

Documentation of the *Tripectenites ventricosus*
Invasion into the Forereef and its Possible
Effects on the Community

Or...

good study and
excellent discussion
of results. Good
coverage of available
literature.

"Move over bud, there's a
new kid in town"

A study performed by
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and
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for the Biology FSP '91
- Discovery Bay Marine Lab
- Jamaica

two to five years, which seems related to increased wrasse densities, primarily *T. ventricosus*.

We also suggest several mechanisms by which *T. ventricosus* might have been excluded from the fore reef by *D. antillarum*, and why it has taken so long for *T. ventricosus* to colonize the fore reef.

①

(To Yo) Introduction:

Sea urchins are known to play a large role in the coral reef community. They are voracious eaters, and are documented to forage on such prey items as non-encrusting algae, encrusting algae, corals, detritus, and benthic zooplankton (Jangoux and Lawrence, 1982).

Until 1983, one of the most ubiquitous urchins in Caribbean reefs was Diadema antillarum (Lessios, 1988).

Other urchins such as Tripneustes ventricosus occurred at much lower densities (J. Woodley p.c.). In 1983, there was a massive die off of D. antillarum supposedly by a species specific, water born pathogen (Lessios, 1988).

Numbers of D. antillarum plummeted to less than one percent of their original populations in many areas (Hughes et al., 1986). Soon after 1983, an algal explosion

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occurred due to the absence of intense grazing by Diadema (Morrison, 1988; Hughes et al., 1986). Hughes documented increases of algal cover to ninety five percent-post die off as compared with twenty percent-pre die off. This kind of effect on algal growth was also documented by experimental removal of Diadema by Sammarco in 1974. In years following the die off, it did not seem that the densities of other urchins were increasing despite the empty niche and subsequently bountiful food resource. The event that our study is hinged upon, is that in 1991, for the first time ever experienced in the history of the Discovery Bay Marine Laboratory, there appeared to be a noticeable presence of T. ventricosus on the forereef (J. Gilbert, J. Woodley, pers. comm.). T. ventricosus was first documented on

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the fore reef by Doles and Walter (89 FSP), where

they found one in three hundred square meters of

transect work. In 1991, T. ventricosus was visually

obvious in the shallow fore reef, and extended in
some places down to fifty feet.

^{study}

The goal of our ~~experiment~~ was to document

this phenomenon in three ways. First we wanted

to perform a thorough survey of T. ventricosus

and D. antillarum on the fore reef to get a more

accurate idea of their abundances and distribution.

We included D. antillarum in our survey to further

document their post die off abundances, and to use

these abundances in proposing possible interspecific

relationships between T. ventricosus and D. antillarum.

Second, we realized that if T. ventricosus was

replacing the near empty niche left by *D. antillarum*,

then we would expect to see a continued negative effect on the algal abundances in the fore reef-

more urchins / less algae, as had been previously documented

(Doles & Walter, 1989 FSP; de Ruyter Van Stevenick and Breamen 1989

in Doles and Walter, 1989). To examine this, we wanted

to perform a survey of fleshy algae cover and *Lobophora variegata* cover in the fore reef. Then we would

compare the percentages we obtained to pre-Diadema

die off algal cover and immediately post-Diadema

die off algal cover to notice any trends occurring.

Third, we wanted to answer the question of why

Tripneustes has appeared on the fore reef in such

unprecedented numbers. Our foremost prediction

was that there had been a limited resource

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of food for which D. antillarum formerly outcompeted T. ventricosus and excluded them from the fore reef. To examine this, we would measure interspecific relations and reactions between D. antillarum and T. ventricosus for a limited food resource.

(To.) Methods:

The survey of T. ventricosus and D. antillarum was performed from February 27th to March 4th, 1991 at the location "M," on the fore reef in Discovery Bay, Jamaica, West Indies. Underwater buoys were set up directly south of M, toward the reef crest at depths of 30ft., 20ft., and 10ft. Five 10m x 2m transects were taken at each depth of 10, 15, 20, 25

⑥

and 30ft. The first transect at each depth was performed by placing the starting point (0) on the imaginary line created by the buoys, and running the transect west along the same depth contours. Random placement for ~~and~~ four successive transects was achieved by using random numbers generated from a calculator to indicate the starting point in meters from the end of the preceding transect, for the "second", "third", "fourth", and "fifth" transects, all along the same depth contours. (see appendix A). The transect itself was essentially a ten meter long rope tied down with weights to prevent underwater drift. Surveying was performed by running a two meter piece of pu. tubing, perpendicular to the rope (a meter on each side), down the length of the rope.

All *O. antillarum* and *T. ventracosus* that fell within the

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boundaries of the transect were recorded. In areas of complex coral structure, care was taken to look inside pits and under ledges.

The algae survey consisted of ten, 1m. long transects

at each depth of 10, 15, 20, 25, 30 30 meters. The

survey was performed in the same areas as the water

survey, west of the buoys. Two, metal meter sticks

were dropped from 10ft. above the floor at each depth,

and wherever the meter sticks landed was where the

surveys were taken. Percent cover of fleshy algae,

was derived by counting the number of centimeters of

meter stick that appeared over fleshy algae. Fleshy

algae refers to all 3-dimensional algae that was

non encrusting (eg L. variegatus, Dictyota sp., Sargassum sp., Haliplodes sp., etc.) The same process was repeated in counting

(3)

L. variegatus percent cover.

For future researchers, we will describe our laboratory experiments, although they were unsuccessful (see discussion). To test interspecific relations between

D. antillarum and T. ventricosus for a food source, we

set up twelve tanks in the Discovery Bay marine "wet"

Laboratory, Discovery Bay, Jamaica, W.I. We then collected

twelve D. antillarum and twelve T. ventricosus from the

fore reef at depths of fifteen to twenty feet. knowing

that L. variegatus is a common food source for both

urchins, we collected half a mesh "collecting" bag of

it from the blue hole. The urchins were placed, one

of each species, to a tank. In six of the tanks,

the D. antillarum was further enclosed by an upside

down large beaker, while the T. ventricosus roamed

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freely. In the other six tanks, the situation was

reversed with *T. ventricosus* being further enclosed,

while *D. antillarum* roamed freely. Lobophora clumps

were "rubber banded" to six inch diameter rocks and

placed "one" per each tank. Since *D. antillarum* feed

only at night, we created night conditions in the

tanks by covering them at six o'clock p.m. with black

plastic bags- to prevent extraneous incandescent or

fluorescent light from entering. The urchins were

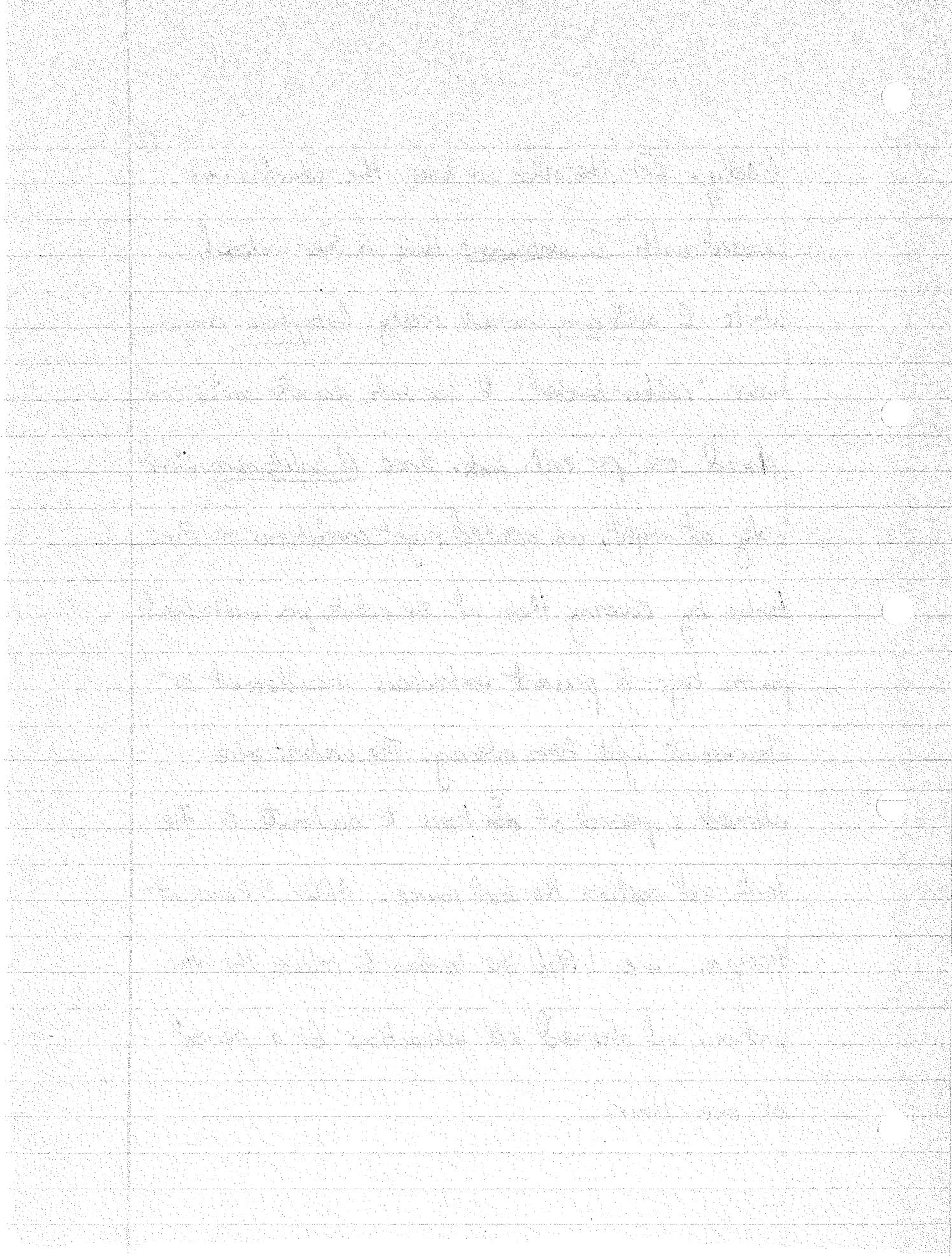
allowed a period of ~~3~~ hours to acclimate to the

tank and realize the food source. After 3 hours, at

9:00 p.m., we lifted the beadars to release the other

urchins, and observed all interactions for a period

of one-hour.



Results:
(E.g. T.Y.)

Results of urchin density surveys are in figure 1 and table 1. Including data from ten feet, there was not a significant correlation between either fleshy algae or Lobophora and urchin density ($r = -0.153$ and -0.176 respectively, $n = 52$, $p > .05$). However, excluding data for reasons to be explained in the discussion, % fleshy algae cover and % Lobophora cover are significantly negatively correlated with the combined urchin density ($r = -0.636$, $n = 41$, $p < .01$ and $r = .389$, $n = 41$, and $p < .05$, respectively (see figure 2)). Fleshy algae is significantly positively correlated with depth both with the ten foot data ($r = 0.834$, $n = 52$, $p < 0.01$) and without the ten foot data ($r = 0.694$, $n = 41$, $p < 0.01$). Lobophora variegata was significantly positively correlated with depth when including data at 10 feet ($r = .570$, $n = 52$, $p < .01$).

However there is not a significant correlation of L. variegata over depth when the data from ten feet is excluded ($r = .30, n = 41, p > .05$). Excluding ten feet, urchin density was negatively correlated with depth ($r = -.680, n = 20, p < 0.01$) (see figure 2). Current and past urchin densities are given in table 1, and current and past L. variegata and Fleshy algae % cover are given in tables 2 and 3 respectively. Raw data for algae % cover and urchin densities are in appendix B. (rough form)

Discussion (e)

It is undeniable that T. ventricosus has established a sizeable population off the west fore-reef at M1. It appears to now be the dominant sea urchin in the community. Its densities are currently several orders of magnitude greater than D. antillarum at most depths, except at 10' where the densities are equal, and 15' where T. ventricosus densities are 60% lower (Table 1). At 20' and 30', T. ventricosus densities are also more than 5 times D. antillarum densities of two years ago (Dales and Walter, 1989:158). Thus, in two years, this species of urchin has gone from being an uncommon resident, only 1/300 m⁻² (Dales + Walter, 1987:158), to what appears to be the most abundant urchin. In contrast, D. antillarum still appears

to not have recovered from the die-off in 1983 and April, 1990 (Hughes, et. al., 1987; J. D. Woodley, personal communication). In fact, D. antillarum densities are much lower at 10', 20', and 30' than they were just two years ago (Table I) (Dales and Walter, 1989 FSP).

It has often been documented that wrack density and grazing pressure has considerable effects on algae communities, particularly by limiting fleshy algal abundance (Hughes, et. al., 1987; Vangeneux, et. al., 1982; Lessios, 1985; Levitan, 1986; Morrison, 1986). Decreasing algae cover with decreasing depth has been attributed to variations in grazing pressure, by de Ruyter van Stevenich and Bremner, 1982 (in Dales and Walter, 89 FSP).

They also correlated decreasing L. variegata

cover to D. antillarum densities. We hypothesized that effects of increased I. ventricosus densities would manifest themselves through a similar negative correlation of algae % cover to wrack densities; and, that fleshy algae % cover would have decreased as a result of increased wrack densities, primarily of I. ventricosus. Within limits, our data support these hypotheses.

Our correlations show a significant decrease in algae cover with increasing wrack density, but only when we discount our algal and wrack survey data at 10'. We believe these omissions are justifiable for several reasons. It was obvious to us that a drastic habitat change occurs between 10' and the more similarly structured

Deeper depths. at 10', live corals were almost totally absent, as were large coral mounds and upright rubble. Sargassum sp. were the dominant plant type, and only token amounts of other fleshy algae were present. Wave surge was also considerably more noticeable here than at greater depths. Community structure at these other depths had a much wider diversity and greater abundance of algae, had lots of live corals of many species, and had a greater representation of other marine organisms such as sponges and gorgonians. These differences between 10 feet and the others surveyed depths lead us to conclude that the communities are subject to much different conditions and

pressures, and are thus not properly comparable in terms of algae cover and wrack densities. We suspect these differences may be due to higher wave surge dredging algae and killing coral, lack of damselfish to protect patches of macroalgae from overgrazing, and heavy herbivory from grazing fish (Morrison, 1988) whose juveniles are known to inhabit shallow waters (J. D. Woodley, personal communication). Although we cannot support this reasoning by firm documentation of actual differences, personal communications with lab director Dr. J. D. Woodley, and our own discussion lead us to believe these omissions are reasonable for our analyses.

It appears that *L. ventricosus* is

demonstrating an influence on the algae community of the fore-reef. In 1989, Dollo and Walter demonstrated that the % cover of L. variegata is negatively correlated with D. antillarum densities. With current D. antillarum densities down, there is still a negative correlation with overall wrasse density, and a similar correlation to T. ventricosus density. Table 2 illustrates that L. variegata % cover has declined at all depths since '89, which coincides with the increase in wrasse densities caused by the influx of T. ventricosus. Similarly, Table 3 shows that fleshy algae % cover has also gone down in the face of declining D. antillarum numbers and

increasing T. ventricosus abundance. Thus, these results support our hypothesis that T. ventricosus has joined, if not replaced, D. antillarum as an important player in determining algae abundance on the fore reef. This limiting of algae growth has important implications for the entire pre-reef community, such as for herbivorous fish populations (Morrison, 1988) and coral communities (Hughes, et.al., 1987).

Although it is often suggested that wrasse grazing is responsible for the density distribution patterns of algae (Dales and Walter, 1989; Kim FG 1987; de Ruyter van Stevenich and Breeman in 1987 in Dales and Walter, 1989) it must be noted that this is not necessarily the only influential factor. We found that fleshy algae cover and L. variegata

cover are also significantly correlated with depth. Wrasse density is also negatively correlated with depth. Thus, we are not able to definitely say what the causal relationships are. A multiple regression would help discern this, but we do not have that capability here at the lab. Other factors aside from wrasse activity which could be causing the aforementioned algae distributions could be light and competition factors (Vadas, et.al., 1982), wave action (J.P.D. J.P. Woodley, personal comm.), increasing damselfish territories at increasing depth (Merril, 1981 FSP), and fish herbivory patterns (Morrison, 1996). Nevertheless, in light of the fact that algae

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percent cover fluctuates markedly with changes in urchin densities (Hughes, et al., 1987), we believe grazing urchins, specifically *T. ventricosus*, are the most important factor affecting trends and changes in algae distribution and cover between 15° and 30°.

Once we established that *T. ventricosus* had indeed colonized the west fore reef, we wanted to know why, and how. Unfortunately we were unable to provide any answers to these questions through our own field and lab work. But, there are several likely explanations.

T. ventricosus and their close relative *T. antillarum* share many of the same resources (Miller, 1980 FSP; Jorgens and Lawrence, 1982). We've

(2)

shown that T. ventricosus are now having similar influences on the reef community as D. antillarum has had in the past. Therefore, the two species probably compete for limited resources. Thus, it seems most probable that the recent (1983) 95-100% reduction of the formerly highly dense D. antillarum populations (Hughes, et. al., 1985) has allowed T. ventricosus to colonize the fore-reef. We propose that D. antillarum had hitherto out-competed and excluded T. ventricosus.

Both interference and exploitative competition may have been the proximate mechanisms for T. ventricosus exclusion. Aggression over limited food, and predation on larvae and/or adult

I. ventricosus are two possible interference competition mechanisms. Liz Miller (FSP 1980) documented inter-specific aggression between these two species in the field. In nine of fourteen trials, D. antillarum aggressively responded to encounters with I. ventricosus. Pre-die off densities of D. antillarum were such that coral reefs were often nearly completely denuded of fleshy algae (Lessios, 1988). With food in scarce supply, it is quite possible that individuals would end up competing for this limited resource. Should D. antillarum be the more aggressive within, it could monopolize the food supply and thereby exclude I. ventricosus.

We attempted to document and

quantify such interspecific competition for limited food, but failed in the lab. We attribute the failure to the negatively geotactic nature of D. antillarum which resulted in their staying at the rim of their tanks (Hyman, 1955).

More importantly, in general the wrasses did not demonstrate any particular interest in feeding, although they did occasionally eat when placed in direct contact with the algae. This failure does not exclude the possibility that interspecific aggression occurs on the reef at high wrasse densities.

A second interference competition mechanism could be predation on I. ventricosus by D. antillarum. D. antillarum are known to be omnivorous, and will eat all types of benthic

and suspended invertebrates (Jongoux and Lawrence, 1982). Thus, it is quite possible that the small, free floating T. ventricosus larvae are preyed upon by D. antillarum. Incidentally, T. ventricosus seem to be strictly herbivorous (Jongoux and Lawrence, 1982) which would exclude them from preying on D. antillarum larvae. T. ventricosus spines have also been found in D. antillarum guts (Jongoux and Lawrence, 1982) which suggests possible predation on T. ventricosus, or aggressive interspecific interactions. Though, it could be that these spines were ingested accidentally.

Another strong possibility for how T. ventricosus might be excluded from high

D. antillarum density region is exploitative competition for food. D. antillarum is known to seriously denude substrate, reducing fleshy algae cover to as low as 1% in areas capable of supporting 95% cover (Lessios, 1988). While D. antillarum can survive on extremely wide variety of plant and animal matter, I. ventricosus has a much more limited diet which is generally restricted to fleshy algae and grasses (Jemgoux and Lawrence, 1982). Thus, this exploitation and limitation of suitable food for I. ventricosus by D. antillarum seems to be a very strong possible cause for I. ventricosus exclusion. It is interesting to note that currently both species are

found to be existing sympatrically, though their maximum densities are at different depths (Figure 1).

If it is true that I. ventricosus have only now been able to survive on the fore-reef because of the drop in P. antennatum densities, the question that remains is: why has it taken I. ventricosus so long to colonize the fore reef? Although the die-off occurred in 1983, it was not until after 1989 that I. ventricosus appeared in considerable numbers. Again, we propose several explanations, but have no personal experimental evidence to support them.

There is generally only one peak spawning season for I. ventricosus, which occurs in March

Recruitment of *T. v.* larvae to Discovery Bay fore-reef probably is unrelated to density of adults there (17) since larvae would be dispersed from elsewhere.

on April (Hyman, 1955). This would mean that

there would have only effectively been seven

major reproductive events since the 1983 die-off. Free floating larvae would have to

cross over the reef crest from the pre-existing

T. ventricosus population of the back-reef, against

the prevailing currents, to reach the

fore reef. It is possible that successful

migration is a rare occurrence. Should

some successfully establish there, it

seems unlikely they would experience much

reproductive success while densities were

low (Lessios, 1988). Urchins must be able to find

other urchins to mate with because they

are dioecious (Hyman 1955). If only a few larvae

establish per year, it could be several years

before the densities on the fore reef reach such a level where T. ventricosus encounter one another often enough to produce larvae on the site. A lack of small T. ventricosus on the fore reef now, despite low D. altilatum densities, suggests that perhaps larval mortality is usually high, and thus recruitment slow (Sal Converse, east-West Program, personal communication). Finally, if the colonization occurred not by larvae but by migration of adults, it could conceivably take within a long time to work their way from the back reef over or around the reef crest to the fore reef.

It is uncertain what these workers

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distribution and density patterns will be like in the future. Perhaps if D. antillarum rebound, T. ventricosus will again be excluded from the fore reef. It also might be possible that T. ventricosus will be able to survive at deeper depths, now that they have accessed them, in spite of increasing D. antillarum densities. Our reasoning is that it is known that D. antillarum densities decrease with depth (Dale & Walter, 1989), and that when placed at depth will walk back up to shallower water (Woodley, pers. comm.). Why this is so is not fully understood. One possible reason is that D. antillarum could be subject to greater numbers of attacks from

(30)

Damsel fish at greater depths. Damsel fish density increases with depth (Merril, 1991 FSP)

Because D. antillarum suffer more severe attacks from damsel fish than I. ventricosus and other wrasses (Shane and Zimmer, 1984 FSP; Williams, 1979), perhaps I. ventricosus will tolerate life at depths deeper than D. antillarum because they aren't subjected to as severe damsel fish attacks. A third scenario is that D. antillarum will never achieve its pre-die off densities, and the two species will continue to co-exist.

We have documented here that I. ventricosus has now colonized the fore reef for the first time in the history of the marine lab; and, they seem to be having a similar effect on algae cover as D. antillarum.

have in the past. We have suggested several mechanisms for how and why *T. ventricosus* might have been excluded, and how it has been able to colonize them. We strongly recommend that further studies be documented to support or refute these hypotheses, and that these wren populations be monitored in the future to see what the outcome of the recent colonization will be.

Table 1 : urchin densities at depths (present + past) (32)

(T.Y.)

	10'	15'	20'	25'	30'
(Gilmartin + Young '91) <u># Tripneustes/m²</u>	.01 ± .02	.52 ± .11	.82 ± .82	.19 ± .13	.16 ± .10
(Gilmartin + Young '91) <u># Quadrat/m²</u>	.01 ± .02	1.32 ± .81	.03 ± .07	0	0
(Walter + Odles '87) <u># Diadema/m²</u>	.18	-	.16	-	.02

Table 2 : Lobophora % cover at depths (present + past)

Lobophora % cover	10'	15'	20'	25'	30'
(Kimm '87)	-	-	12	-	33
(Branstrator + McBride) 189	.24	-	31.67	-	51.40
(Gilmartin + Young '91)	1.14 ± 2.95 n=11	7.54 ± 5.62 n=10	27.55 ± 12.83 n=10	25.95 ± 14.78 n=10	20.46 ± 10.60 n=11

Table 3 : Fleshy algae % cover at depths (present + past)

Fleshy algae % cover	10'	15'	20'	25'	30'
Pre Die off: (Carpenter in Hughes '87)	22	-	-	-	40
Post Die off: (Hughes '87)	95	-	-	-	94
Present: (Gilmartin + Young '91)	17 ± 16.43 n=11	38.20 ± 20.45 n=10	62 ± 8.58 n=10	77.7 ± 14.29 n=10	76.71 ± 13.03 n=10

Figure 1 Urchin density vs. Depth at M₁

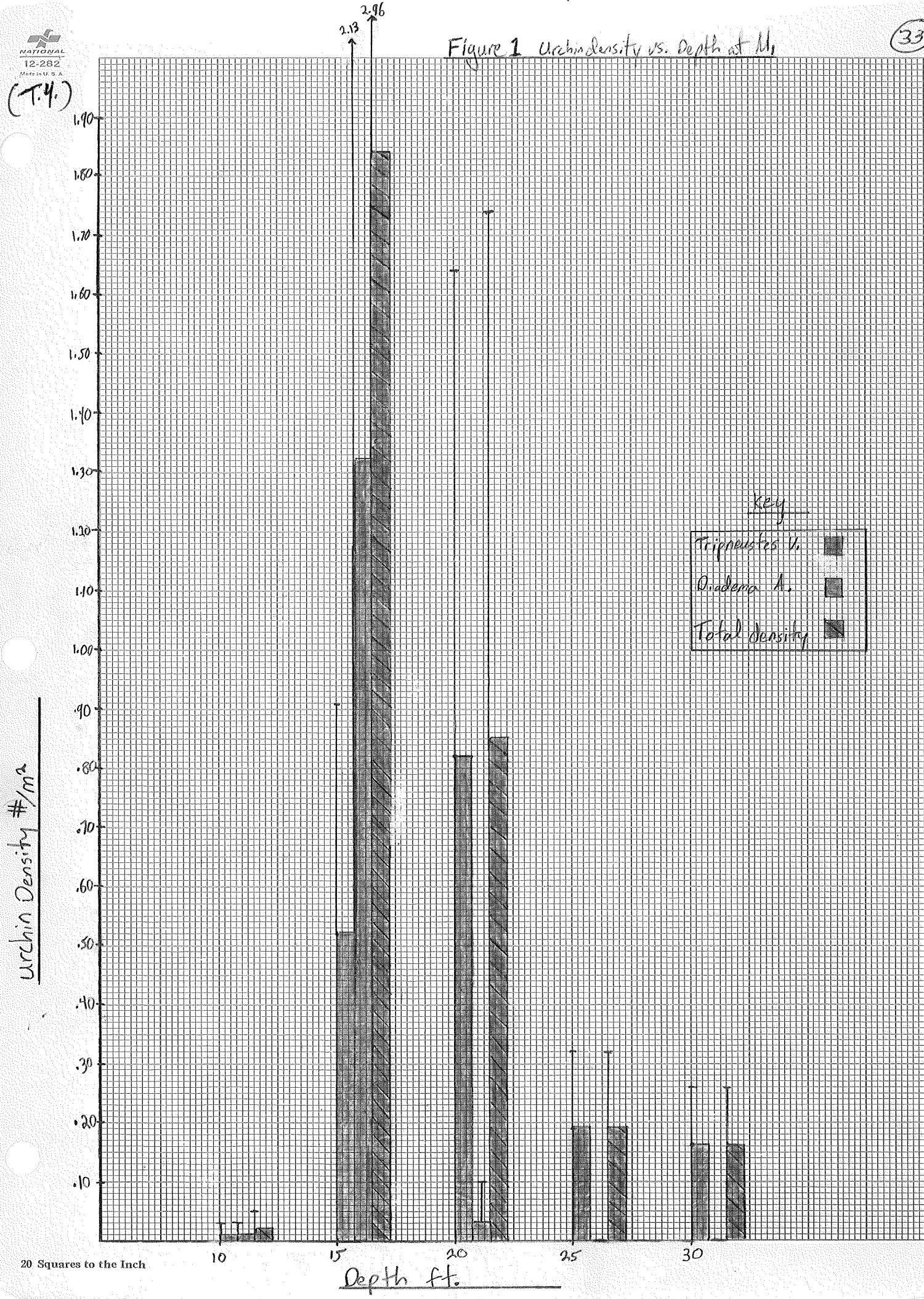
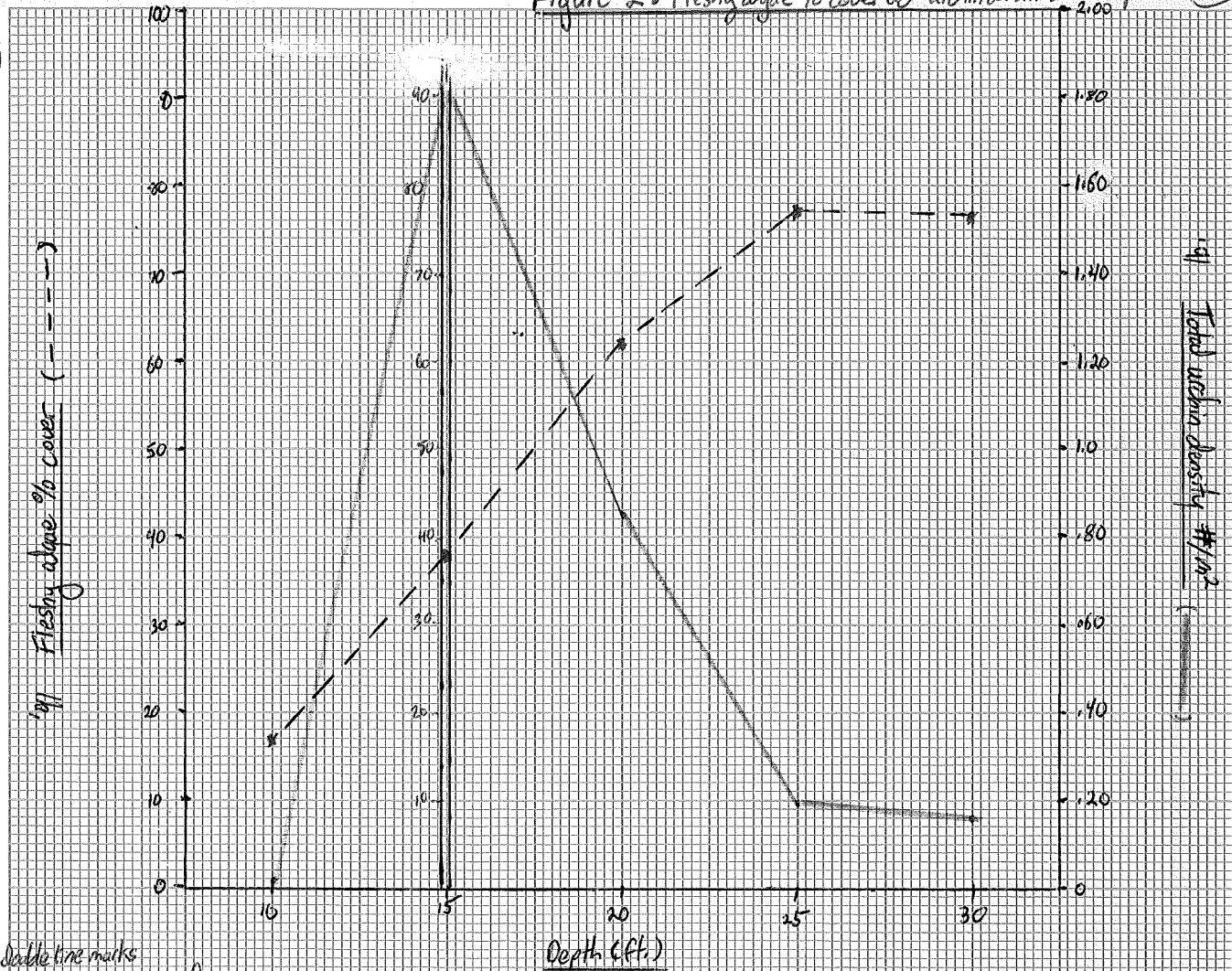
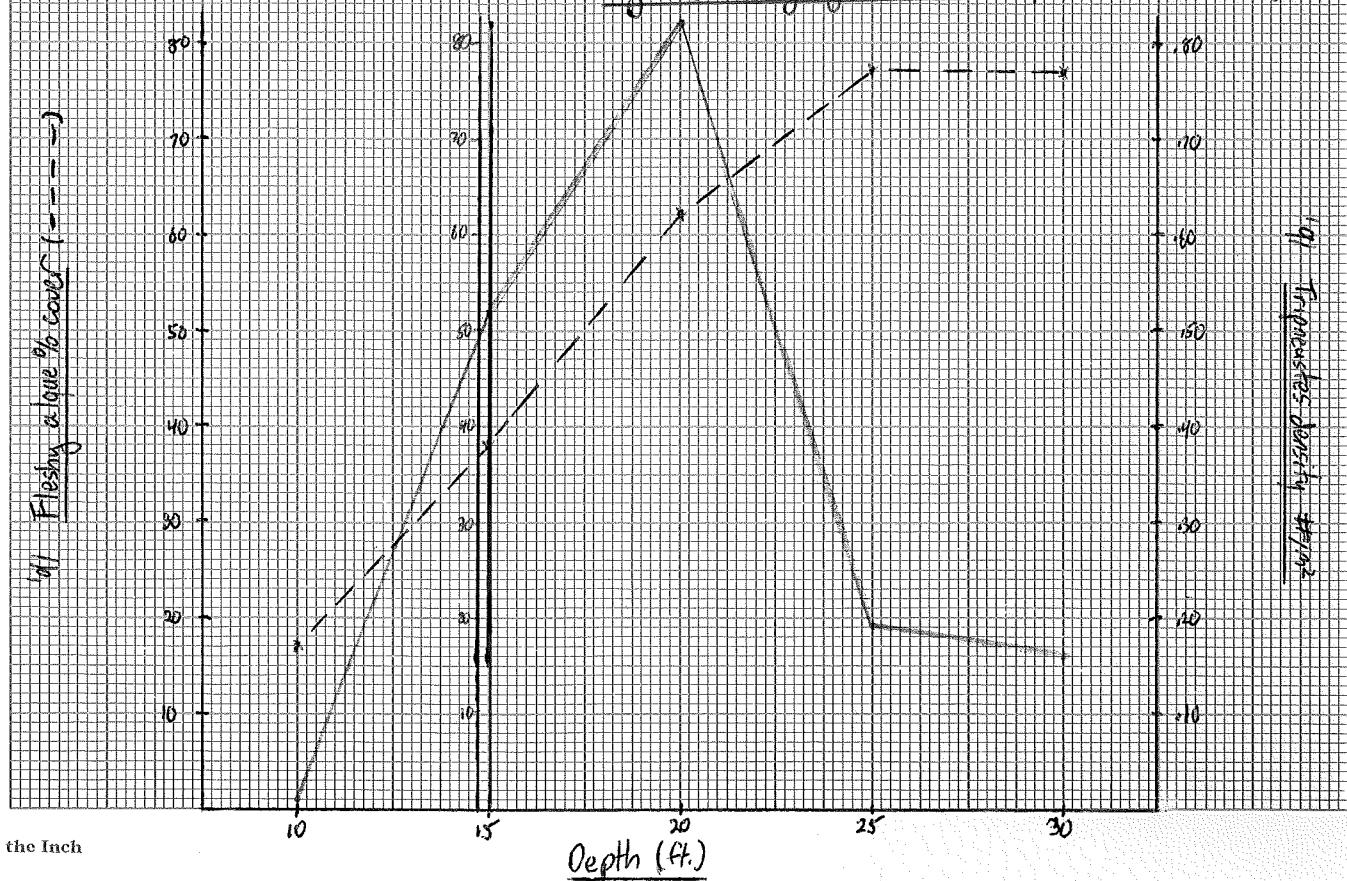


Figure 2: Fleshy algae % covered and wrack densities at depths (34)



notes blue double line marks
graph if soft data is removed

Figure 3: Fleshy algae % cover and Tripponectes densities over depths



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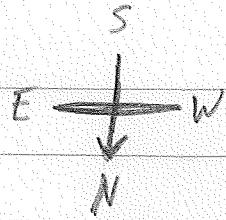
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 (FSP, 89)

Morril '81 - FSP Damselfish study

Back reef



reef crest

5ft.

10ft.

15ft.

20ft.

25ft.

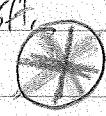
30ft.

35ft.

40ft.

45ft.

fore reef

M₁

note: first transects at each
depth along the invisible line !

- other transects are randomly
placed along each depth

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Appendix AB (page 1 of 2)

Algae Cover

<u>10'</u>	<u>15'</u>	<u>20'</u>	<u>25'</u>	<u>30'</u>
<u>Lob.</u> , <u>Fleshy</u>	<u>L.</u> , <u>F.</u>	<u>L.</u> , <u>F.</u>	<u>L.</u> , <u>F.</u>	<u>L.</u> , <u>F.</u>
7.5 27	13 80	53.5 65	29 65	23 75
0 26	11 50	32 67	54 94	17 90
0 13	1 10	37 75	10 61	24 87
0 6	9 42	12 64	40.5 84	38.5 85
0 27	15.4 57	13.5 59	42 83	24.5 80
0 41	4 20	15.5 58	18 87	23.5 60
0 6	14 35	31 67	20 100	23.5 82
3 3	4 37	33 68	16 60	7 65
0 20	0 20	30 50	13 75	6 50
0 16	4 32	18 47	17 68	6 85
2 2	$s=5.62$, $\bar{x}=38.30$	$\bar{x}=27.55$, $s=12.93$	$x=6.2$, $s=8.58$	$x=25.25$, $s=14.78$
			$s=14.03$	$s=14.03$
				$\bar{x}=30.96$, $s=76.91$

$\bar{x} = 1.14$

$s = 2.35$

$n = 11$

Compare our data to previous #'s (Skelton, Kim, & Hughes) $\bar{x}=10.6$, $s=13.03$

Fleshy vs. Ave. Within Dens.; Lob. vs. Ave. Within Dens.,

Lob. vs. Fleshy vs. Depth, Lob. vs. Dens. By Graph. Lob. & Fleshy vs. Depth
Within #'s (Density) (Regression, -?)

<u>10'</u>			<u>15'</u>			<u>20'</u>			<u>25'</u>		
T.	D.	Total	T.	D.	Total	T.	D.	Total	T.	D.	Total
0(0)	0(0)	0(0)	6	8	14	45	3	48	5	0	5
1(05)	0(0)	1(05)	5	36	41	9	0	9	0	0	0
0(0)	0(0)	0(0)	24	49	73	4	0	4	7	0	7
$\bar{x}=0(0)$	$1(05)$	$1(05)$	5	23	28	9	0	9	3	0	3
$s=.01$	$0(0)$	$0(0)$	12	16	28	15	0	15	4	0	4
$s=.02$											
<u>30'</u>	$\bar{x}=0(0)$	$s=.02$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$
T.	D.	Total									
2	0	2									
6	0	6									
3	0	3									
$\bar{x}=0(0)$	$0(0)$	$s=.02$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$
$s=.06$	$0(0)$	$s=.04$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$	$s=.03$	$\bar{x}=0(0)$
1	0	1									
4	0	4									

Bot graph of Density vs. depth (m^2/m^3)

Compare to old D. densities

(Table + Bot graph vs. '84)

T vs. D correlation

	$\bar{x} = 6.7$	$\bar{x} = 42$	$\bar{x} = 44.1$	$\bar{x} = 33.4$	$\bar{x} = 26.6$
	$\frac{10}{27.8} = 20.71$	$\frac{15}{16.3} = 10$	$\frac{20}{82.3} = 10$	$\frac{25}{44.6} = 30.7$	$\frac{30}{30.7} = 26.6$
01	0	22	47.8	57.5	18.9
	0	10	49.3	16.4	27.6
	0	21.4	18.8	48.2	<u>45.3</u>
	0	27	22.9	50.6	30.6
	100	30	26.7	20.7	.16
	0	40	46.3	30	39.1
	0	10.8	49.5	26.7	28.7
	100	0	60	17.3	10.8
		12.5	38.3	25	12
					7.1
					36.8

W. M. H. 10/10/08

(Appendix B (p. 2 of 2))

URCHINS

10'

T.	D.	Tot.	T.	D.	Tot.
\bar{x}	.01	.01	.52	1.32	1.84
S.D.	.02	.02	.41	.81	1.12

(n=5)

20' 15'30'

T.	D.	Tot.
.82	.03	.85
.82	.07	.89

25'

T.	D.	Tot.
.19	0	.19
.12	0	.13

30'

T.	D.	Tot.
.16	0	.16
.10	0	.10

ALGAE

L.	F.	L.	F.	L.	F.	L.	F.	L.	F.	
\bar{x}	1.14	17	7.54	38.30	27.55	62	25.95	77.7	20.46	76.91
S.	2.35	16.43	5.62	20.45	12.93	8.58	14.78	14.03	18.6	13.03
n	11	4	10	10	10	10	10	10	11	11

 \bar{x} Lob/Flesh

10' 15' 20' 25' 30'

89.6.7% 9.7 44.4 33.4 26.6

~~F = 6.96, p < .05~~

F = 0.152 n = 57

p < .05 df = 59



F = .233

F^2 = .054

n = 52

df = 50

P > .05