the starfish to attack a second time while they were moving rapidly. Observations in larger aquaria suggest that where the abalone can outdistance the starfish or reach a crevice, they escape.

These results suggest that abalone become susceptible to predation by *Coscinasterias* only occasionally on most reefs, but if there are large numbers of starfish on the reef and mussels become scarce the starfish may form dense aggregations in areas with abalone such that an abalone escaping from one starfish may run into a second, and be caught because they do not have a firm grip on the substratum. This hypothesis remains speculative because we have not yet observed a "switching event" in which the starfish begin feeding on abalone.

"Switching events" appear to be rare. We have been monitoring the size and density of mussels and the starfish feeding on Sticks Reef and a reef offshore from Point Cook. The abalone have not been subjected to large scale predation since 1986. In the intervening years the new yearclass of mussels appears to have become established while there are larger mussels still present, and the starfish have a reduced feeding rate in the first half of the year.

While we have shown that serious depletion of abalone stocks will only occur infrequently on some reefs, such depletion of both adult and juvenile abalone may result in severely reduced abalone harvests from that reef for many years, as juvenile recruitment to a reef appears to depend on local stocks of adults. There has been some migration of adult abalone onto Sticks Reef, to the extent that small commercial harvests have been possible, but the loss in potential production appears to have been substantial.

Abalone divers may be able to avoid such losses in the future by monitoring the recruitment of smaller mussels to offshore reefs early in each year. It is when the recruitment fails, and all the larger mussels are later consumed that predation on abalone may occur. If a proportion of the starfish are removed to lower the densities at this stage, extensive predation on abalone may be avoided. It should be emphasised however, that in most years the abalone stocks are not under threat.

Figure 1

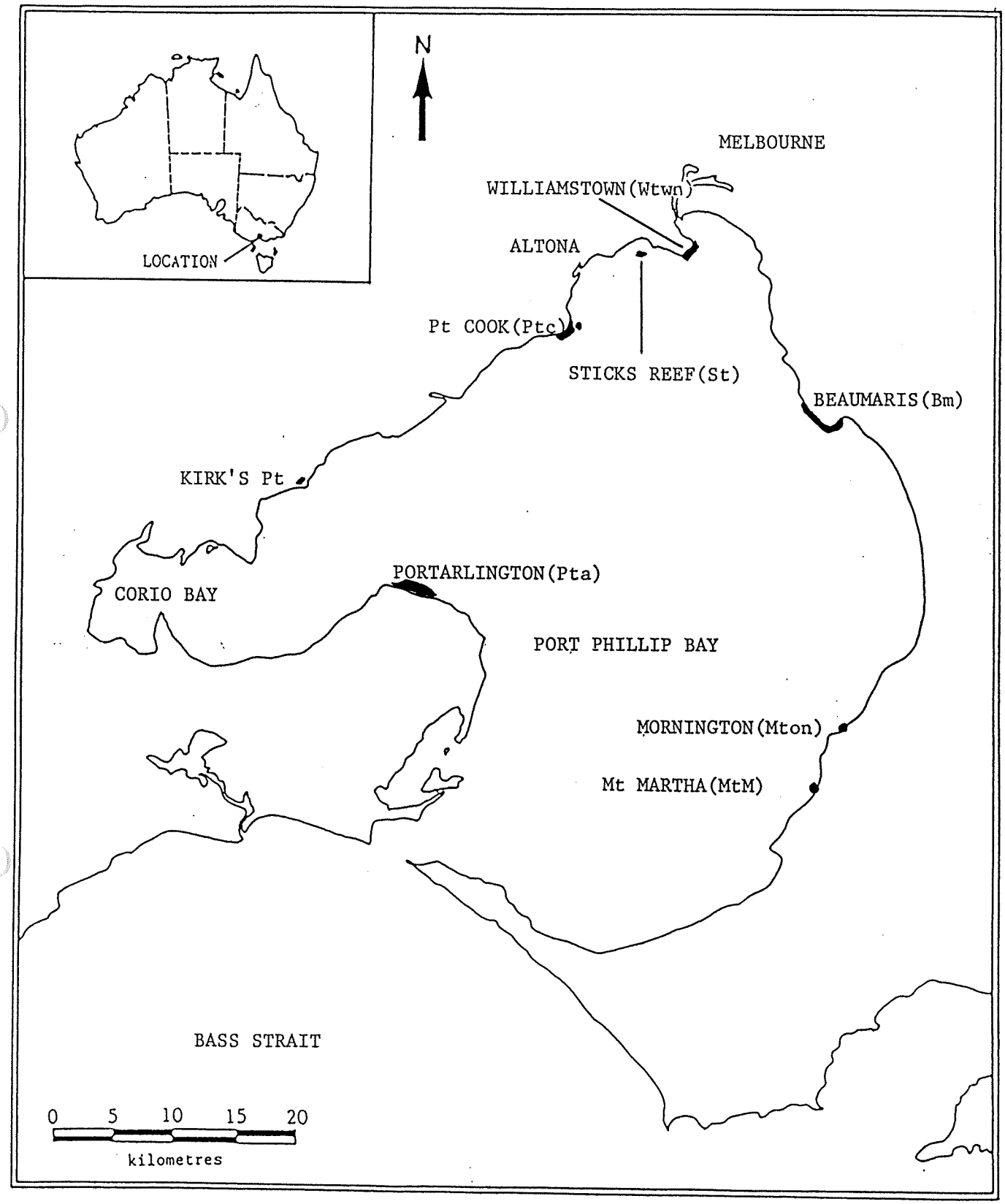
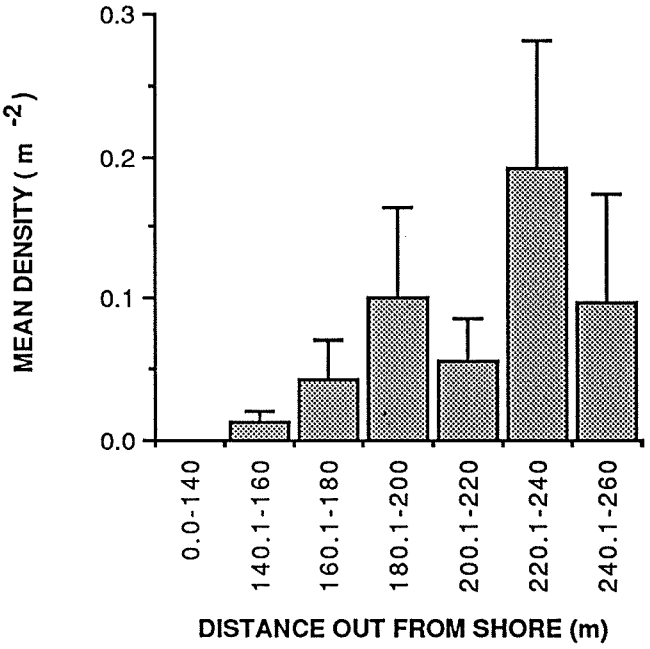
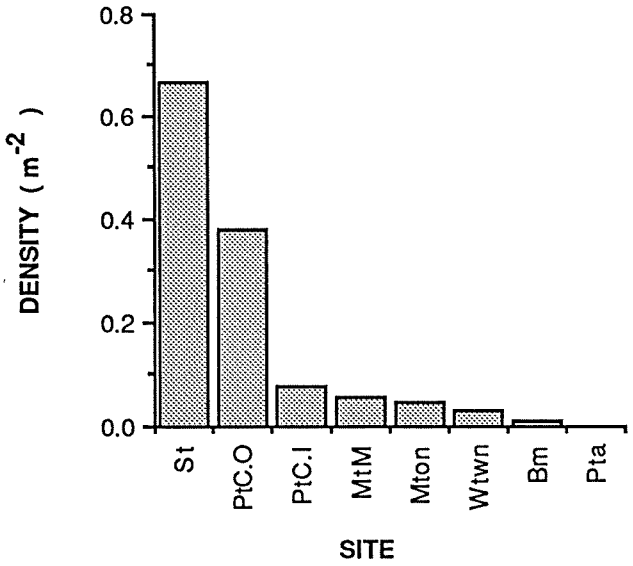

N
LOCATION
MELBOURNE
WILLIAMSTOWN (Wtwn)
ALTONA
Pt COOK (Ptc)
STICKS REEF (St)
BEAUMARIS (Bm)
KIRK'S Pt
PORTARLINGTON (Pta)
CORIO BAY
PORT PHILLIP BAY
MORNINGTON (Mton)
Mt MARTHA (MtM)
BASS STRAIT
0 5 10 15 20
kilometres

FIGURE 2.



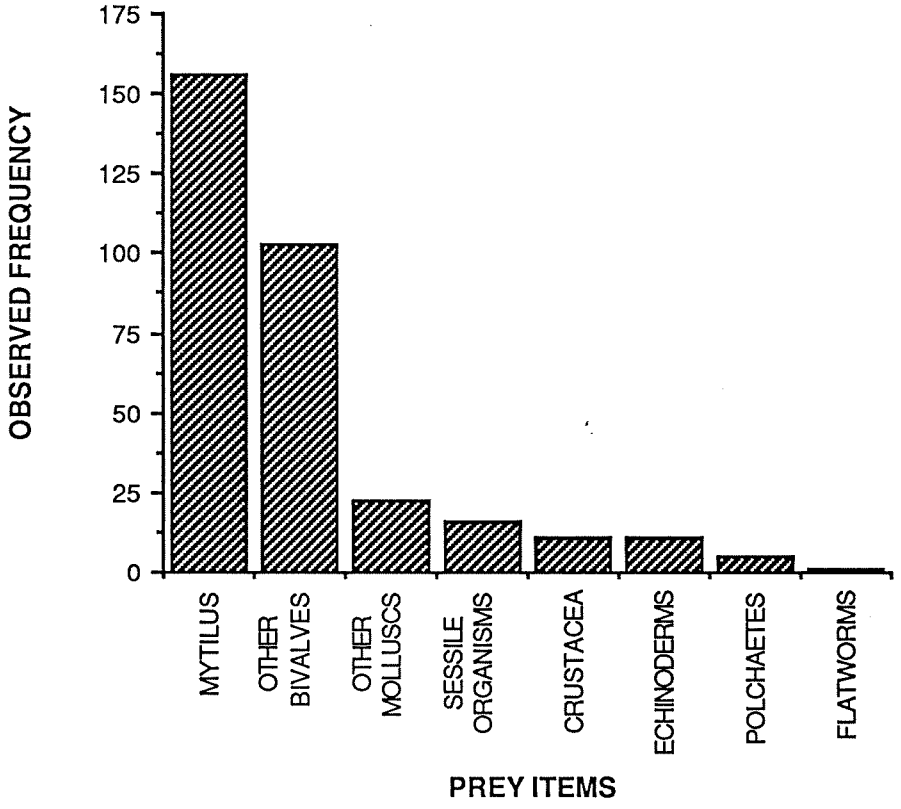
DENSITIES AT WILLIAMSTOWN OF COSCINASTERIAS.
SHOWING HOW MEAN DENSITY CHANGES WITH DISTANCE FROM SHORE (ERROR BARS =1 Std.Error)

FIGURE 3



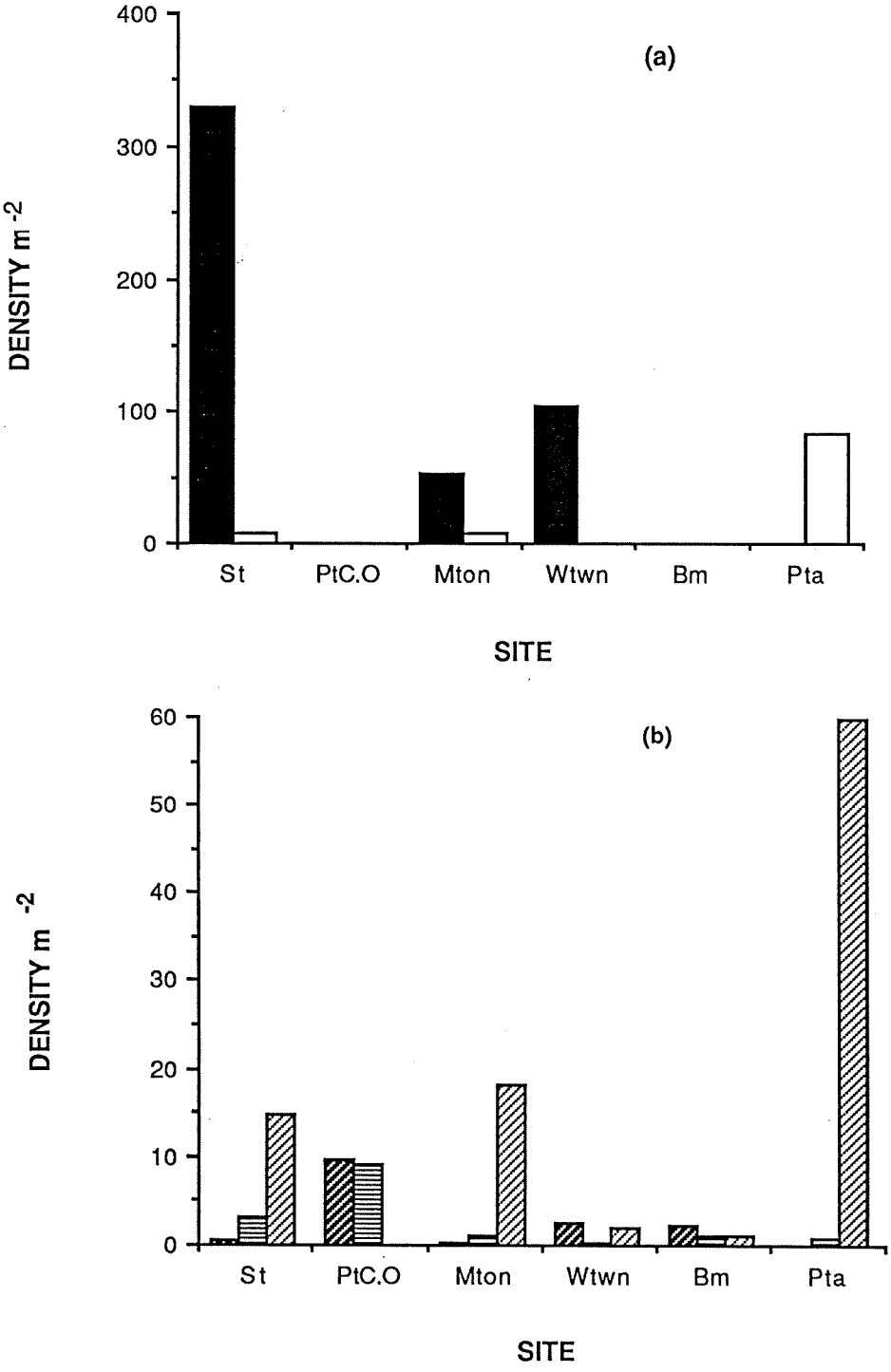
DENSITIES OF *C.calamaria* **AT EACH SITE SURVEYED. THE STICKS REEF DENSITY IS THE AVERAGE FOR 1986,87 AND 88.**

FIGURE 4



OBSERVED FREQUENCIES OF PREY EATEN BY COSCINASTERIAS FOR ALL SITES COMBINED.

Figure 5



RELATIVE ABUNDANCES OF PREY TYPES ON REEFS.

- MUSSELS
- OTHER BIVALVES
- ABALONE
- URCHINS
- SNAILS

FIGURE 6.

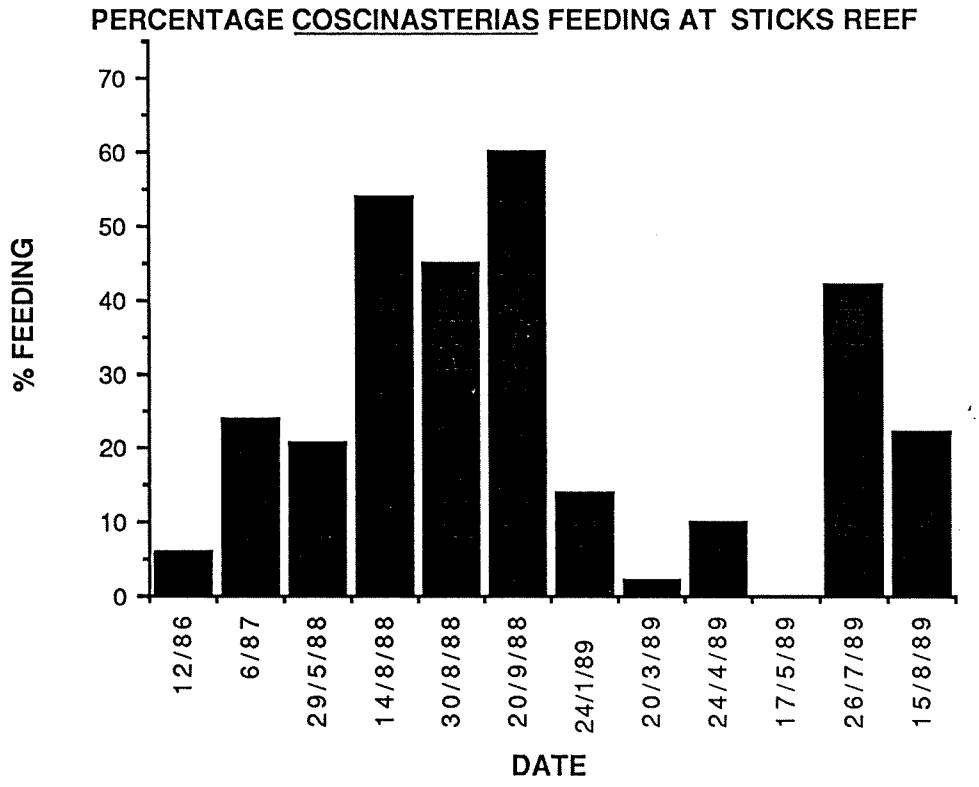
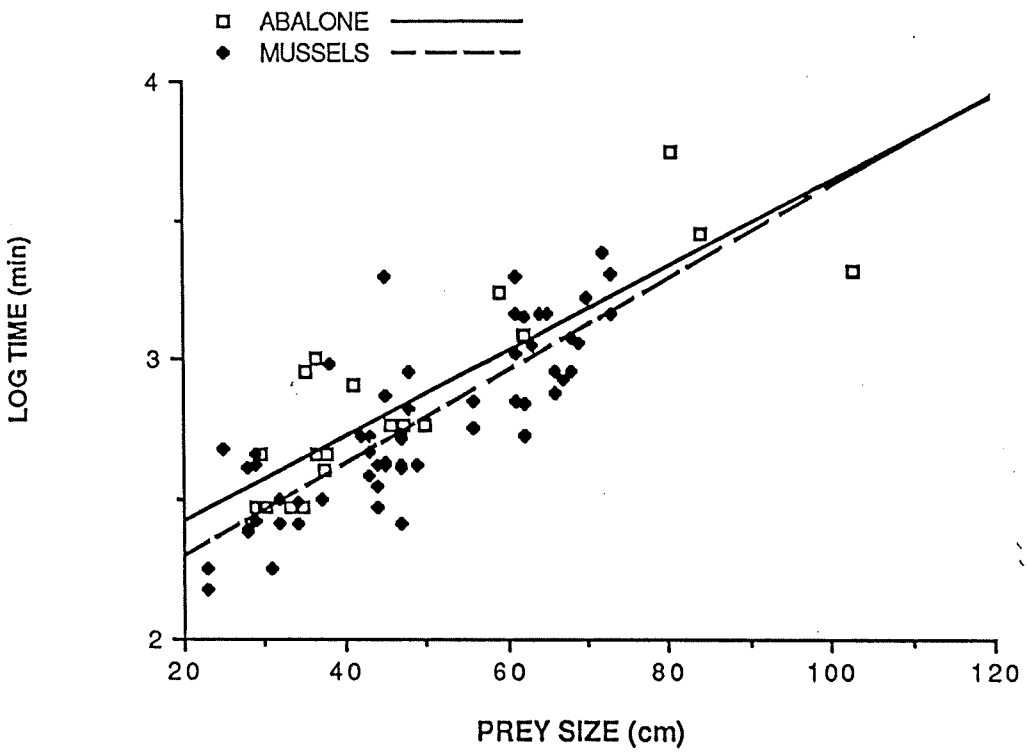

PERCENTAGE COSCINASTERIAS FEEDING AT STICKS REEF
% FEEDING
70
60
50
40
30
20
10
0
12/86
6/87
29/5/88
14/8/88
30/8/88
20/9/88
24/1/89
20/3/89
24/4/89
17/5/89
26/7/89
15/8/89
DATE

FIGURE 7



THE TIME REQUIRED BY COSCINASTERIAS TO FEED ON MUSSELS AND ABALONE IN LABORATORY EXPERIMENTS.