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SEAGRASS AND *CAULERPA* MONITORING IN HILLSBOROUGH BAY
FIFTH ANNUAL REPORT

SUBMITTED TO

THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

TAMPA OFFICE

MARCH 1, 1994

CITY OF TAMPA

DEPARTMENT OF SANITARY SEWERS

BAY STUDY GROUP

EXECUTIVE SUMMARY

The City of Tampa, Bay Study Group has been monitoring water quality in Hillsborough Bay since 1976 and has documented improvements in several water quality parameters since the early 1980's. The improvements in water quality was followed by the emergence of shoalgrass, Halodule wrightii, in several areas of Hillsborough Bay.

The Bay Study Group began a monitoring program in 1986 of the seagrasses H. wrightii and Ruppia maritima, and the alga, Caulerpa prolifera. The purpose of the study was to monitor changes in seagrass coverage, because seagrass may serve as an indicator of water quality. However, the study is not intended to link the discharge from the Hookers Point Advanced Wastewater Treatment Plant with changes in the seagrass community. H. wrightii baywide areal coverage was about 0.2 hectares (ha) in the initial survey in 1986 and has now increased to about 11ha. Coverage for R. maritima has fluctuated between 0.2ha and 2.2ha since 1986.In 1993, R. maritima coverage in Hillsborough Bay was 1.7ha. C. prolifera coverage has varied greatly over the study period. After reaching maximum coverage of 220ha in 1986, C. prolifera meadows were reduced nearly an order of magnitude following a "25 year" rainfall event in 1988. C. prolifera coverage was 55ha in 1993.

The Bay Study Group transplanted about 13m^2 of H. wrightii into Hillsborough Bay in 1987 and the transplanted material attained coverage of nearly 1200m^2 in 1992. However, coverage in 1993 was reported at just over 600m^2, although this apparent reduction is not due to a large loss of transplanted material. Several transplants coalesced with with naturally occurring H. wrightii and were not included as transplant coverage. Transplanted H. wrightii helped to identify areas of Hillsborough Bay suitable for seagrass growth and has provided source material for recolonization.

Seagrass recolonization occurring in the intertidal and subtidal areas of Hillsborough Bay apparently is a result of increased water clarity.

INTRODUCTION

The City of Tampa, Bay Study Group (BSG), created in 1976, has monitored the effects of pollution abatement in Hillsborough Bay since 1979. Within the last decade, water quality improvements and evidence of minor seagrass revegetation in Hillsborough Bay prompted the BSG to initiate a seagrass study to compliment other programs assessing the environmental status of Hillsborough Bay.

Documentation of natural seagrass coverage began in April 1986 with a thorough groundtruthing effort which located and described Halodule wrightii, Ruppia maritima and the attached benthic alga, Caulerpa prolifera. Four additional intensive groundtruthing efforts to document H. wrightii were completed in October 1989, October 1991, October 1992, and October 1993. In addition, study sites have been established for H. wrightii and C. prolifera. Generally, these sites are monitored three times a year.

The BSG, in cooperation with the FDNR and the NMFS Tampa Bay Experimental Seagrass Planting Effort, has also been involved in two transplantings of seagrass into Hillsborough Bay. The first transplanting effort occurred during June and July of 1987 utilizing H. wrightii source material from the Courtney Campbell road widening project. About 900 H. wrightii "bare root" units were planted in an intertidal area adjacent to western Interbay Peninsula. In addition, nearly 350 H. wrightii "sod blocks" were planted in seven areas of Hillsborough Bay also using the Courtney Campbell source material. The second transplanting effort occurred in May 1989 and utilized source material from Port Manatee. Two 10x20m subtidal plots were planted in Hillsborough Bay with H. wrightii and Syringodium filiforme "sod blocks." Both efforts were designed to locate areas of Hillsborough Bay suitable for seagrass transplanting, to establish a source of vegetative material, and to determine if artificially introduced seagrass could generate functional seagrass communities.

The purpose of the BSG seagrass study is to monitor changes of seagrass coverage in Hillsborough Bay. Seagrass is an important Tampa Bay habitat and may serve as an indicator of water quality. The seagrass program is not intended to link the discharge from the Hookers Point Advanced Wastewater Treatment Plant with changes in the seagrass community.

This is the fifth annual report to FDEP to satisfy the requirements set forth in specific condition #14 of FDEP operation permit D029-1845321B.

METHODS

The report by the BSG, "An Ongoing Survey of Halodule wrightii, Ruppia maritima, and the Alga, Caulerpa prolifera in Hillsborough Bay, Florida: Initial Assessment and Design" describes study site locations and experimental design for the naturally occurring seagrass and C. prolifera projects through the 1991 spring survey. It does not, however, contain project modifications made after the 1991 spring survey or any seagrass transplanting information. Therefore, recent modifications to the natural seagrass and C. prolifera projects and of the seagrass transplanting methods are included below.

MODIFICATION OF PROJECT DESIGN

Halodule wrightii (Study Sites)

Determination of seagrass areal coverage utilizing low altitude (<500 feet) aerial photographs was evaluated in the spring of 1991. A study site in northwestern Hillsborough Bay was expanded from the original 7x7m grid to a 30x40m rectangle. On the morning prior to a monthly helicopter photographic survey, a white 60cm disk was placed at each corner of the rectangle. Five nearly vertical photographs were taken of the study area. Seagrass coverage from each photograph was determined by planimetry using the 30x40m rectangle as a scale. Only seagrass coverage continuous into the original 7x7m grid was assessed as study site coverage.

Similarly, areal estimates of seagrass at each study site were determined using low altitude aerial photographs for all surveys following the survey conducted in the summer of 1991 (survey 15). Expanded grids, comparable to the one described above, were used to estimate seagrass coverage at the study site. Generally, areal coverage was determined from a minimum of three photographs of each site. Each site was visited within a week of the overflight to collect data concerning short shoot density, blade length, blades per short shoot, and epiphytic cover.

In 1990 and 1992, estimates of seagrass areal coverage using on site measurements versus aerial photography were compared. One site was used in 1990 and five sites in 1992. Each on site assessment was completed within two weeks of the aerial photography.

Halodule wrightii (Baywide Survey)

In the 1991 baywide survey, seagrass coverage in the northeastern and western areas of Hillsborough Bay was estimated from field measurements of each patch. However, due to the large increase of seagrass patches in southeastern Hillsborough Bay, low altitude aerial photography was utilized for patch counts. Ten patches were measured in the field to determine an "average patch size." The average patch size was multiplied by the patch count to yield an areal estimate of the seagrass in this section of the bay.

In the 1992 and 1993 surveys, seagrass coverage was determined in the northeastern area and most of the western area of Hillsborough Bay by making field measurements of each patch. However, in one portion of western Hillsborough Bay, just south of Ballast Point, and in southeastern Hillsborough Bay, low altitude aerial photographs were used to determine seagrass coverage. A scale for distance was determined for each photograph using landmarks or reference points placed in the field prior to overflights. Seagrass coverage was estimated by calculating the percent seagrass coverage of a grid placed over each photograph.

Halodule wrightii (1994 modifications)

As discussed above, revisions in the BSG seagrass program have been necessary due to the changes in seagrass coverage in Hillsborough Bay. In 1994, further modifications will eliminate seasonal areal coverage determinations for study sites. Instead, the intertidal and subtidal shelf to a depth of two meters will be subdivided into about twenty sections and annual areal coverage will be reported for each section. Areal coverage will be estimated from high altitude (ca. 6,000 feet), near vertical, photographs taken in the fall from fix winged aircraft. All subdivisions will be groundtruthed within four weeks of the overflight. Monthly low altitude helicopter overflights will continue in order to follow developments which may be overlooked in an annual assessment.

Seasonal visits to study sites will continue in order to acquire ancillary information concerning short shoot density, blade length, and epiphytic cover. Further, additional study sites will be established in a range of depths in each subdivision.

Determination of areal coverage for transplanted H. wrightii will discontinue after 1993. Transplants have begun to coalesce with other expanding patches of H. wrightii making delineation of the transplant boundary infeasible. However, one or more transplants may be retained as study sites.

The Tampa Bay National Estuary Program has proposed to establish ten transects in Hillsborough Bay in order to evaluate seagrass coverage. Transects would be oriented perpendicular to shore and run from the shoreline to just outside the two meter depth contour. Five transects would traverse areas containing submerged aquatic vegetation and five transects would cover bay bottom barren of vegetation. The BSG may be responsible for data collection and, if so, the data from the ten transects would be included in future annual reports to the DEP.

Caulerpa prolifera

C. prolifera transects have been modified from a five meter wide transect to a one meter wide transect. Two one square meter quadrats are randomly selected every twenty meters for detailed study. Baywide coverage was estimated from methods similar to those used to calculate the 1993 seagrass coverage.

Ruppia maritima

The single R. maritima study site, M-2 was discontinued in 1992, instead, the current program generates baywide information of this seagrass in Hillsborough Bay. Areas containing R. maritima coverage are assessed using low level aerial photography and maximum annual areal coverage will be estimated from the same used method to determine H. wrightii and C. prolifera coverage. These areas are visited in spring, summer, and fall and random patches are selected for evaluation of short shoot density, blade length, blades per short shoot, and epiphytic cover.

STUDY SITE LOCATIONS AND SURVEY TIMES

Study site locations for natural H. wrightii, transplanted seagrass and C. prolifera are shown in Figures 1, 2, and 3 respectively. Study sites are visited each year during the spring, summer, and fall, with the initial assessment (survey 1) conducted in the fall 1986 and the most recent assessment (survey 22) conducted in the fall 1993.

Only the eight natural H. wrightii study sites were visited in surveys 1 and 2. All subsequent surveys, except survey 15, involved the evaluation of both natural and transplanted seagrasses. Only transplanted seagrasses were measured in survey 15.

In the survey 11, the PVC poles delineating study site K-2 were missing and the site was not located. An alternate site, K-6, was selected in the same area. In survey 12, one PVC pole at the K-2 site was found and the site was reconstructed for continued analysis.

Areal coverage of four study sites was not determined in survey 16. Two sites did not have sufficient short shoot density to define seagrass coverage from aerial photographs. The other two sites were not included in the fall photographic assessments due to time constraints.

TRANSPLANT METHODS

Sod Block

H. wrightii "sod block" and "bare root" units were used in the initial transplanting effort during June and July of 1987. Approximately 350 pieces of sod removed from the Courtney Campbell area were planted at seven areas around Hillsborough Bay.

Areas 2 through 7 (Figure 2) were planted at predetermined elevations at various locations in Hillsborough Bay. Each area contained sod planting sites spaced 50m apart in transects following the shoreline. Transect lengths ranged from 100 to 1675m. Each sod planting site consisted of two "sod blocks" planted 1m from a PVC pole. At each site, "sod blocks" were placed on opposite sides of the pole. The average sod measured 14x23x15cm and contained 170 short shoots and 23 apical meristems.

Four, parallel, 1000m transects were planted in Area 1 (Figure 4) using the same method described for Areas 2 through 7. Area 1 transects, however, were not planted at predetermined elevations and were oriented in a north to south direction.

Two additional 10x20m plots were planted in the Kitchen area (Figure 4), in May 1989, using source material from Port Manatee. One plot was planted with H. wrightii and the other plot was planted with S. filiforme. The location for these plots appeared suitable for transplants based on the results from the 1987 plantings. Each monospecific plot contained 66 "sod blocks" planted on 2m centers. The average H. wrightii sod measured 15x24x15cm and contained 129 short shoots and 21 apical meristems. The average S. filiforme sod measured 18x25X15cm and contained 110 short shoots and 10 apical meristems. These plantings failed after nine months.

During a survey, each "sod block" area is determined by measuring the major and minor axis of each block and calculations made using the formula for an ellipse $A = \pi(a+b)/2$ where a is the length of the major axis and b is the length of the minor axis.

Bare Root

A 10x20m plot was planted at a predetermined elevation in Area 8 (Figure 2) with 861 "bare root" units. An average unit contained 15 short shoots and 3 apical meristems and was planted on 0.5m centers using a 15cm steel staple as an anchor.

Areal determinations of the "bare root" units has progressed through three phases. Initially, ten rows of units were randomly selected and the number of persisting units in each row was counted. Two units from each of these rows were randomly selected and the area of each unit determined using the formula for an ellipse. The total area of all units were extrapolated from these results. In the second phase, the units began to coalesce (survey 4), and it became impossible to differentiate between units. On site measurements similar to the method used to define areal coverage at natural seagrass study sites were employed. The third phase began in survey 16 when areal coverage was estimated using low level aerial photography.

RESULTS AND DISCUSSION

Halodule wrightii

Areal Estimates From Photographs

Areal estimates of seagrass coverage determined from low altitude aerial photography were compared to on site measurements for four of the eight natural study sites and one transplant site. Seagrass coverage estimates from low altitude photographs averaged 12 percent lower than coverage measured on site. Short shoot densities of less than $1000m^{-2}$ may not be sufficient to accurately define the perimeter of a seagrass patch from an aerial photograph. This may result in a lower estimate than coverage determined on site. However, seagrass coverage estimated from photographs appear to adequately reflect seagrass trends in Hillsborough Bay. Estimates from aerial photographs and on site measurements are listed in Table 1.

Table 1. Coverage (m^2) estimated from on site measurements and low altitude aerial photographs.

DATE	SITE	ON SITE ESTIMATE	AERIAL ESTIMATE	PERCENT DIFFERENCE
10/90	B-1	305	284	-6.8
4/92	K-6	16.7	12.3	-26.3
6/92	AREA 8	105	86	-18.1
7/92	K-3	440	460	4.5
8/92	M-1	100	76	-24.0
9/92	B-1	1120	1115	-0.4

Hillsborough Bay Baywide Coverage (Not Including Transplants)

The BSG has conducted annual surveys in 1986, 1989, 1991, 1992, and 1993 to document seagrass coverage in Hillsborough Bay. H. wrightii coverage increased from about $2,000m^2$ in 1986 to $110,000m^2$ in 1993. In the first survey, over half of the coverage was located in the southeastern portion of the bay while sparse coverage was found in western Hillsborough Bay, predominantly from the north end of

Macdill AFB to just north of Ballast Point (Figure 1). Coverage has continued to expand in these two areas. More recently, sparse H. wrightii coverage has developed in eastern Hillsborough Bay north of the Alafia River and near Bullfrog Creek, and just north of Catfish Point in western Hillsborough Bay. Coverage by survey is shown in Figure 5.

Study Site Coverage

When established in 1986, study site K-1 represented the sole patch of H. wrightii on the bar on the southeastern tip of Whiskey Stump Key (Figure 4). Areal coverage remained virtually unchanged until survey 11, when modest expansion was documented (Figure 6). In 1987, new patches of H. wrightii began to develop and expand in other areas of the bar, and, in the fall of 1990 (survey 13), began to coalesce with coverage at the study site. Increased areal coverage from survey 13 through survey 18 represents expansion of study site coverage and coalition with adjacent seagrass. By survey 18, virtually the entire bar was covered with H. wrightii. An apparent decrease in coverage in surveys 19 and 20, as determined from photographic interpretation, represents poor delineation of the seagrass perimeter due to seasonal low short shoot density. On site observations confirmed no dramatic loss in areal coverage for these two surveys. Increased coverage reported in surveys 21 and 22 does not reflect considerable expansion from survey 20, instead, delineation of the seagrass due to increased short shoot density resulted in a more defined photographic signature allowing more precise areal coverage determinations. Annual short shoot densities at this site average less than $1000m^{-2}$ as compared to average short shoot densities of nearly $1500m^{-2}$ found at other study sites (Figure 7).

Study site K-2 (Figure 8) areal coverage fluctuated between $3m^2$ and $33m^2$ through survey 21. However, in survey 22 areal coverage was over double of any previously reported at this site. The growth represents true expansion of the study site with no coalition with extraneous patches.

Study site K-3 (Figure 9) areal coverage increased from $19m^2$ in the initial survey to about $550m^2$ in survey 22. Increases in areal coverage following survey 7 reflect the expansion of the study site seagrass as well as coalition of the study site coverage with adjacent seagrass beds. However, in survey 19, there was a 28 percent decrease in coverage. During the summer of 1992, macroalgae including Ulva lactuca, Spyridia filimentosa and Gracilaria spp. accumulated in this area of the Kitchen and covered the patch for about six weeks. Macroalgae mats on the study site may be responsible for the decrease in coverage found in surveys 19 and 20.

Study site K-4 (Figure 10) lost all H. wrightii coverage in late 1987. A thick mat of macroalgae, mostly U. lactuca covered this site for three months and was apparently the cause of seagrass loss at this site. On site inspections have continued in each survey, except survey 15, with no indication of recolonization.

Study site K-5 (Figure 11) areal coverage has generally increased in each survey with the exception of survey 20. In survey 20, the patch became fragmented into several discrete areas of seagrass and only the coverage extending into the original grid was reported. As in study site K-3, macroalgae mats covered this site for nearly two months in the summer of 1992. Although increased coverage was reported for the site in survey 19, the macroalgae mat may have stressed portions of the patch and contributed to the fragmentation reported in the spring of 1993. Increases in areal coverage following survey 7 reflect the expansion of the study site seagrass as well as the coalition of the study site coverage with adjacent seagrass beds.

Study site K-6 (Figure 12) areal coverage nearly tripled from $23m^2$ in survey 11 to $57m^2$ in survey 14. However, in surveys 17-19, coverage was reduced to about $20m^2$. The patch began to expand again in 1993, with areal coverage reaching nearly $150m^2$. The growth represents true expansion of the study site with no coalition with extraneous patches.

Study site T-1 (Figure 13) is located on the slope of a dredged channel which allows coal barge access to Tampa Electric Company's Big Bend power plant and is frequently subjected to propeller wash from tugboats. The channel was last dredged in 1990 and the decrease in areal coverage at this site after survey 13 may be due to the dredging activity.

Study site M-1 areal coverage (Figure 14) represents a combination of expansion of the study site seagrass, coalition of the study site coverage with adjacent developing seagrass patches, and fragmentation of the study site coverage into several seagrass patches. Seagrass fragmented from the study site is not included as part of the coverage reported for this site. Seagrass patches in this area tend to separate into smaller patches due to sediment accretion and movement of sandbars along Interbay Peninsula. Sandbars, generally oriented southeast to northwest in this area, have been noted to shift over 3m per month for several consecutive months. Sediment movement through seagrass meadows may create areas where seagrass does not persist due to wave action and/or prolonged exposure during low tide. Additionally, sediment transport may rapidly alter the elevation in a seagrass bed, resulting in either erosion or burial and subsequent loss of seagrass. However, seagrass continues to recolonize in this area when not affected by sudden fluctuations in bathymetry.

Study site B-1 (Figure 15) areal coverage increased from about $12m^2$ to nearly $1300m^2$ in survey 22. The increase in coverage represents expansion of study site seagrass coverage and coalition with adjacent developing seagrass patches. One of the patches coalescing with the study site was _H. wrightii_ transplanted in 1987 approximately 50m from the perimeter of the site coverage.

In summary, total areal coverage for the eight _H. wrightii_ study sites was $147m^2$ in 1986. Total areal coverage for all sites in the fall of 1993 (survey 22) was $4181m^2$. Table 2 shows the areal coverage by survey for each study site.

Table 2. Areal coverage (m^2) by seasonal survey for Halodule wrightii study sites. SP=SPRING SU=SUMMER FA=FALL NS=NO SAMPLE *Estimated Coverage ** Only four study sites surveyed for coverage.

SITE	K-1	K-2	K-3	K-4	K-5	K-6	B-1	M-1	T-1	TOTAL
SURVEY #										
FA86 1	17	8	19	12	47		12	16	16	147
SP87 2	8	6	21	15	50		12	14	19	144
SU87 3	18	13	26	20	61		18	20	23	197
FA87 4	26	8	34	0	67		21	25	22	204
SP88 5	12	3	39	0	80		23	15	22	194
SU88 6	17	5	48	0	107		23	15	18	233
FA88 7	20	6	56	0	114		35	18	49	298
SP89 8	11	4	67	0	198		40	17	30	368
SU89 9	8	6	75	0	240		49	24	22	424
FA89 10	22	10	67	0	275		66	36	46	520
SP90 11	33	NS	55	0	307	23	107	32	28	585
SU90 12	75	22	85	0	324	39	200	52	46	842
FA90 13	291	33	99	0	*300	54	305	85	61	927
SP91 14	458	29	110	0	373	57	552	91	9	1678
SU91 15	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
FA91 16	NS	NS	186	0	323	NS	520	98	NS	**1127
SP92 17	785	7	315	0	376	12	859	176	5	2534
SU92 18	1240	19	440	0	575	20	1115	100	2	3511
FA92 19	108	30	315	0	875	19	884	91	1	2323
SP93 20	47	17	316	0	228	28	868	80	0	1583
SU93 21	964	25	497	0	1033	27	1300	22	0	3868
FA93 22	988	71	549	0	1220	25	1291	37	0	4181

Transplanted Coverage

The H. wrightii "bare root" units, planted in Area 8 (Figure 2) in a 10x20m plot, increased in areal coverage from 2.3m^2 initially planted to 291m^2 in survey 13 (Figure 16). However, areal coverage has decreased in each following survey, with no coverage reported in surveys 21 and 22. As previously discussed, this is an active zone of sediment accretion and shifting sandbars which may limit H. wrightii expansion. Therefore, the decrease in areal coverage seen in Area 8 does not indicate degradation of water quality but an alteration of the topography in an area of persistant seagrass growth. Table 3 shows coverage for each of the transplant areas by survey.

Table 3. Areal coverage (m^2) by seasonal survey of H. wrightii "sod block" plantings in Areas 1-7 and H. wrightii "bare root" units in Area 8. SP=SPRING SU=SUMMER FA=FALL DS=DISCONTINUED SAMPLING NS=NO SAMPLE NOTE: Area 8 coverage determined from aerial coverage after survey 15. * Does not include Area 8.

AREA	1	2	3	4	5	6	7	8	
SURVEY #									TOTAL
INITIAL	5.3	2.1	0.4	0.2	0.6	0.4	1.7	2.3	13.0
SU87 3	2.2	0.4	0.7	0.2	0.5	0.6	0.6	1.8	7.0
FA87 4	4.4	0.5	0.9	0.5	0.3	0.8	0.5	6.7	14.6
SP88 5	1.4	0.2	0	0.1	0.4	TRACE	0.6	1.8	4.5
SU88 6	21.9	9.1	0	0	0.4	0	5.4	45.8	82.5
FA88 7	57.6	13.3	0	0	1.7	0	8.5	70.6	151.7
SP89 8	59.7	26.7	0	0	4.8	0	16.6	78.8	186.6
SU89 9	13.9	58.4	0	0	5.5	0	42.7	176.4	296.9
FA89 10	59.2	61.5	0	0	15.5	0	64.7	223.3	424.2
SP90 11	63.8	43.3	DS	DS	32.3	DS	78.6	255.0	473.0
SU90 12	112.1	76.4			41.3		121.1	260.5	611.4
FA90 13	180.6	96.9			59.2		184.3	291.0	812.0
SP91 14	212.9	96.9			82.8		138.2	251.1	781.9
SU91 15	321.0	111.2			137.2		228.5	NS	*797.9
FA91 16	351.8	93.0			188.0		211.8	221.6	1066.2
SP92 17	42.7	81.8			151.9		272.9	204.0	753.3
SU92 18	2.7	211.0			461.5		417.4	86.0	1179.0
FA92 19	1.6	97.3			282.5		290.6	71.0	743.0
SP93 20	0	20.0			341.0		287.9	1.3	650.2
SU93 21	0	70.0			439.4		216.6	0	726.0
FA93 22	0	14.2			127.8		465.9	0	607.9

In October 1993, four years after the initial planting of H. wrightii "sod blocks", transplants persisted in three of seven test areas. H. wrightii "sod block" plantings (Figure 17) expanded from an initial coverage of $10.7m^2$ in 1987 to peak coverage of $1100m^2$ in survey 18 (summer 1992). Areal coverage increased steadily from survey 5 through survey 16. However, three transplants in Area 1, representing about 35 percent of the "sod block" coverage in survey 16, were not found in survey 17, and, as a result, coverage declined over 30 percent. A reduction in areal coverage was also reported in survey 19, following the trend noted for total coverage of the H. wrightii study sites (Table 2). In survey 22, the apparent reduction in coverage is the result of one Area 5 transplant, which measured over 350m^2 in survey 21, coalescing with naturally occurring coverage. Delineation of the transplant perimeter was impossible, therefore, this transplant was not included in the coverage total.

Transplants in Areas 1, 2, 5, and 7 (Figures 18-21) and Area 8 (Figure 17) had very similar patterns of growth through survey 6. In general, little change occurred in the first year after planting (surveys 3-5 or 6). All areas, however, exhibited substantial growth between the summer of 1988 (survey 6) through the fall of 1991 (survey 16). In survey 17, H. wrightii areal coverage decreased slightly in Areas 2, 5, and 8 and nearly an order of magnitude in Area 1 while H. wrightii coverage in Area 7 increased. Areal coverage increased in Areas 2, 5, and 7 in survey 18 contrasting with decreasing coverage in Areas 1 and 8. All transplant coverage declined in survey 19. Although no transplant coverage was reported in area 1 in 1993, this area (the Kitchen) continues to to support a major portion of the H. wrightii in Hillsborough Bay. Transplants in area 2 have persisted through survey 22 though most continue to struggle. New growth has appeared in elevations lower than the transplanted material in area 2 suggesting that the original planting location may have been too shallow to establish a permanent H. wrightii presence. Areas 5 and 7 continue to support healthy transplants through survey 22.

Transplants did not survive in Area 3, Area 4, and Area 6. Area 3 is subject to wakes from frequent ship traffic and this high energy zone may not be suitable as a transplant site. Area 4 is adjacent to a large stormwater culvert and cover by debris discharged from this culvert probably caused the loss of transplants at this site. Area 6 had small areas of natural H. wrightii at the time of the transplanting effort. However, dense mats of macroalgae covered the area for several months in early 1988 and apparently killed all transplanted and most natural H. wrightii.

Ruppia maritima

Several areas of persistent R. maritima meadows have been identified in Hillsborough Bay. About 1.7ha of R. maritima was found in Hillsborough Bay in 1993. The intertidal area between Gadsden Point west to the Macdill AFB marina channel contained about 4000m^2 of R. maritima and scattered coverage was found along eastern Interbay peninsula and in the Kitchen. About 1ha was documented between Pendola Point and the Alafia River. R. maritima coverage has been sparse in McKay Bay after reaching 0.8ha in 1990.

Caulerpa prolifera

Since monitoring began in 1986, C. prolifera has been shown to vegetate large areas of subtidal flats in a short time period and also to quickly diminish from vast areas due to sudden die-offs. Growth has been observed in four general areas of Hillsborough Bay: 1) along the southeastern Interbay Peninsula;

2) near Ballast Point; 3) along Davis Island; and 4) between Pendola Point and the Alafia River. Additionally, in 1993, a narrow band of C. prolifera was documented on the western end of Bird Island (Figure 1). Documentation of coverage in these areas has been assessed by aerial photography from helicopter overflights and by measuring the percent cover in marked-off transects.

Subtidal areas up to three meters in depth along the southeastern Interbay Peninsula represent a region where C. prolifera has exhibited both rapid increase and rapid loss in coverage. Estimates from aerial photography documented a 40 fold increase in coverage to 200ha between April and December in 1986. A 90 percent reduction in coverage occurred in the fall of 1988 immediately following a "25 year" rainfall event which lowered salinities to 2ppt in some parts of Hillsborough Bay. C. prolifera transect M-3, was reduced to trace amounts (Figure 22) following the rain event. No C. prolifera coverage was observed at study site M-3 during surveys 8-22. However, sparse C. prolifera has been developing south and north of the transect since 1992.

Similarly, transect B-2 near Ballast Point also suffered marked coverage reductions after the "25 year" rainfall event (Figure 23). There was sparse C. prolifera coverage in the transect in 1990 (surveys 11-13) and no coverage observed during surveys 14-20. However, sparse coverage returned in surveys 21-22. In 1993, a C. prolifera meadow located immediately north of the transect was estimated at 2.1ha, more than twice the coverage found in this area in 1992.

C. prolifera was found adjacent to the ship channel along subtidal flats of Davis Island in October 1986. Results from the transect Y-1 indicate low percent coverage through survey 5, and trace amounts in surveys 6-10 (Figure 24). Scattered C. prolifera coverage was observed in the deeper portion (1-2m) of the study site during survey 11. However, trace amounts were recorded in surveys 12 and 13. No coverage was observed during surveys 14-22. The initial decline to only trace amounts occurred prior to the "25 year" rainfall event and was presumably not a result of reduced salinities.

In the northeastern region of Hillsborough Bay, between Pendola Point and Archie Creek, C. prolifera meadows have undergone rapid expansion and decline since first noted in October 1987. In this area, C. prolifera did not experience a large scale die-off following the "25 year" rainfall event. Salinity reductions near Pendola Point after the rainfall event may not have been as large compared to salinity reductions observed along the western side of Hillsborough Bay. The Pendola Point transect P-1 reflects the growth pattern of C. prolifera in this region. The percent cover in transect P-1 (Figure 25) has varied between 38 and 100 percent through survey 22. The C. prolifera meadows in this area were reduced from about 190ha in 1990 to about 10ha in the fall of 1991. During the summer of 1991, the salinity was about 15ppt for nearly eight weeks in this area and may have been responsible for the reduction in coverage. However, the areal extent of the algae increased slightly in 1992 to about 13ha and then doubled in 1993 to 28.3ha. The percent coverage in study site P-1 appears to be seasonal, usually peaking during in the summer.

A subtidal area from Gadsden Point west to the Macdill AFB marina channel is also surveyed for seagrass and C. prolifera coverage. C. prolifera meadows in this area were estimated to cover 25.1ha in 1993.

In summary, C. prolifera has rapidly colonized large intertidal and subtidal areas of Hillsborough Bay since 1986. Furthermore, this alga appears to be sensitive to low salinity for extended periods. Overall coverage was estimated at 55ha in the fall of 1993.

CONCLUSION

Recent water quality improvements in Hillsborough Bay have apparently allowed recolonization of H. wrightii into many intertidal and shallow subtidal areas of Hillsborough Bay. A majority of the H. wrightii renewal has occurred in the Kitchen, although many naturally occurring patches of H. wrightii have also been located in western and northwestern sections of the bay. It appears that protected intertidal and subtidal areas support more extensive and generally healthier seagrass beds than areas disturbed by natural or anthropogenic processes.

In 1987, H. wrightii was transplanted into several intertidal areas in Hillsborough Bay which lacked seagrass coverage. Successful plantings identified several areas suitable for seagrass growth. As a result of the test plantings, these areas now have source material available for natural revegetation processes.

In 1991, four years after the 1987 transplant effort, the material collected from the Courtney Campbell Causeway had increased in area nearly two orders of magnitude. However, there was a 20 percent reduction in areal coverage in 1992, with greatest loss in Area 1 and Area 8. In 1993, Areas 5 and 7 continued to support thriving transplants while Area 2 transplants, apparently planted too shallow, appear to struggle.

As H. wrightii meadows expand in Hillsborough Bay, transplanted material will continue to coalesce with natural seagrass rendering further assessments of transplant coverage irrelevant.

H. wrightii found on the deeper portions of the subtidal shelf, including transplanted material, may receive near minimum light requirements to sustain growth. Low light penetration in the spring of 1992 (see fourth annual report, 1993) may have caused the losses noted for seagrass in these areas. Generally, H. wrightii in the deeper areas, such as the Area 1 transplants, fared poorer in 1992 than in the past five years. Further, the decrease in coverage for transplanted and naturally occurring H. wrightii in survey 19 (fall 1992) follows unusually low light penetration found in the summer of 1992. Similarly, the 1989 H. wrightii and S. filiforme transplant effort may have not been successful due to low water column light penetration.

Areal photography has shown that many areas of Hillsborough Bay have established R. maritima meadows which may vary in coverage from year to year. The information gained from the study site did not represent baywide trends.

C. prolifera generally persists in deeper waters than H. wrightii, indicating that the alga may be a pioneer of areas with relatively low light penetration. C. prolifera rapidly colonized large intertidal and subtidal areas of Hillsborough Bay in 1986 followed by large scale die offs in 1988. This loss of C. prolifera in 1988 may be a result of exposure to low salinity for long periods.

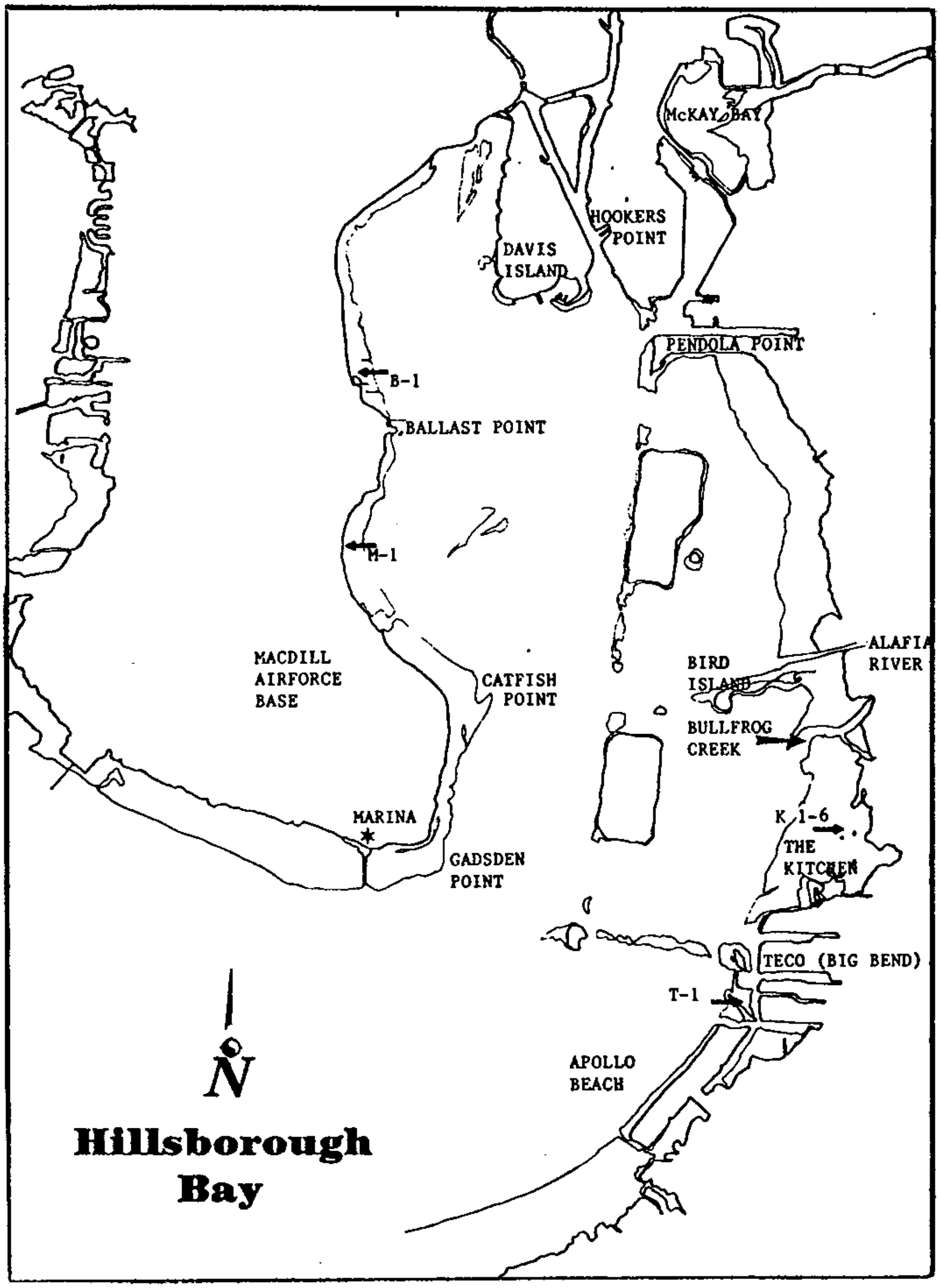

Figure 1. Location of natural <u>Halodule wrightii</u> study sites B-1, M-1, T-1, K-1, K-2, K-3, K-4, K-5 and K-6 in Hillsborough Bay.

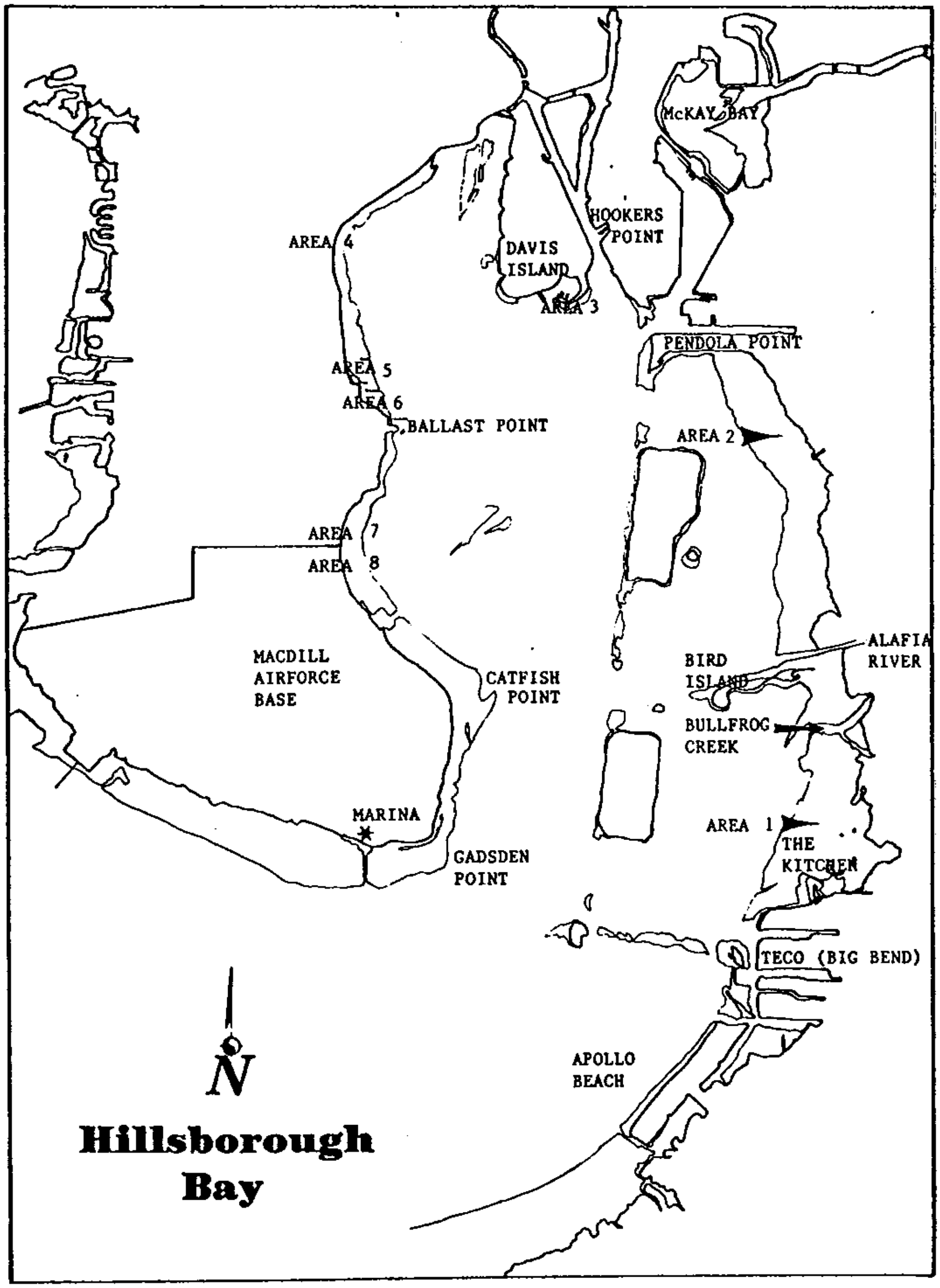

Figure 2. Seagrass testplanting sites in Hillsborough Bay.

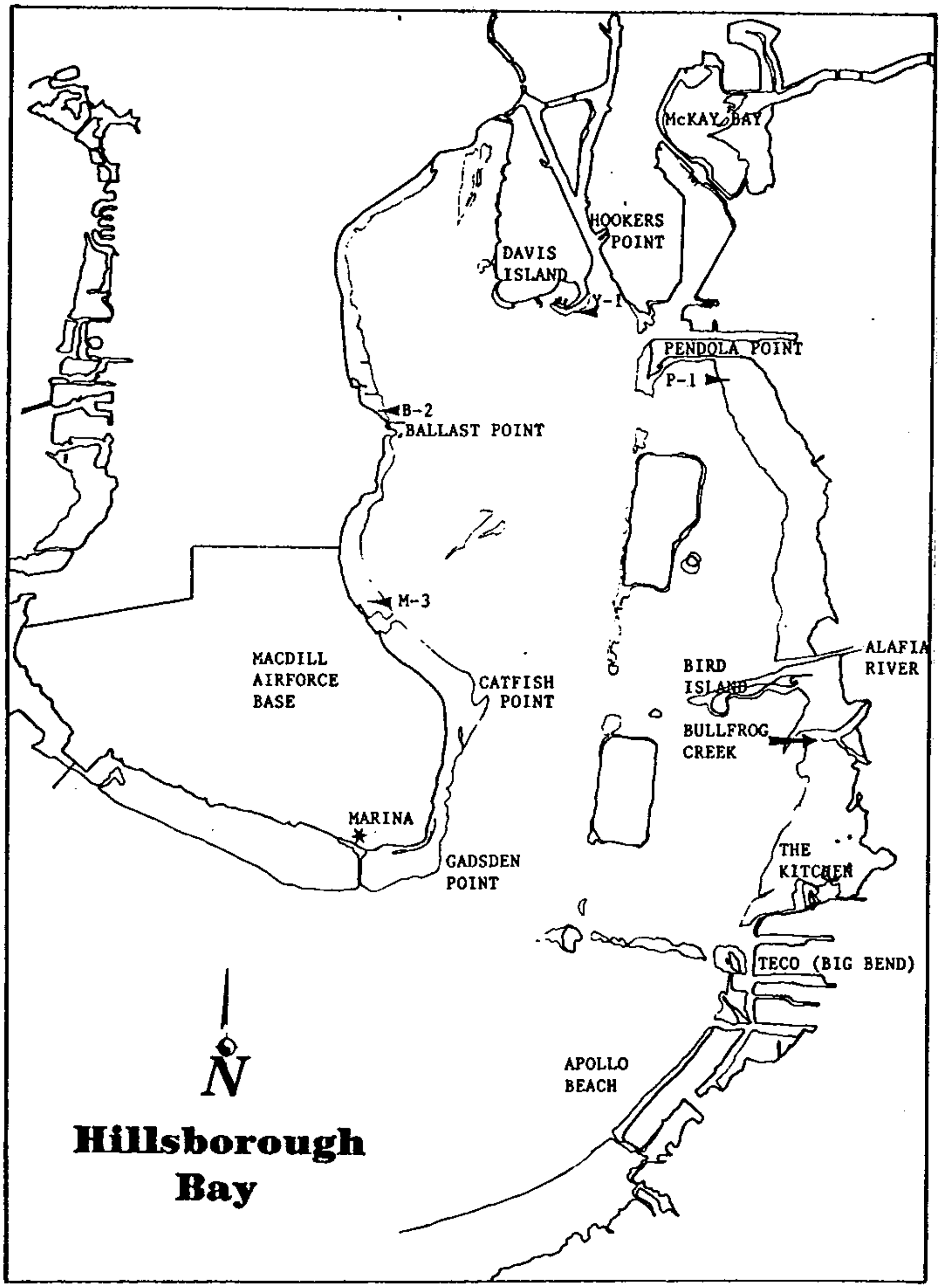

Figure 3. Location of Caulerpa prolifera transects in Hillsborough Bay.

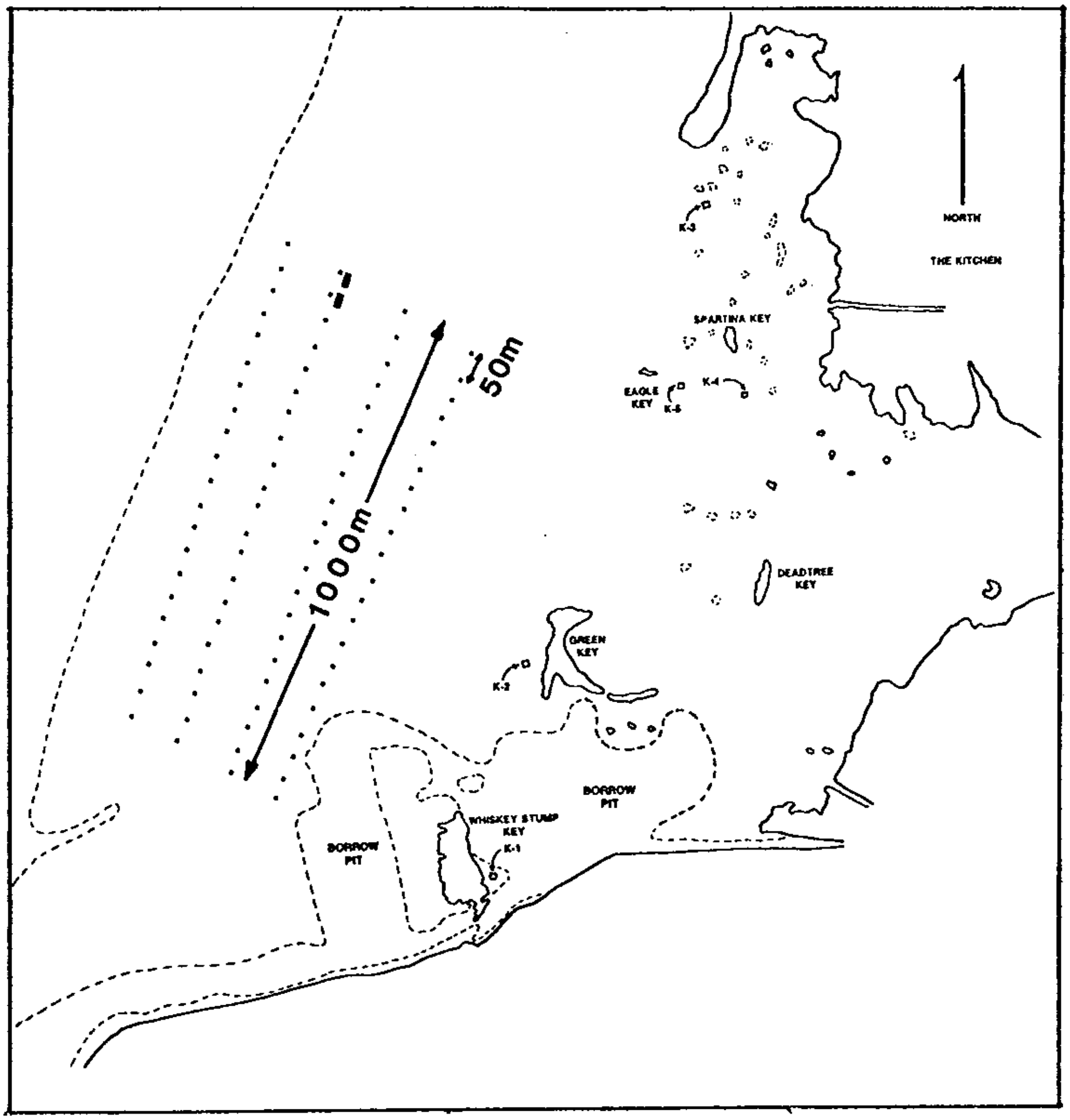

Figure 4. Seagrass testplanting sites in the Kitchen area (Area 1) of Hillsborough Bay. Filled squares show 1987 planting transects and filled rectangles show 1989 planting plots. Locations of natural Halodule wrightii study sites K-1, K-2, K-3, K-4, K-5 and K-6 also are shown.

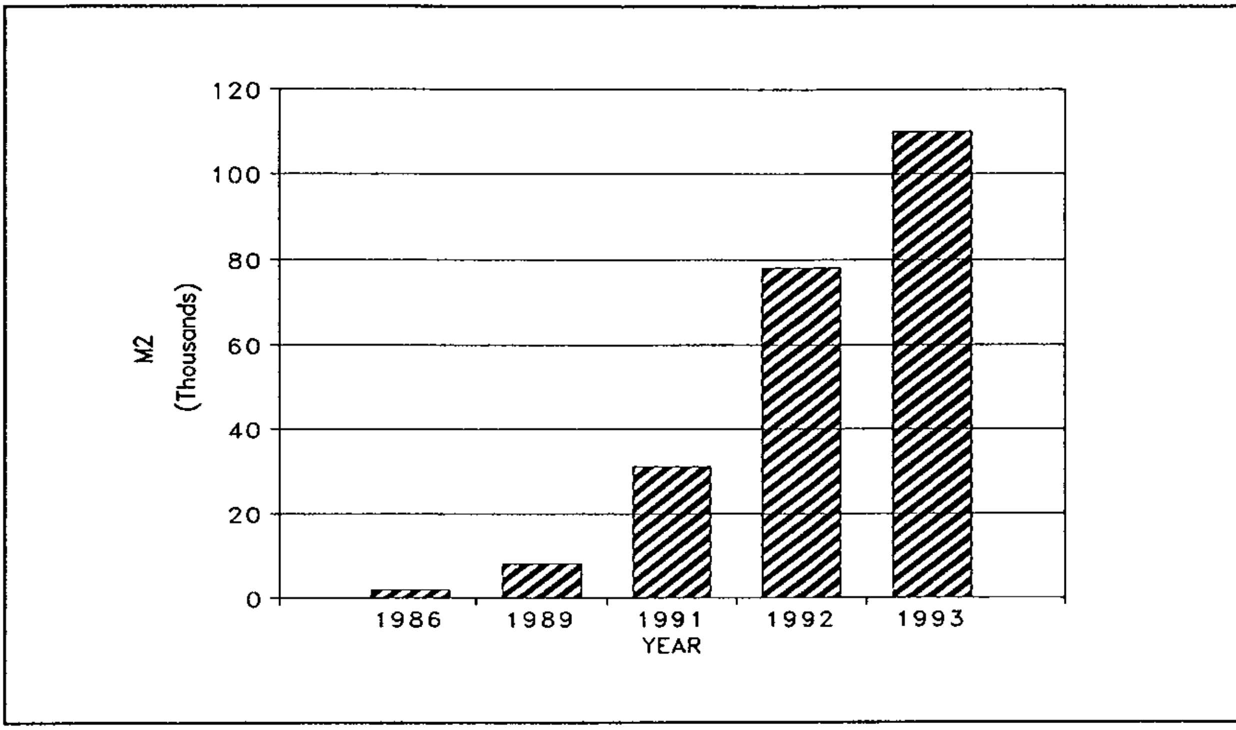

Figure 5. Increase in <u>Halodule wrightii</u> coverage in Hillsborough Bay from 1986-1993.

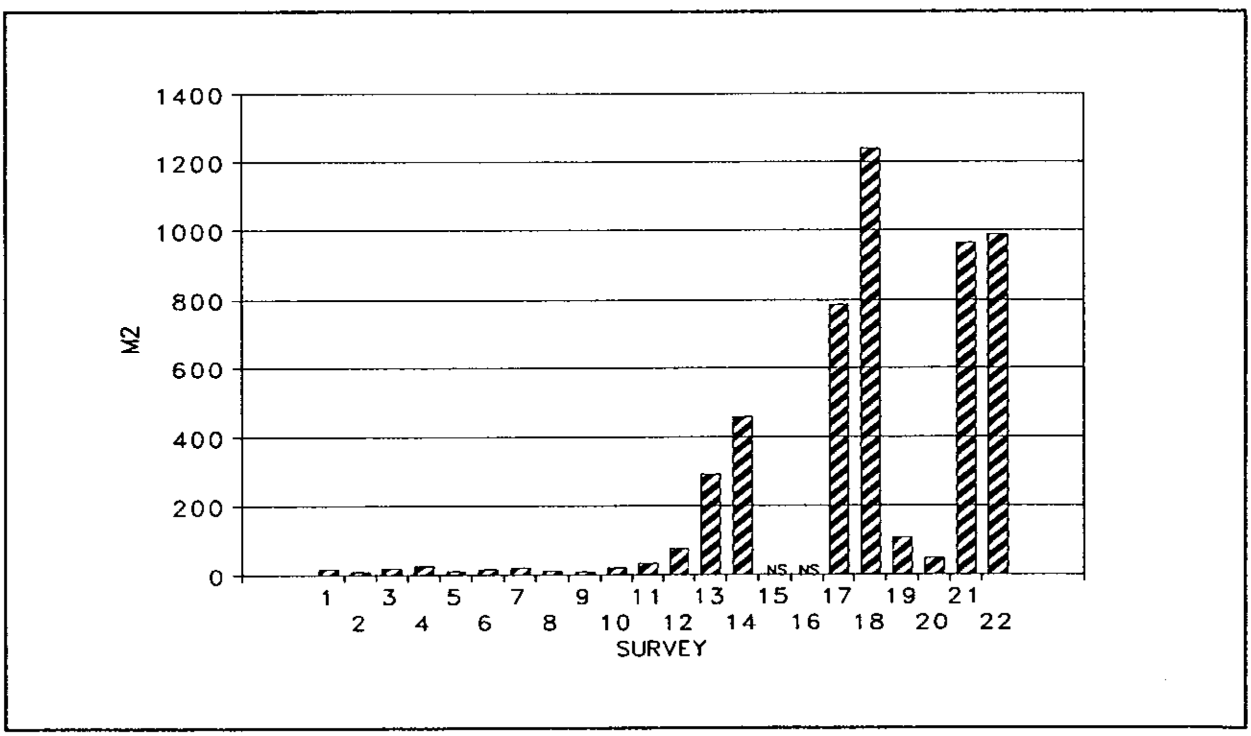

Figure 6. Areal coverage by survey for the natural <u>Halodule wrightii</u> study site K-1. NS=No Sample

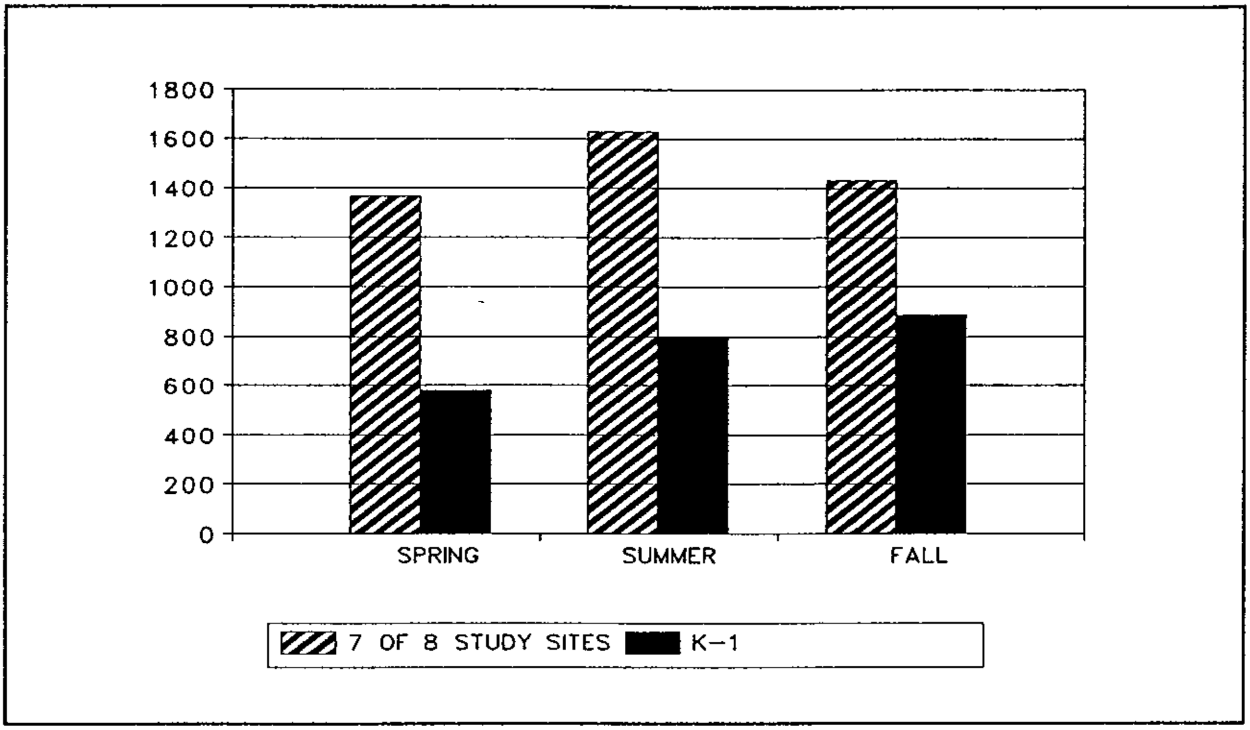

Figure 7. Average seasonal short density at study site K-1 and average seasonal short shoot density of the seven other study sites (K 2-6, M-1, and B-1) combined.

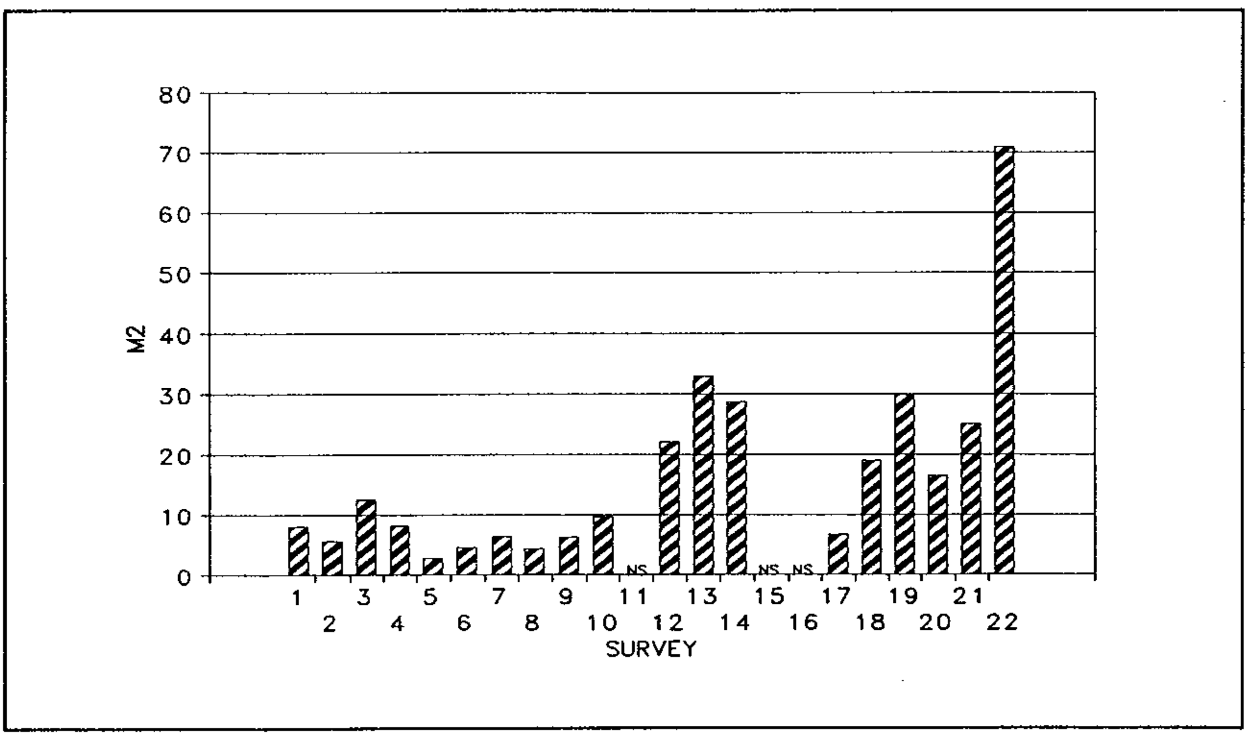

Figure 8. Areal coverage by survey for the natural Halodule wrightii study site K-2. NS=No Sample

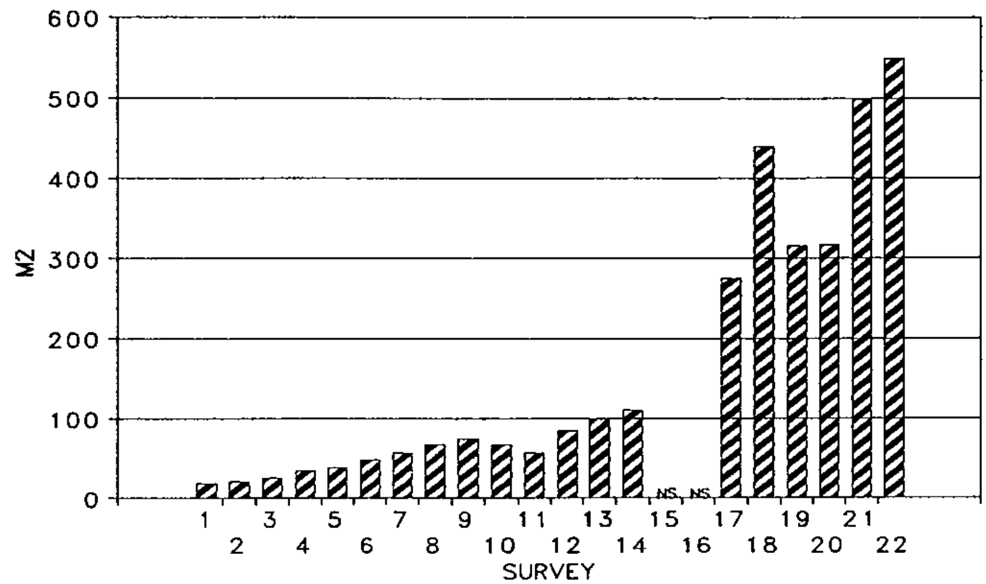

Figure 9. Areal coverage by survey for the natural <u>Halodule wrightii</u> study site K-3. NS=No Sample

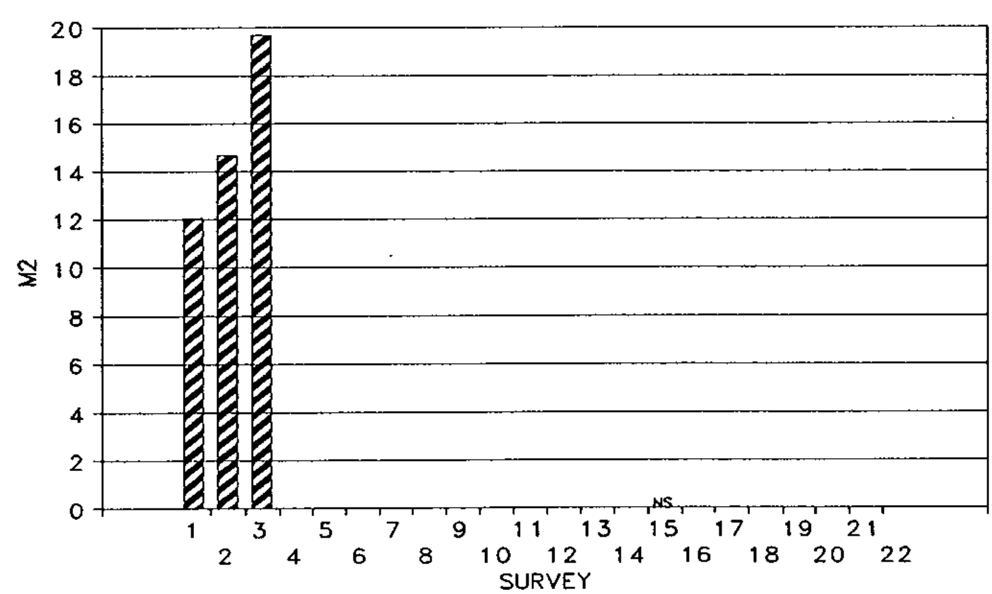

Figure 10. Areal coverage by survey for the natural <u>Halodule wrightii</u> study site K-4. NS=No Sample

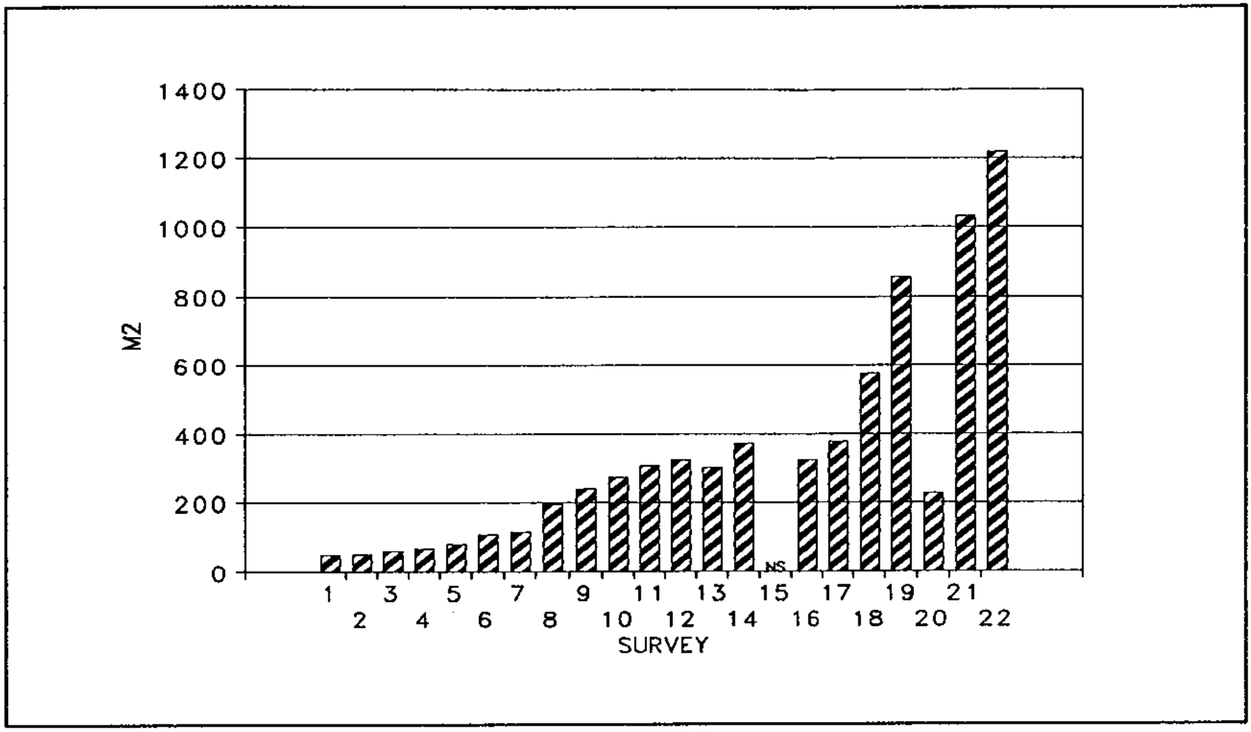

Figure 11. Areal coverage by survey for the natural <u>Halodule wrightii</u> study site K-5. NS=No Sample

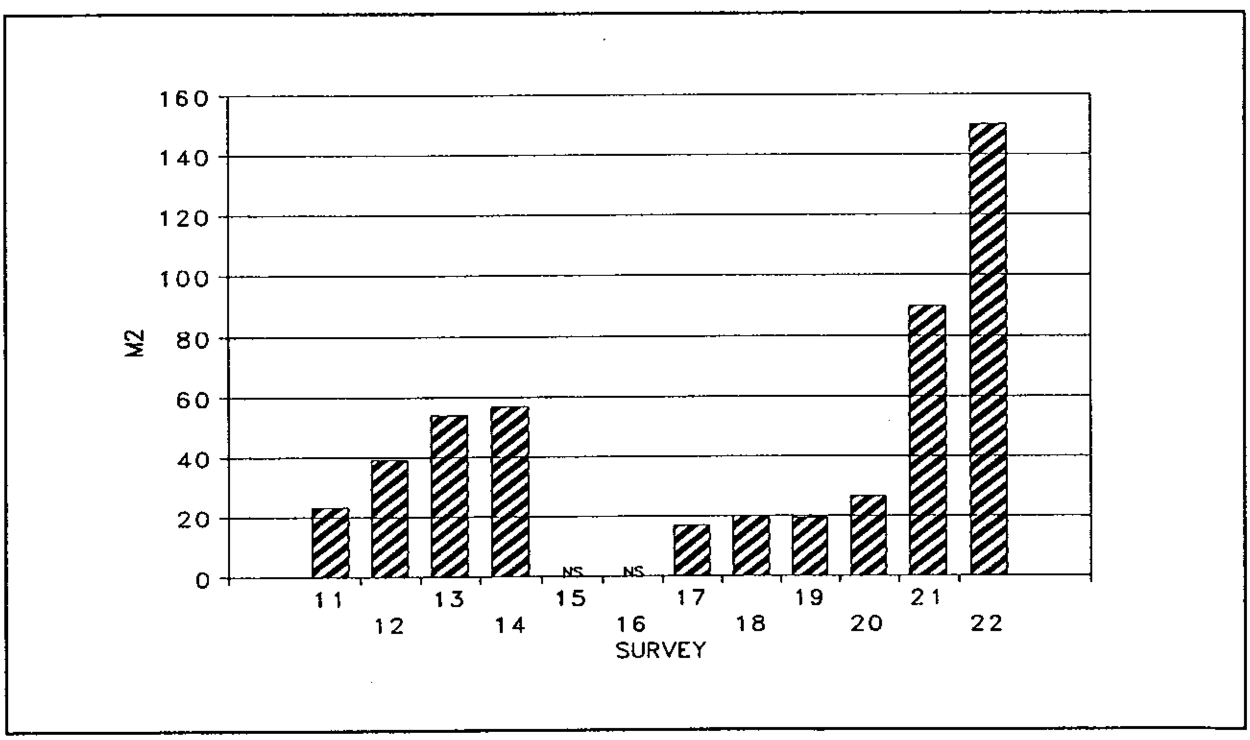

Figure 12. Areal coverage by survey for the natural <u>Halodule wrightii</u> study site K-6. NS=No Sample

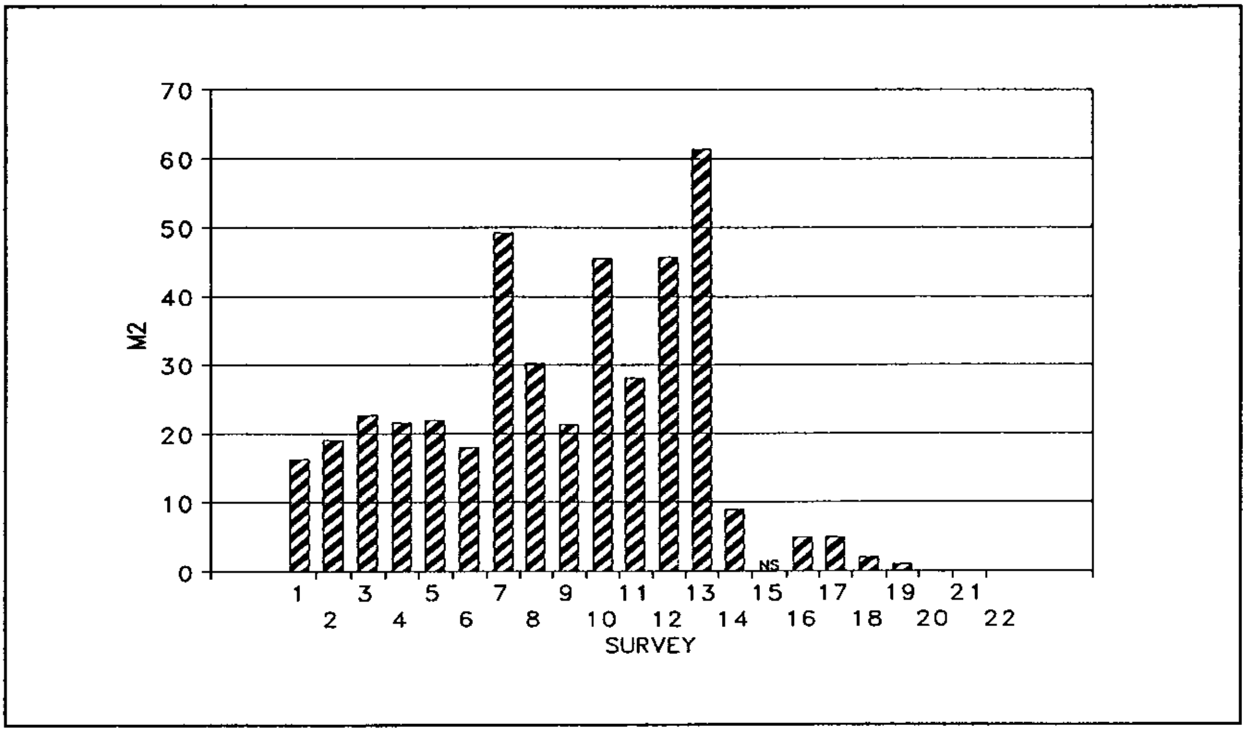

Figure 13. Areal coverage by survey for the natural Halodule wrightii study site T-1. NS=No Sample

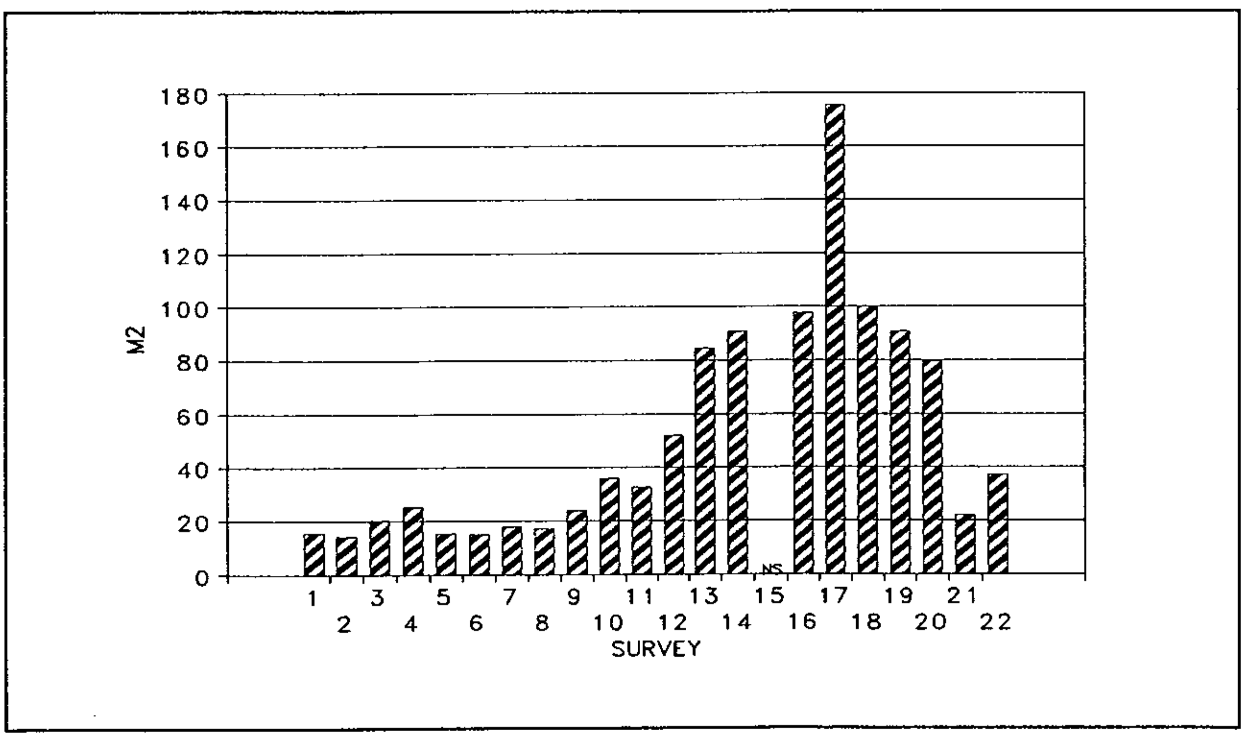

Figure 14. Areal coverage by survey for the natural Halodule wrightii study site M-1. NS=No Sample

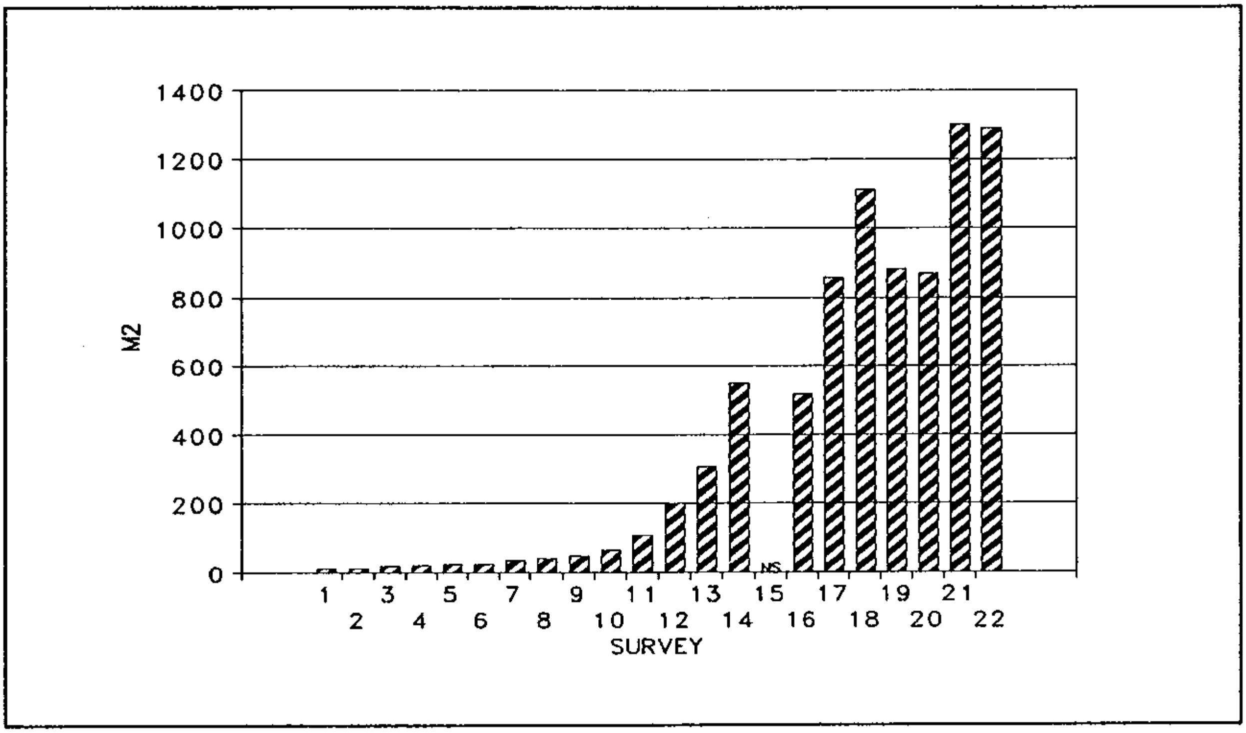

Figure 15. Areal coverage by survey for the natural Halodule wrightii study site B-1. NS=No Sample

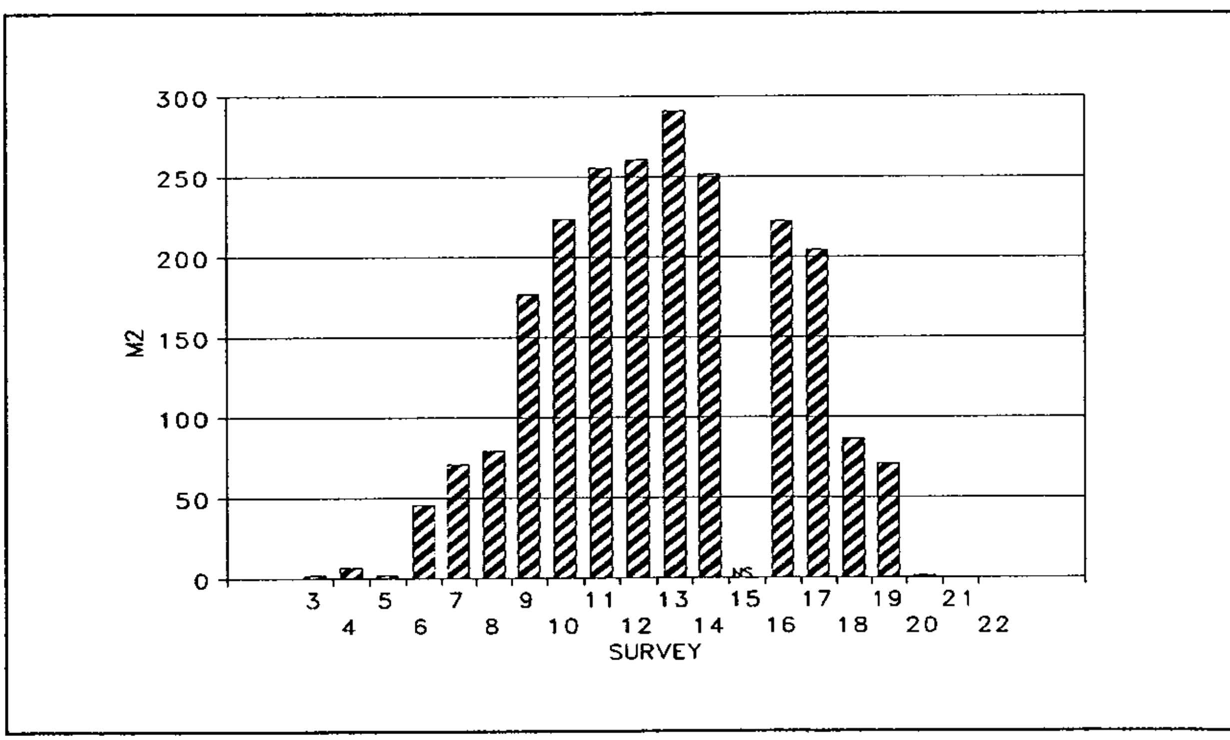

Figure 16. Areal coverage by survey for transplanted Halodule wrightii "bare root" units in Area 8. NS=No Sample

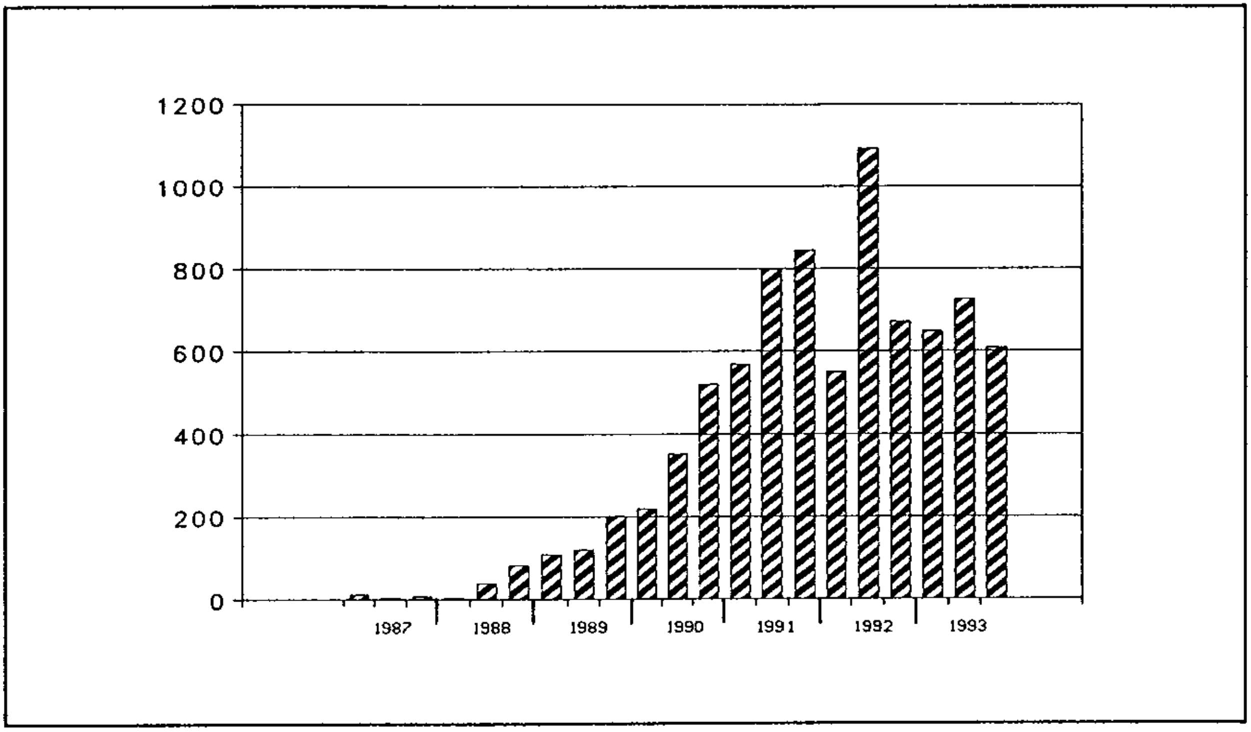

Figure 17. Areal coverage by survey for transplanted <u>Halodule wrightii</u> "sod blocks". NS=No Sample

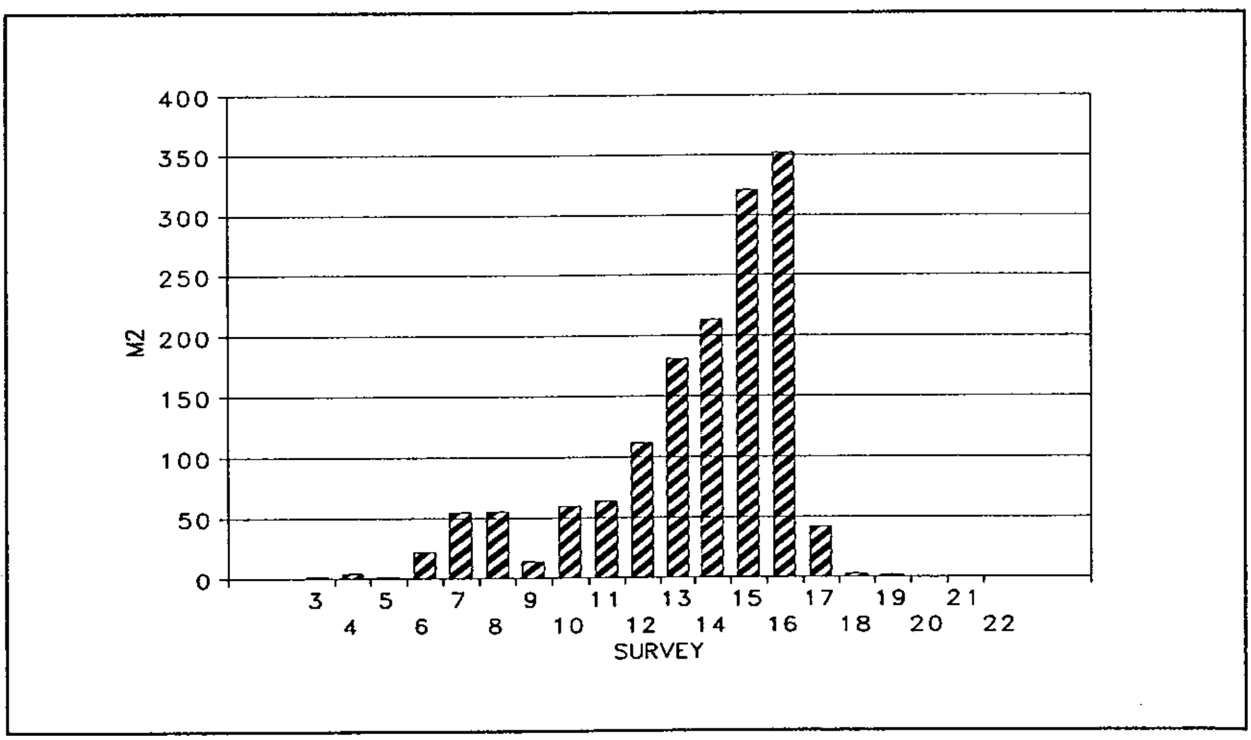

Figure 18. Areal coverage by survey for transplanted <u>Halodule wrightii</u> "sod blocks" in Area 1.

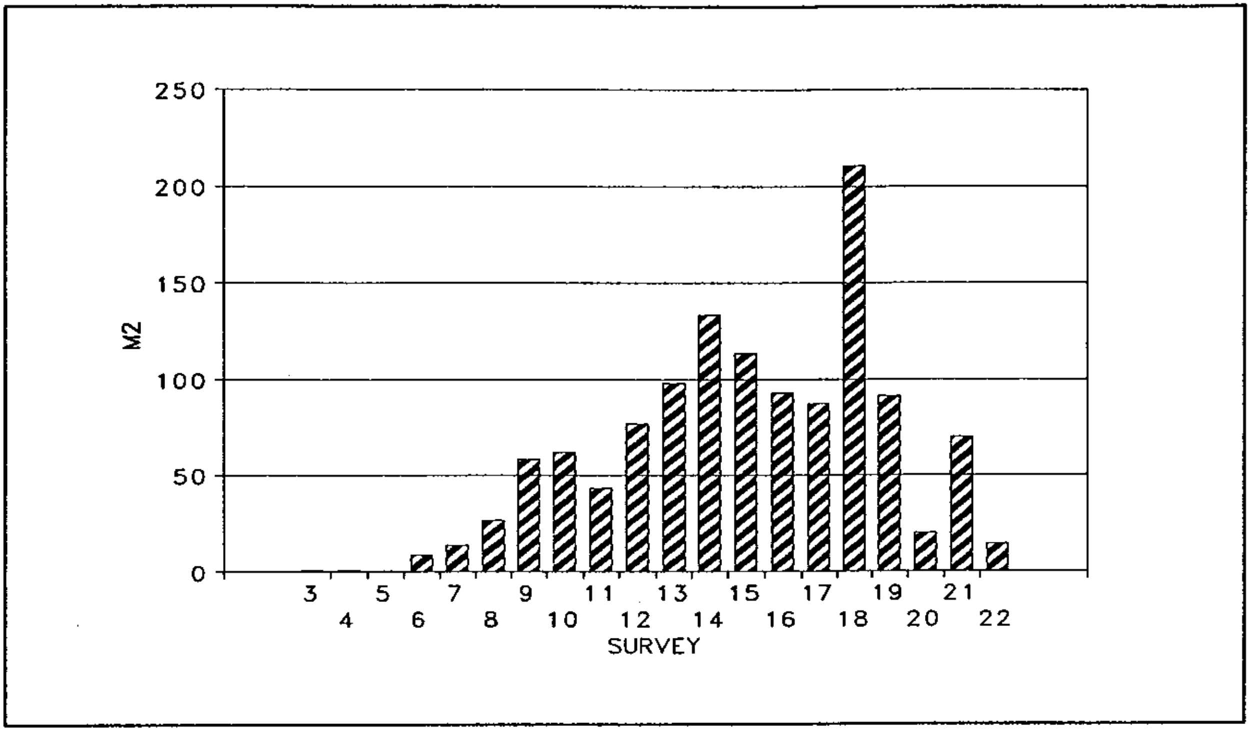

Figure 19. Areal coverage by survey for transplanted <u>Halodule wrightii</u> "sod blocks" in Area 2.

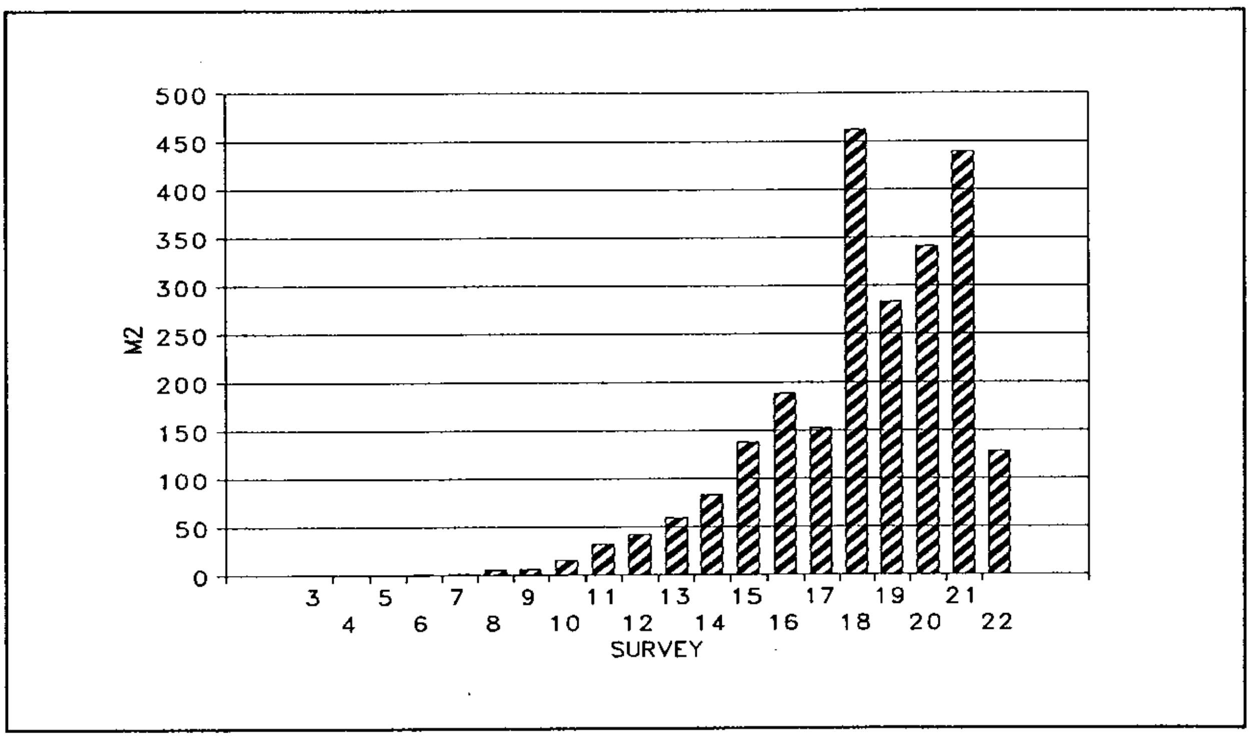

Figure 20. Areal coverage by survey for for transplanted <u>Halodule wrightii</u> "sod blocks" in Area 5.

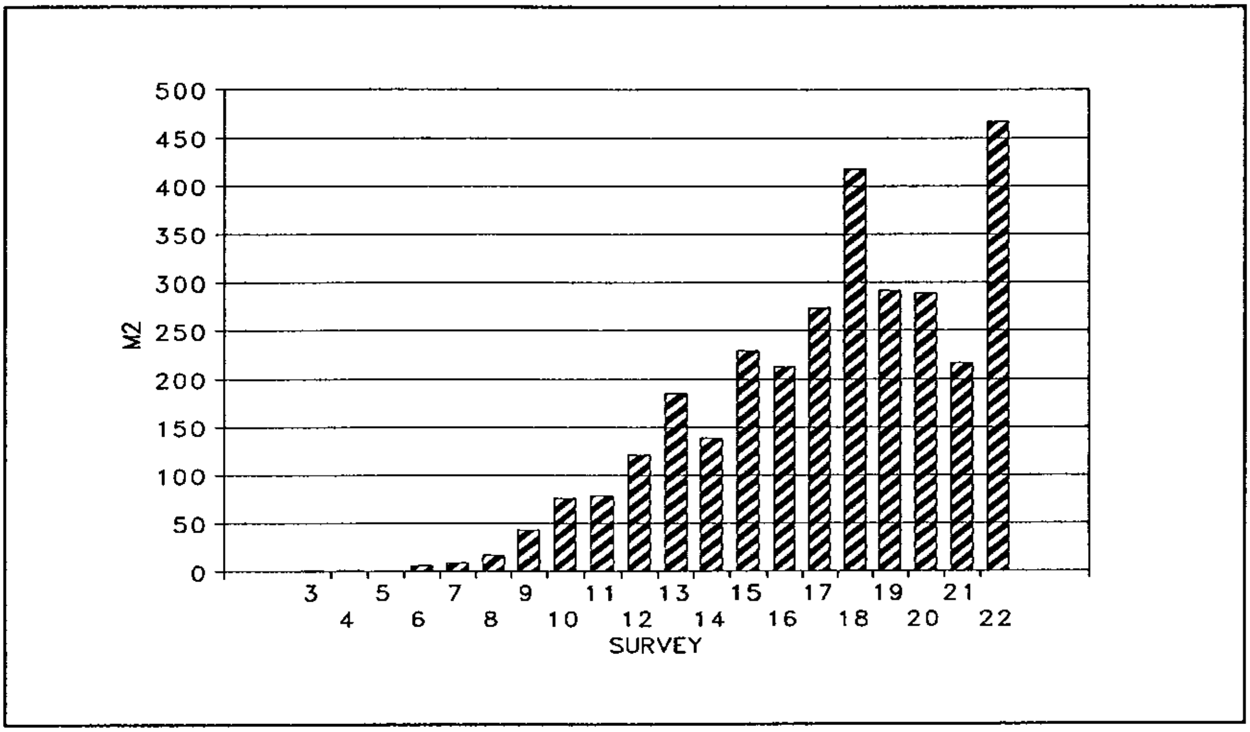

Figure 21. Areal coverage by survey for transplanted Halodule wrightii "sod blocks" in Area 7.

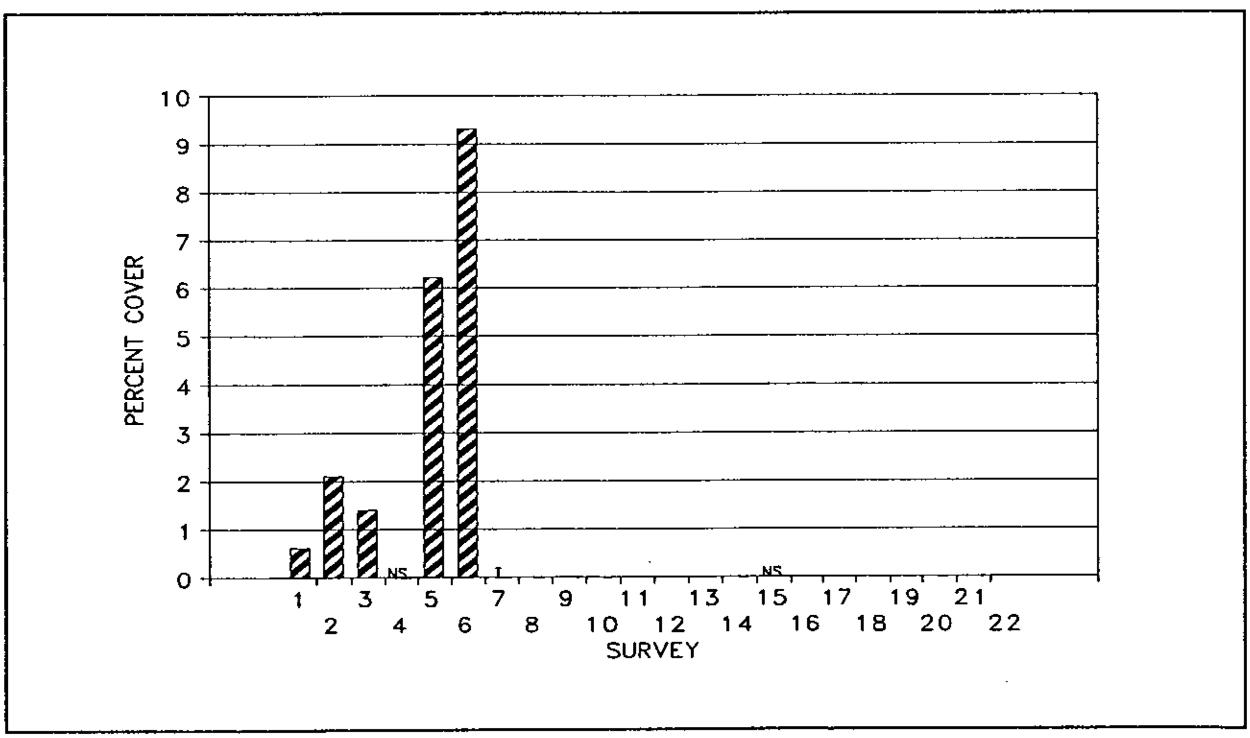

Figure 22. Percent cover by Caulerpa prolifera at study site M-3. NS=No Sample T=Trace

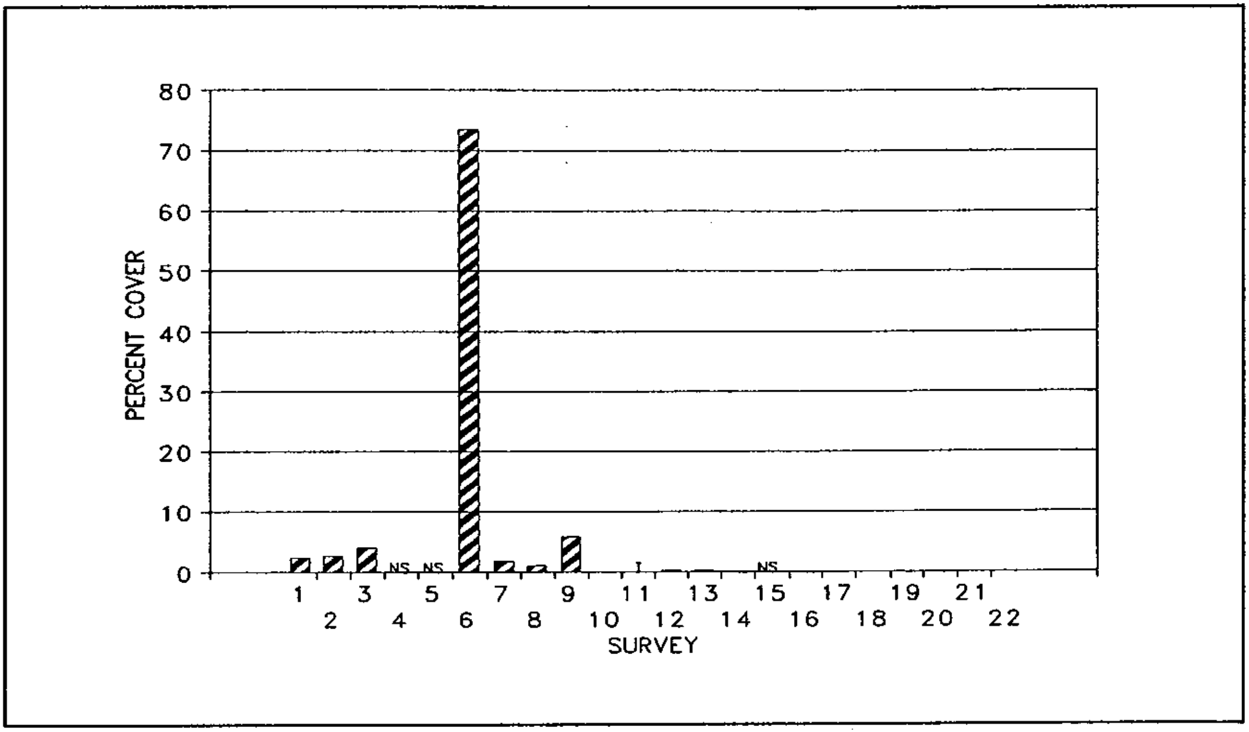

Figure 23. Percent coverage by Caulerpa prolifera at study site B-2. NS=No Sample T=Trace

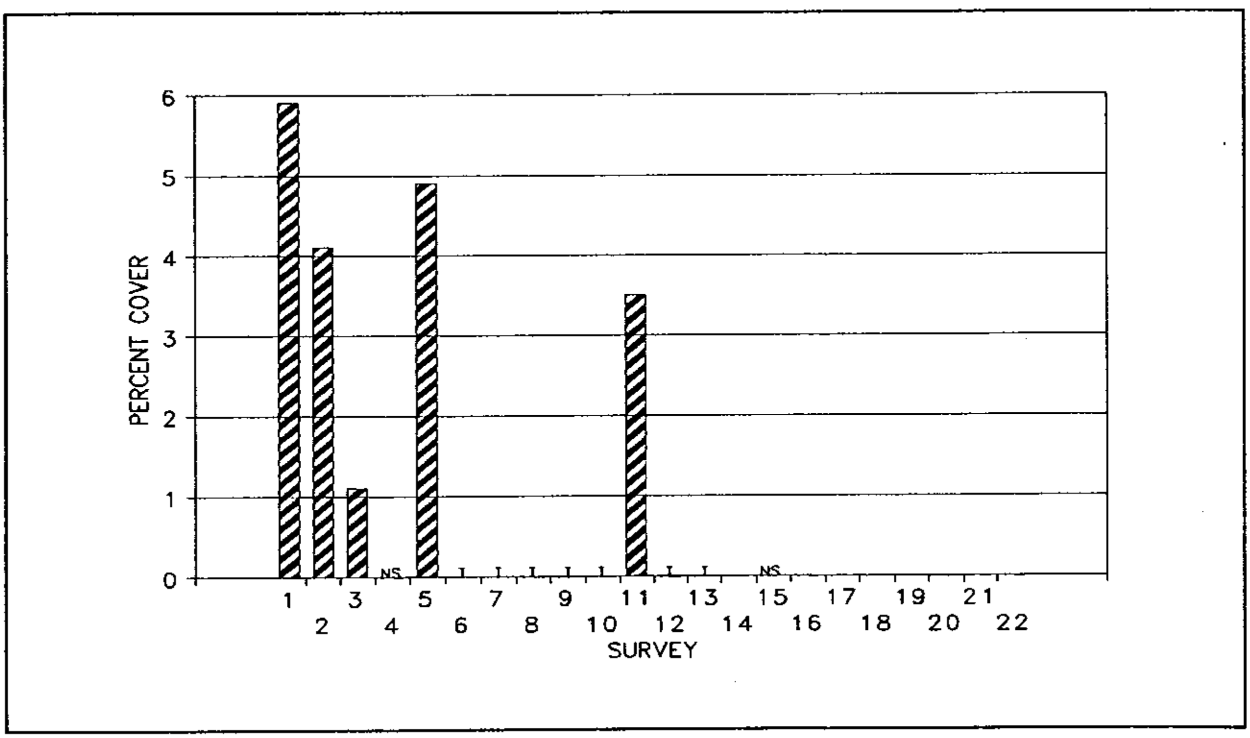

Figure 24. Percent coverage by Caulerpa prolifera at study site Y-1. NS=No Sample T=Trace

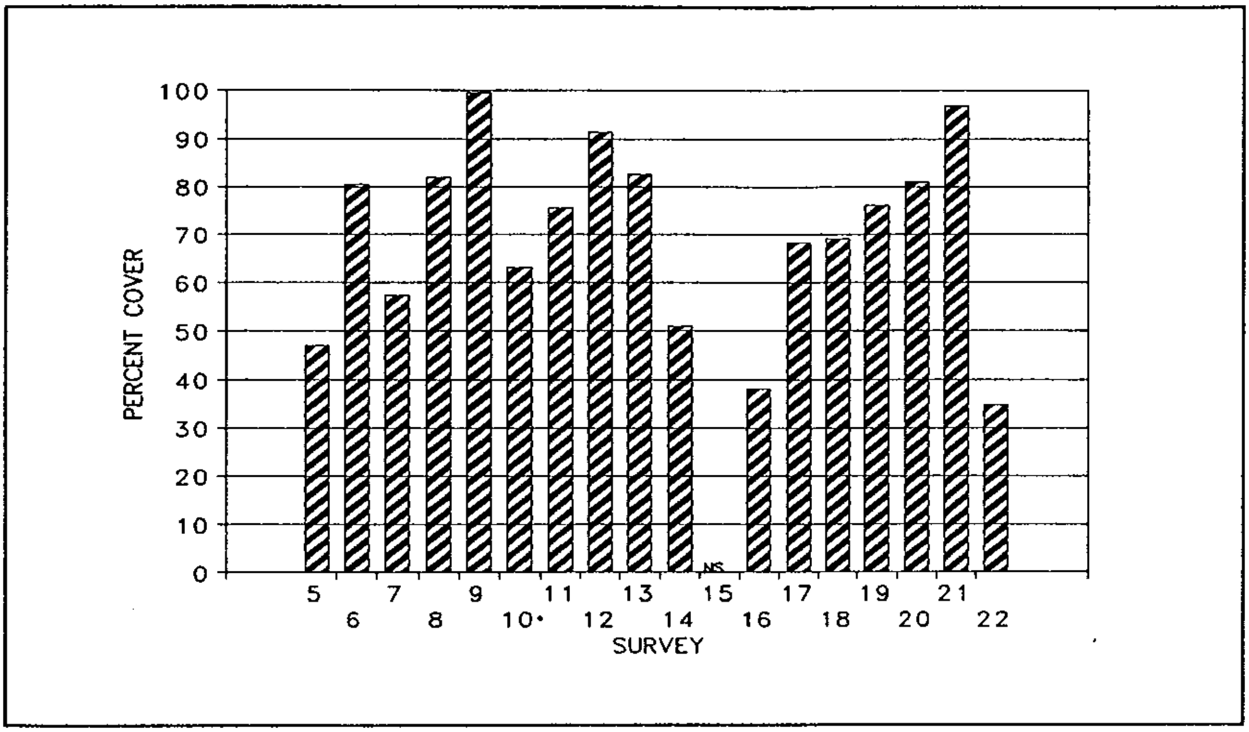

Figure 25. Percent coverage by Caulerpa prolifera at study site P-1. NS=No Sample