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Seagrass and Caulerpa monitoring in Hillsborough Bay Thirteenth Annual Report

City of Tampa Department of Sanitary Sewers

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

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THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

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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 were 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 Howard F. Curren Advanced Wastewater Treatment Plant with changes in the seagrass community. *H. wrightii* baywide areal coverage was about 2000m^2 in the initial survey in 1986 and increased to about 85.5ha by 2001. Coverage for *R. maritima* fluctuated between 2000m^2 in 1986 to 40ha in 1996. However, following the maximum reported in 1996, *R. maritima* coverage declined to about 2ha in 2001. *C. prolifera* coverage has varied greatly over the study period. After reaching maximum coverage of 280ha in 1988, *C. prolifera* meadows were reduced nearly an order of magnitude following a "25 year" rainfall event in the fall of 1988. The presence of *C. prolifera* was documented in Hillsborough Bay through 1994, however, no attached *C. prolifera* coverage has been noted in Hillsborough Bay since 1996.

Seagrass recolonization has occurred in the intertidal and shallow subtidal areas of Hillsborough Bay in response to improved water quality. Sizeable *H. wrightii* meadows are now established in southeastern Hillsborough Bay and along the Interbay Peninsula in western Hillsborough Bay.

INTRODUCTION

The City of Tampa, Department of Sanitary Sewers, Bay Study Group (BSG), created in 1976, has monitored the effects of pollution abatement that occurred in Hillsborough Bay when the Howard F. Curren Advanced Wastewater Treatment Plant (formerly Hookers Point Wastewater Treatment Plant) was upgraded to secondary treatment in 1978 and advanced treatment in 1979. During the mid 1980's, 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 submerged aquatic vegetation (SAV) in Hillsborough Bay (including McKay Bay) began in April 1986 with a thorough groundtruthing effort which located and estimated the areal coverage of *Halodule wrightii* (shoalgrass), *Ruppia maritima* (widgeongrass) and the attached benthic alga, *Caulerpa prolifera*. Twelve additional intensive surveys of *H. wrightii* were completed the fall of 1989 and 1991-2001. Study sites were established to provide data on seasonal change in canopy height, short shoot density, and areal coverage for *H. wrightii*, *R. maritima* and *C. prolifera*, however, monitoring of *R. maritima* and *C. prolifera* at specific study sites has been discontinued. As *H. wrightii* areal coverage increased beyond the limits of the study sites, coverage assessments shifted from on site measurements to estimates using aerial photography. Generally, study sites were monitored three times a year until 2000 when winter assessments were added.

In 1996, the BSG established thirteen seagrass transects in anticipation of the Tampa Bay seagrass monitoring program coordinated by the Tampa Bay Estuary Program (TBEP) and the Southwest Florida Water Management District's Surface Water Improvement Management program (SWIM). The monitoring program, which commenced in the fall of 1998, incorporates many ideas outlined in the Comprehensive Conservation and Management Plan produced by TBEP. This plan aims to restore and protect Tampa Bay seagrass meadows principally through the management of nitrogen discharges to the bay. The BSG is one of several agencies involved in the coordinated seagrass monitoring program. Participation in this program may result in future changes to the BSG seagrass monitoring protocol.

The BSG transplanted *H. wrightii* into Hillsborough Bay in 1987 and 1989. Monitoring of *H. wrightii* transplants in Hillsborough Bay has been discontinued due to coalition with naturally occurring coverage. Data for transplants were included in the reports submitted through 1994. Transplant coverage is now included as part of the baywide *H. wrightii* areal coverage estimate.

The purpose of the BSG seagrass program is to monitor changes of SAV, excluding drift macroalgae, in Hillsborough Bay because seagrass is an important Tampa Bay habitat that may also serve as an indicator of water quality. However, the seagrass program is not intended to link the discharge from the Howard F. Curren Advanced Wastewater Treatment Plant with changes in the seagrass community.

This is the thirteenth annual report submitted to the Florida Department of Environmental Protection (FDEP) to satisfy the requirements set forth in Reclaimed Water and Effluent Limitations and Monitoring Requirements condition #10 of the Howard F. Curren WWTP operation permit FL0020940-001-DW1P.

METHODS

The BSG seagrass program has been modified several times since 1986. A report by the BSG in 1988, "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 monitoring design for the naturally occurring seagrass and *C. prolifera* projects through the 1991 spring survey. It does not, however, contain seagrass transplant information and project modifications made after the 1991 spring survey. Transplant information and methods used to evaluate SAV during 1991, 1992, and 1993 were discussed in the annual report submitted to DEP in March, 1994.

Study Sites

Halodule wrightii:

The intertidal and shallow subtidal flats around the perimeter of Hillsborough Bay were divided into twelve seagrass study areas (Figure 1). An additional seagrass study area was added in 1994 to include the northern spoil disposal island, 2-D. Within each of the thirteen seagrass study areas, at least one patch of *H. wrightii*, if present, was chosen as a seagrass study site.

Each study site is evaluated on a seasonal basis. During each visit to a study site, short shoot density, blades per short shoot, and blade length are measured. Short shoot density is determined using a $100cm^2$ (10cmx10cm) square. Blade length (emergence from the short shoot basal stalk to tip of the blade) is measured to the nearest centimeter. Subjective evaluations concerning epiphytes and seagrass health are recorded. Epiphytic cover is rated as clean, light, moderate, or heavy. Seagrass appearance is rated as poor, fair, good, or very good. Salinity, water temperature, dissolved oxygen, pH, and water depth are recorded. However, only the short shoot density and blade length data are presented as the purpose of this report is to present changes in SAV excluding macroalgae.

Ruppia maritima:

One *R. maritima* transect was established in western Hillsborough Bay in 1987 and discontinued in 1992. Species verification and observations on inflorescence are made during the seasonal visits to the thirteen seagrass study areas.

Caulerpa prolifera:

Five *C. prolifera* transects (Figure 2) in Hillsborough Bay were visited seasonally through the fall of 1994. However, due to the paucity of *C. prolifera* in Hillsborough Bay in 1995, the BSG discontinued detailed investigation of these five transects pending the potential return of significant *C. prolifera* coverage. Results for transect coverage through 1994 may be found in the 1995 report.

TBEP Transects:

The BSG established thirteen transects in the fall 1996 in order to follow spatial and temporal seagrass trends. Eleven transects are in Hillsborough Bay and two in Middle Tampa Bay (Figure 3). Four of these transects traverse historical SWIM seagrass study sites. The transects are divided into 100m sections and range between 160-1360m in length.

Each transect is visited annually, during the fall, and the coverage of each seagrass species is estimated using a 1x1 meter square. Along each transect, meter squares are placed at a minimum of 25m intervals except at the 100m section traversing the seaward edge of the seagrass meadow. Meter square placement is at 10m intervals along this section. Coverage for each seagrass species within each meter square is estimated using the Braun Blanquet rating system. The system incorporates ratings of 0-5 where: a) 0 represents the absence of coverage, b) 0.1 represents a single short shoot c) 0.5 represents less than 1 percent coverage, d) 1 represents 1-5 percent coverage, e) 2 represents 6-25 percent coverage, f) 3 represents 26-50 percent coverage, g) 4 represents 51-75 percent coverage, h) 5 represents 76-100 percent coverage, and I) "reported" represents coverage found along the transect, but which did not fall within meter square placements. Generally, the "reported" category is used for noting seagrass in areas which previously have not had coverage.

The water column depth is recorded at the meter square placements along each transect. The data are used to generate a bottom contour for each transect, however, the profile is not related to an elevation datum nor are the data corrected for tidal stage.

Information on seagrass characteristics, hydrographic conditions, and photosynthetic active radiation (when sufficient water column depth allows measurements) is collected where each transect traverses the mid and edge portion of the seagrass bed, and the two meter water depth contour. In addition, water sample from each collection site are taken at mid depth for chlorophyll *a* and turbidity analysis. These data are not included in this report (see above).

Areal Coverage

Photographs taken from high and low altitudes are used to aid in the determination of SAV coverage for each seagrass study area of Hillsborough Bay. Specifically, high altitude aerial photographs (ca. 1000-3000ft.) are used to estimate areal coverage where SAV is present in a large, continuous meadow. After a scale is determined for each photograph, a grid composed of 1x1mm squares is placed over the photograph. The number of $1mm^2$ squares covering a SAV signature in the

photograph is counted and the areal extent of the SAV is determined by multiplying the number of squares counted times the scale determined for a square. Further, low altitude (ca. 500ft.) overflights are generally conducted monthly and are used to locate and enumerate small *H. wrightii* patches not seen in the high altitude photographs. In addition, the monthly reconnaissance flights assist in tracking the development of SAV during the year.

Intertidal and shallow subtidal flats which have the potential for SAV coverage are visited on foot in the fall. During each visit, SAV seen in the low and high altitude photographs is groundtruthed. In addition, any SAV not seen on the photographs is documented. Small patches of *H. wrightii* are enumerated and measured and the area of each patch determined using the formula for an ellipse. There may be occasions where SAV, although widespread, is too patchy to determine the areal coverage from photographs. If the SAV coverage cannot be determined from photographs or groundtruth efforts, the areal coverage is estimated by calculating the percent cover of each species in an area of known acreage.

In the fall of 1997, the BSG began using a global positioning system (GPS) to accurately map large areas of seagrass. The GPS instrument is composed of a Trimble Pro XR differential receiver interfaced with a Trimble TDC1 Asset Surveyor and is capable of recording positions with sub-meter accuracy. The BSG employs the instrument by following the perimeter of a seagrass bed and automatically recording positions every five seconds. Subsequently, the data are downloaded into a PC using the Trimble Pathfinder Office software. In this software, seagrass coverage is mapped on a Tampa Bay base map (ARC-INFO Mapping Data, Southwest Florida Water Management District, 1996). Areal coverage calculations can then be performed.

The terms patchy and continuous are subjective terms used in this report to describe seagrass coverage. Patchy coverage may be viewed as small areas of seagrass or developing patches of seagrass. Generally, these patches are less than fifty meters in diameter and cover less than 2000m^2. Patchy coverage may, in time, coalesce into continuous coverage.

RESULTS AND DISCUSSION

Two species of seagrass, *H. wrightii* and *R. maritima*, and the attached alga, *Caulerpa prolifera*, have been documented in Hillsborough Bay during the course of the seagrass monitoring program. *H. wrightii* and *R. maritima* has been present in the bay each year, however, *C. prolifera* has not been observed since 1997.

Hillsborough Bay Seagrass Coverage 2001

H. wrightii and *R. maritima*, have been observed during the 2001 Hillsborough Bay seagrass survey. *H. wrightii* coverage in Hillsborough Bay increased about 24 percent from about 68.8ha in 2000 to 85.5ha in 2001 (Figure 4). *R. maritima* coverage was estimated to be about 2ha in 2001, similar to the coverage found in 2000. The maximum *R. maritima* coverage was about 40ha in 1996 but declined rapidly to 6ha in 1997.

H. wrightii coverage was present in each seagrass study area (Figure 1), except Area 6 in McKay Bay, while most of the *R. maritima* coverage was found between the Alafia River and Pendola Point (Areas 4 and 5). *H. wrightii* areal coverage is summarized in Table 1.

H. wrightii coverage for the southeastern, northeastern, northwestern, and southwestern portions of Hillsborough Bay is illustrated in Figures 5, 6 ,7, and 8, respectively. These figures are intended to present the general areal extent for *H. wrightii* and are not used for areal coverage calculations.

Seagrass Study Areas and Transects

Results for seagrass distribution and abundance for each transect are reviewed concurrent with a discussion of seagrass areal coverage for each of the thirteen seagrass study areas of Hillsborough Bay (including McKay Bay). In addition, a general topographic profile of each transect is illustrated. There are no transects currently established in Areas 1, 7, and 13. Transects 14 and 15 are outside the boundaries of Hillsborough Bay and the results for the transects will be presented without a discussion of areal coverage.

Seagrass Study Area 1:

H. wrightii coverage in Area 1, near the Tampa Electric Company Big Bend power generating plant declined from about 3500m^2 in 2000 to about 2000m^2 in 2001 (Figure 9). Most of the loss occurred along the east side of Fishhook spoil. There was no *R. maritima* reported in this area.

Seagrass Study Area 2:

H. wrightii and *R. maritima* have been documented in Area 2, which includes the Kitchen in southeastern Hillsborough Bay (Figure 5). *H. wrightii* coverage in this area did not change appreciably between 2000-2001 (Figure 10). *R. maritima* has been found predominantly along the shoreline in the eastern portion of the Kitchen. Generally, sparse coverage has been noted in this area although 29ha was documented in 1996. The *R. maritima* coverage seen in 1996 rapidly diminished to 1000m^2 by 2000. No *R. maritima* was observed in this area in 2001.

Transect S2T2 (Figure 11), which traverses east to west through the Kitchen, illustrates the distribution and Braun Blanquet coverage rating of seagrass in the area. Along this transect, *H. wrightii* presence has been recorded each year. *R. maritima* was seen only in 1997. Generally, *H. wrightii* coverage has been stable with the exception of some minor recolonization between 600-850m in 1999. However, this coverage was absent in 2000. *H. wrightii* abundance appears to be increasing from that found in 1999-2000, especially in the 200-400m segment.

Seagrass Study Area 3:

In Area 3, between the Kitchen and the Alafia River, *H. wrightii* coverage increased over 50 percent to about 3.3ha between 2000-2001 (Figure 12). This positive trend follows two consecutive years of loss as the meadow, estimated at nearly 5.5ha in 1998, became fragmented and coverage waned. *H. wrightii* was the only seagrass species noted in this area during 2001.

Braun Blanquet data from Transect S2T3 (Figure 13), which runs west from the mouth of Bullfrog Creek, illustrates the patchiness of *H. wrightii* in this area. Although several *H. wrightii* patches were reported along the transect during each year, few meter square placements contained any seagrass in each survey.

Seagrass Study Area 4:

After reaching 9000m^2 in 1997, *H. wrightii* coverage between the Alafia River and Archie Creek declined to 200m^2 in 1999 (Figure 14). However, *H. wrightii* coverage increased to about 2000m^2 in 2000 and to about 4000m^2 in 2001.

Generally, *R. maritima* coverage in Area 4 fluctuates from 1ha to 2ha near the mouth of Archie Creek. However, similar to Area 2, *R. maritima* coverage expanded in 1996 to nearly 30ha and subsequently waned in 1997-98. About 1ha of *R. maritima* was estimated to be present in Area 4 during 2001.

Seagrass was not present along Transect S2T4 (Figure 15), however, this transect is located to the south of most *H. wrightii and R. maritima* found in this area.

Seagrass Study Area 5:

Since 1996, *H. wrightii* coverage between Archie Creek and Pendola Point has varied widely as small meadows developed and then fragmented into small patches. In 1997, a small meadow developed ca. 2km north of Archie Creek, however, this area became fragmented in 1998. Similarly, in 2000, coverage expanded to about 4.4ha as a large meadow developed just north of the Delaney Creek Pop-off Canal (Figure 6), however, this meadow became very patchy in 2001 resulting in a decrease in coverage in Area 5 to about 1.3ha (Figure 16).

A nearly continuous band of *R. maritima* has persisted from north of Archie Creek to the Pendola Point peninsula since the early 1990s. Coverage in a Area 5 has been estimated at 2ha since 1999.

In 1997, there was a mixture of *H. wrightii* and *R. maritima* along the first 120m of Transect S2T5 (Figure 17). Braun Blanquet data from the transect survey illustrates the decrease in abundance and loss of *R. maritima* and *H. wrightii* along the 10-120m section of the transect since 1997. *R. maritima* and *H. wrightii* coverage did not change significantly between 1998 and 2001 along Transect S2T5.

Seagrass Study Area 6:

H. wrightii has never been observed in McKay Bay (Figure 1) during the BSG seagrass study. Since 1986, there have been scattered patches of *R. maritima* develop then disappear in northwest and southeast McKay Bay. Patchy *R. maritima* coverage has been recorded within the first 50m of Transect S2T6 in the past two years (Figure 18).

Seagrass Study Area 7:

This study area encompasses the Davis Island shoreline. About 300m^2 of *H. wrightii* was discovered in the northeast section of the seaplane basin (Figure 7) in 1997 and has been the only seagrass species noted in Area 7. *H. wrightii* coverage in this area has changed little since 1997 (Figure 19).

Seagrass Study Area 8:

Between 1996 and 1998, patchy *H. wrightii* and *R. maritima* coverage developed on the shallow flats near the intersection of Bayshore Boulevard and Bay to Bay Boulevard (Figure 7). Since 1999, however, *H. wrightii* coverage has diminished from 200m^2 to about 10m^2 (Figure 20) as many patches disappeared. Further, the small patches of *R. maritima* that were noted during 1997 have been absent since 1998.

Some very sparse *H. wrightii* coverage was documented along Transect S2T8 in 2000 (Figure 21). There was no *H. wrightii* seen on Transect S2T8 in 2001.

Seagrass Study Area 9:

H. wrightii was the only seagrass species reported in Area 9 since 1998. Coverage in this area has remained near 1ha since 1994 (Figure 22). Most of the coverage was found just north of Ballast Point along Bayshore Boulevard (Figure 7).

Seagrass distribution and abundance along Transect S2T9 has not changed appreciably since 1997. Braun Blanquet data from Transect S2T9 (Figure 23) indicates a band of continuous to patchy *H. wrightii* coverage beginning approximately 20m from the seawall and ending at the 70m mark. The coverage pattern found along this transect is typical of the *H. wrightii* distribution found in this area.

Seagrass Study Area 10:

H. wrightii coverage in Area 10 has continued to increase since 1997 (Figure 24). Most of the new coverage developed between southern Ballast Point and the northern boundary of Macdill Air Force Base. Since 1998, there has been a nearly continuous band of *H. wrightii* between Ballast Point and the navigation channel on the east side of Macdill Air Force Base (Figure 8) as *H. wrightii* has began to recolonize the flats within 300m of the shoreline. In 2001, the areal coverage in Area 10 was estimated to be 11.4ha, a 54 percent increase from 2000.
Small areas of *R. maritima* were documented between Macdill Air Force Base and Ballast Point since 1997. No *R. maritima* was noted in Area 10 in 2000 or 2001.

Seagrass coverage along Transect S2T10 included *H. wrightii* and *R. maritima* in 1997 (Figure 25), however, only *H. wrightii* has been observed since 1998. *H. wrightii* coverage has continued to increase between the 100m-300m sections of the transect.

Seagrass Study Area 11:

H. wrightii in Area 11 had been characterized by relatively large fluctuations in annual coverage between 1994 and 1999. However, in the past three years, numerous *H. wrightii* patches have developed from just north of Catfish Point southward to Gadsden Point (Figure 8). In addition, many of these patches have coalesced to form a ca. 15ha meadow at Catfish Point. *H. wrightii* coverage in Area 11 was determined to be nearly 20ha during 2001 (Figure 26).

Prior to 2000, a narrow band of *R. maritima* was documented shoreward of the *H. wrightii* coverage found just north of Catfish Point. However, no *R. maritima* was noted in Area 11 in 2000 or 2001.

There are two transects in Area 11 (Figure 1). Generally, coverage along Transect S2T111 (Figure 27) has been comprised of *H. wrightii* along the first 100m section and has changed little since 1997. *H. wrightii* noted along the 250m-350m portion of the transect probably represents the northern edge of the offshore coverage which has developed between Catfish Point and Gadsden Point.

Seagrass was found on Transect S2T112 for the first time in 1999 (Figure 28). The patchy *H. wrightii* coverage seen in 2000 coalesced in 2001 illustrating the development of the meadow found on Catfish Point.

Seagrass Study Area 12:

H. wrightii coverage in Area 12 has expanded rapidly since 1999. *H. wrightii* coverage increased nearly threefold to 11.2ha during 1999-2000 as discrete patches continued to form, expand, and coalesce. Between 2000-2001, *H. wrightii* increased nearly 50 percent to 16.6ha (Figure 29) resulting in a sizable meadow between Gadsden Point and the Macdill AFB marina (Figure 8).

Patchy *R. maritima* was noted in Area 12 prior to 1999, however, this seagrass species has not been present in this area during the past three years

Seagrass coverage documented along Transect S2T12 (Figure 30) indicates the rapid *H. wrightii* expansion after 1998. The graphic illustrates the formation of the *H. wrightii* meadow between 400m-700m from the shoreline.

Seagrass Study Area 13:

H. wrightii has been the only seagrass species reported in this area. *H. wrightii* noted along the eastern and northern shoreline of the spoil disposal island 2-D (Figure 6) in 2000 persisted through 2001. *H. wrightii* coverage adjacent to a small spoil island just to the east of 2-D increased between 2000 and 2001. *H. wrightii* coverage in Area 13 was determined to be about 1.8ha in 2001 (Figure 31).

Seagrass Study Transect S3T12:

Transect S3T12 is located at the mouth of Broad Creek on the south end of Interbay Peninsula. Information from Transect S2T12 (Figure 32) indicates that *H. wrightii* coverage increased along the transect each year between 1997 and 2001. In 2001, a nearly continuous meadow was present from 50m from the shoreline seaward to the 860m placement.

Sparse to patchy *R. maritima* found in the first 100m of Transect S3T12 in 1997-1998 (Figure 32) has been absent since 1999.

Seagrass Study Transect S3T13:

Transect S3T13 is located at the mouth of Wolf Branch Creek south of Apollo Beach. Data from this transect (Figure 33) indicates that the seaward edge of the *H. wrightii* meadow has receded about 50m since 1998. In addition, the Braun-Blanquet rating from 300-350m has decreased indicating that this seaward edge thinned considerably between 2000-2001.

Very sparse *R. maritima* persisted in the first 100m segment of the transect between 1998-1999, however, this species was not observed in 2000 or 2001.

Seasonal Trends for *Halodule wrightii* Blade Length and Short Shoot Density

Seasonal values for *H. wrightii* blade length (seagrass canopy height) are presented in Figure 34. These data indicate that blade lengths are short in the winter and spring, usually attaining maximum canopy height in the summer, and may retain the summer canopy height through the fall. Generally, blade lengths are substantially shorter in the spring as compared to summer and fall. The median blade lengths are generally longest in the summer, although the lengths are not considerably different than the fall values.

Seasonal values for *H. wrightii* short shoot density are presented in Figure 35. Generally, the short shoot mean density is lowest in the winter and spring. Although the median short shoot density reported for the winter 2001 was similar to the 2000 value, there was a much greater range of densities in 2001. The short shoot mean density usually increases by the summer and is similar to the density found in the fall. Although there appears to be seasonal trends, generally there are no notable differences between seasonal short shoot densities. Finally, there appears to be an interannual trend of decreasing short shoot density between 1996 and 1999.

Caulerpa prolifera

Two *C. prolifera* meadows have developed then degenerated in Hillsborough Bay since 1986. In western Hillsborough Bay, a 40 fold increase in coverage from about 5ha to 200ha was documented between April and December of 1986 (Figure 36). The areal coverage of this meadow was reduced by 90 percent in the fall of 1988 immediately following a "25 year" rainfall event which lowered salinities to 2PSU in some areas of Hillsborough Bay. The decline of this *C. prolifera* coverage is probably a result of extended exposure to unusually hyposaline conditions. Similarly, in an area south

of Pendola Point, the alga expanded from 8000m^2 in 1987 to 190ha in 1990. Following this maximum, *C. prolifera* coverage quickly diminished to 10ha in 1991 and was not noted after 1994. However, these losses do not appear to be related to major rain events. *C. prolifera* has not been observed in Hillsborough Bay since 1996.

CONCLUSION

Recolonization of *H. wrightii* into most intertidal and shallow subtidal areas of Hillsborough Bay has occurred concurrent with improving water quality. *H. wrightii* recolonization between 2000-2001 resulted in a 17ha net increase of seagrass coverage in Hillsborough Bay. This positive change continues the trend seen in 1999-2000 when a net increase of 13ha was reported.

Prior to 2000, most of the *H. wrightii* recolonization had occurred in the Kitchen (Area 2, Transect S2T2), however, in the past two years, *H. wrightii* has rapidly recolonized the flats south of Catfish Point (Area 11, Transect S2T112) and west of Gadsden Point to the Macdill AFB marina (Area 12, Transect S2T12). Meadows in these areas now comprise over 40 percent of the 85.5ha of *H. wrightii* coverage found in Hillsborough Bay. Similarly, *H. wrightii* meadows continue to develop between Ballast Point (Area 10, Transect S2T10) and Macdill AFB, though not as rapidly as the coverage seen along the southeastern Interbay Peninsula. Seagrass recolonization between Ballast Point and the Macdill AFB marina is now driving the recovery of seagrass meadows in Hillsborough Bay as over 35ha of *H. wrightii* has developed in this area in the past two years.

In contrast to the increased seagrass coverage seen in western and southwestern Hillsborough Bay, little change in *H. wrightii* coverage was noted in other areas except Area 4. *H. wrightii* coverage in Area 4 decreased about 70 percent as the meadow located just north of Archie Creek became fragmented.

Although seagrass areal coverage in Hillsborough Bay has started to increase following the period of stagnation seen during the "El Nino" period from 1997-1999, coverage in many areas has changed little or decreased in recent years. Data generated by traditional water quality monitoring programs suggest that conditions are adequate for seagrass recolonization to continue (see the City of Tampa report submitted to the Florida Department of Environmental Protection on May 1, 2002 entitled "Results of the City of Tampa Compliance Monitoring for the Year 2001 and Examination of Long Term Water Quality and Biological Indicator Trends in Hillsborough Bay"). However, these data may not be sufficient to characterize factors which may potentially impede seagrass restoration.

Several areas of Hillsborough Bay have *R. maritima* meadows which vary in size from year to year. In recent years, this species has become a minor component of the seagrass coverage in Hillsborough Bay, although in 1996, it increased to about 40ha, equaling the amount reported for *H. wrightii*. In 2001, *R. maritima* coverage was estimated to be about 2ha, less than 3 percent of the *H. wrightii* coverage in Hillsborough Bay.

C. prolifera has been a major contributor to SAV coverage in the past fifteen years. This alga has been observed growing in deeper waters than *H. wrightii*, suggesting that the alga may be a pioneer SAV species in areas with relatively low light penetration. *C. prolifera* can vegetate large areas in a short period and, conversely, undergo sudden, large scale die-offs. For example, a 90% reduction of the *C. prolifera* meadows in western Hillsborough Bay occurred immediately following exposure to unusually low salinities for an extended period of time in 1988. In other areas, reductions in areal coverage do not appear to be salinity related and occurred more gradually.

Table 1. *Halodule wrightii* coverage (m^2) by area in Hillsborough Bay for the years 1986, 1989, and 1991-2001.

	1986	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AREA													
1	690	700	400	500	2000	2630	2500	3000	5600	3000	3000	3500	2000
2	1125	3300	16300	40801	34000	135000	167000	296000	400000	400000	390000	290000	295000
3	0	0	40	350	250	1200	2500	4500	10800	54300	27000	21000	33000
4	0	0	200	475	500	600	500	1000	9000	1900	200	2000	4000
5	0	0	15	150	600	1200	750	1500	7900	1900	4000	44300	13000
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	300	160	200	200	200
8	0	0	0	0	0	0	0	10	80	90	200	10	10
9	85	140	800	1900	7000	10400	8700	11000	11000	9000	10000	11000	11000
10	40	750	1600	6750	22400	32400	54000	60000	59000	60000	72000	74000	114000
11	0	65	200	650	5000	10500	28500	15000	40000	16700	24000	115200	199000
12	20	20	20	250	1300	2800	17000	11000	11700	22000	30000	112000	166000
13	0	0	0	0	30	100	400	500	600	500	1500	15000	17850
TOTAL	1960	4975	19575	51825	73080	196830	281850	403510	555980	569550	562100	688210	855060

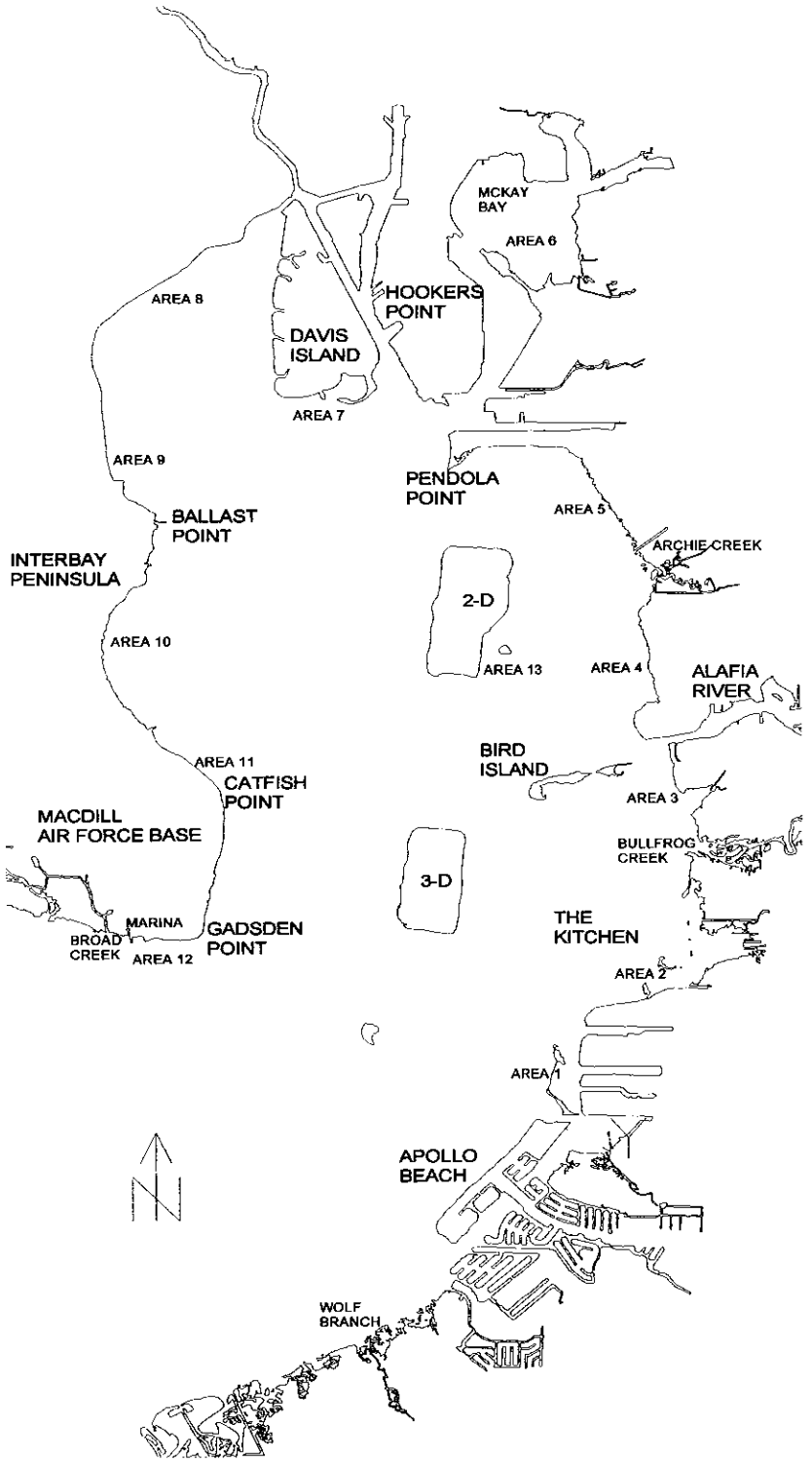


Figure 1. Location of the thirteen seagrass study areas in Hillsborough Bay.

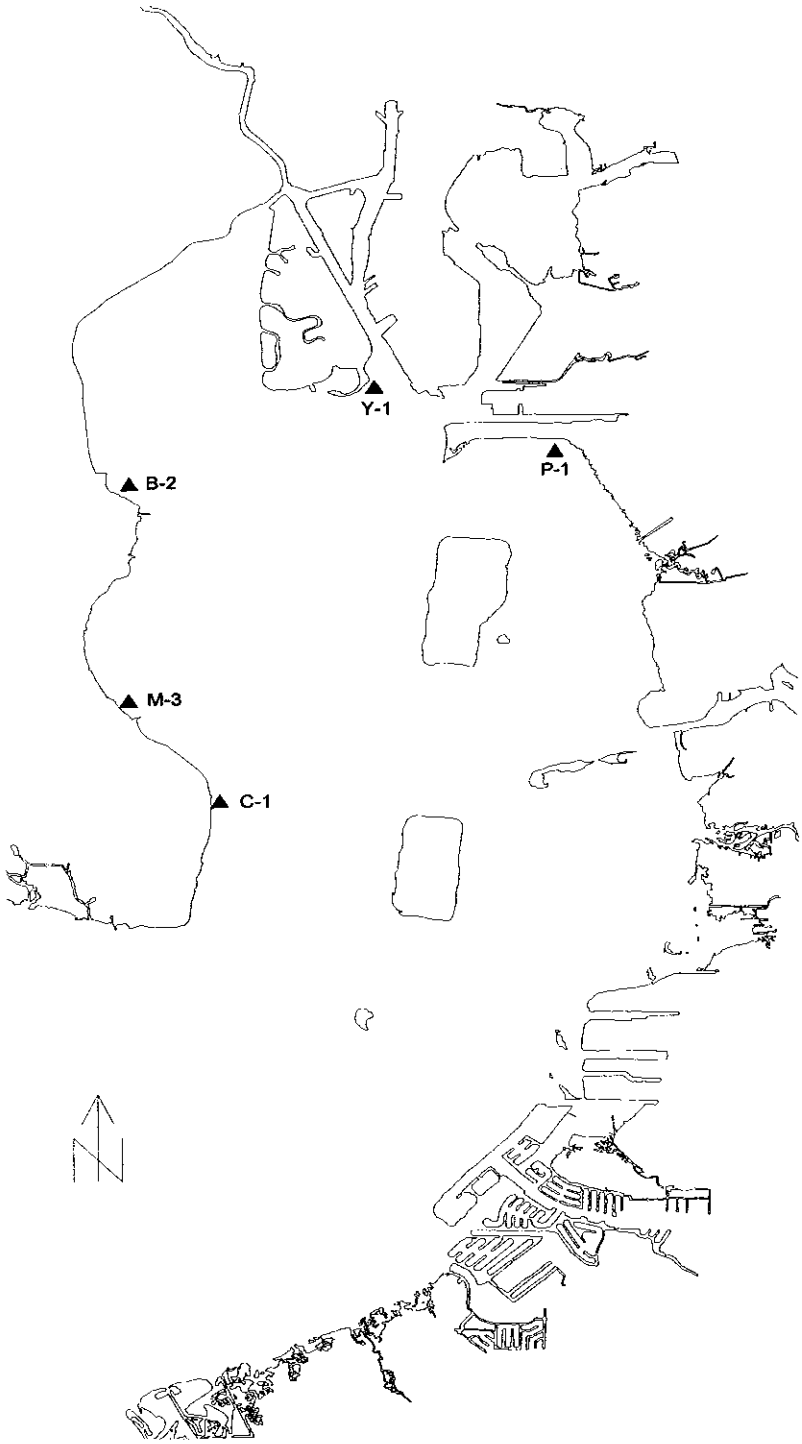


Figure 2. Location of the five *Caulerpa prolifera* transects in Hillsborough Bay.

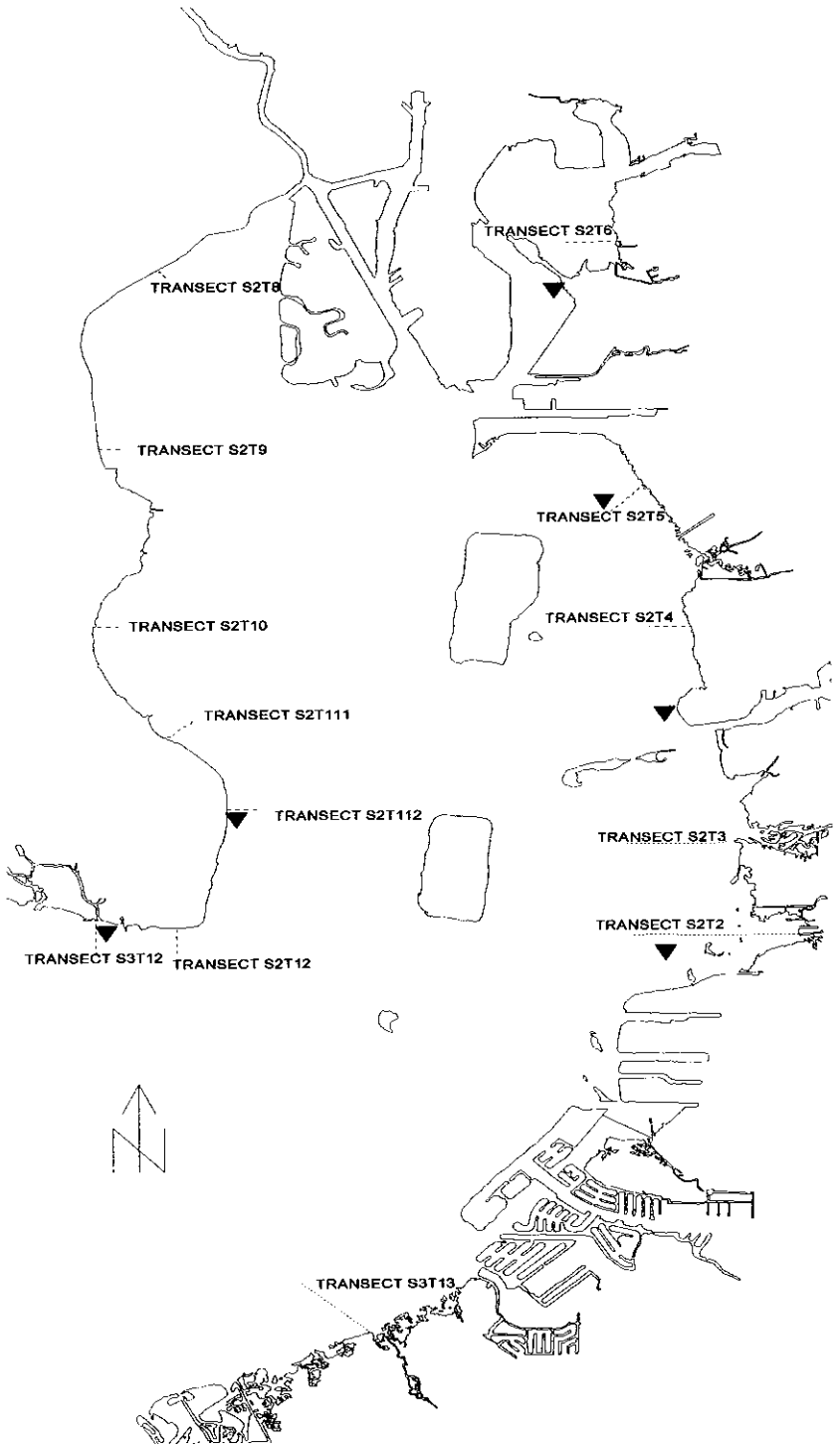


Figure 3. Location of the thirteen Bay Study Group seagrass transects and the SWIM study sites (▼) in Hillsborough Bay.

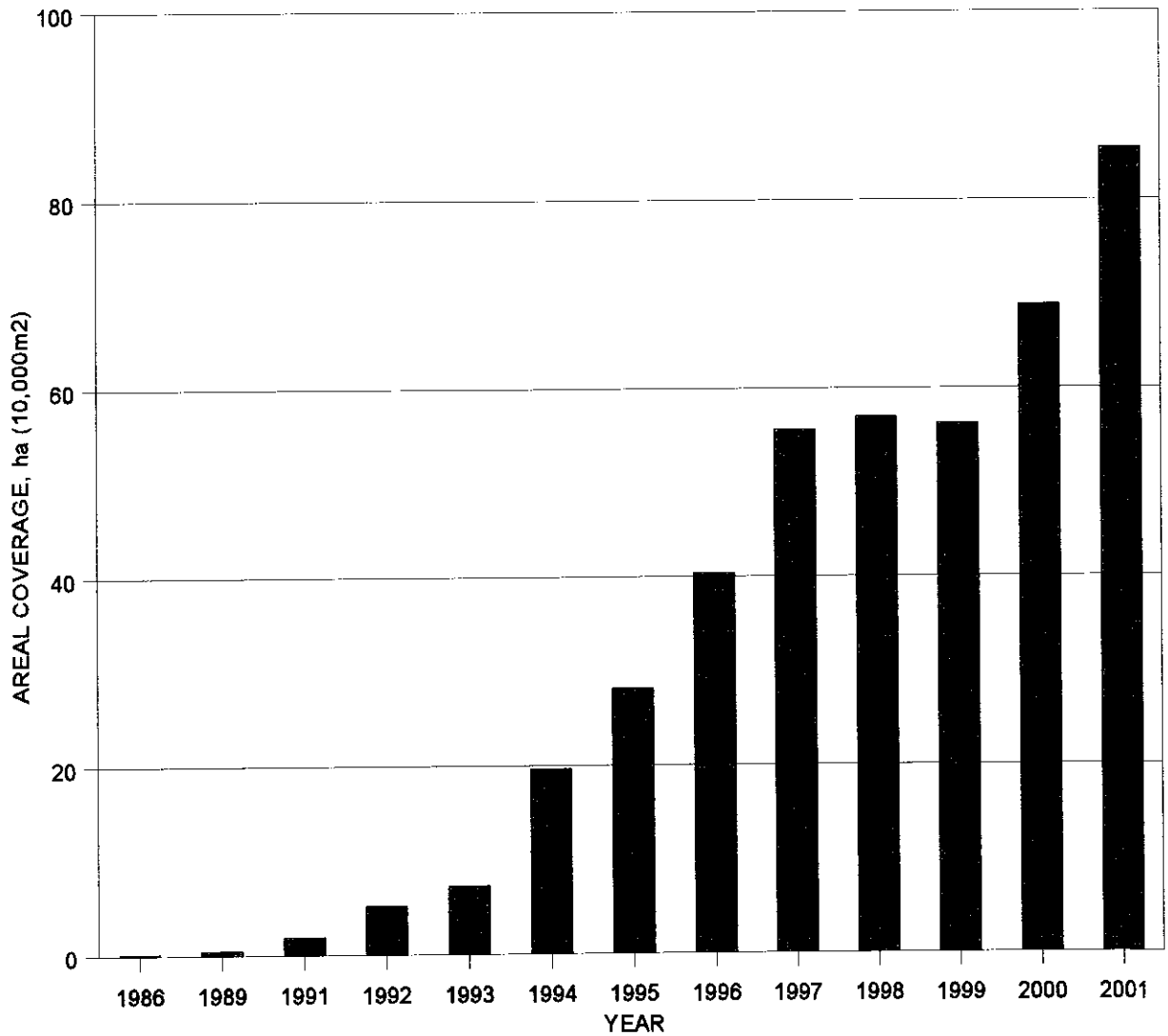


Figure 4. Total *Halodule wrightii* coverage in Hillsborough Bay from 1986-2001.

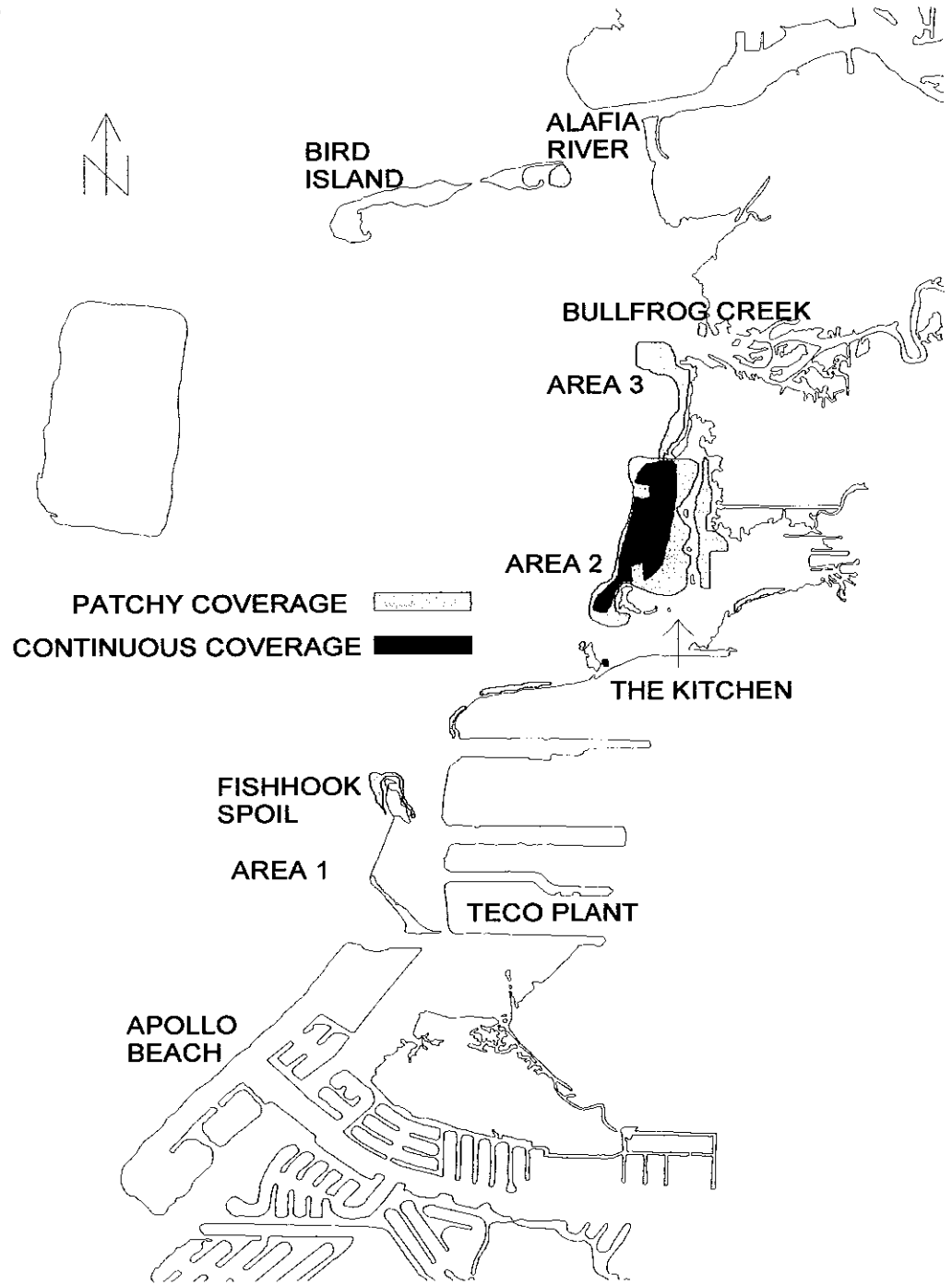


Figure 5. Distribution of *Halodule wrightii* in southeastern Hillsborough Bay (Areas 1, 2, and 3) in 2001.

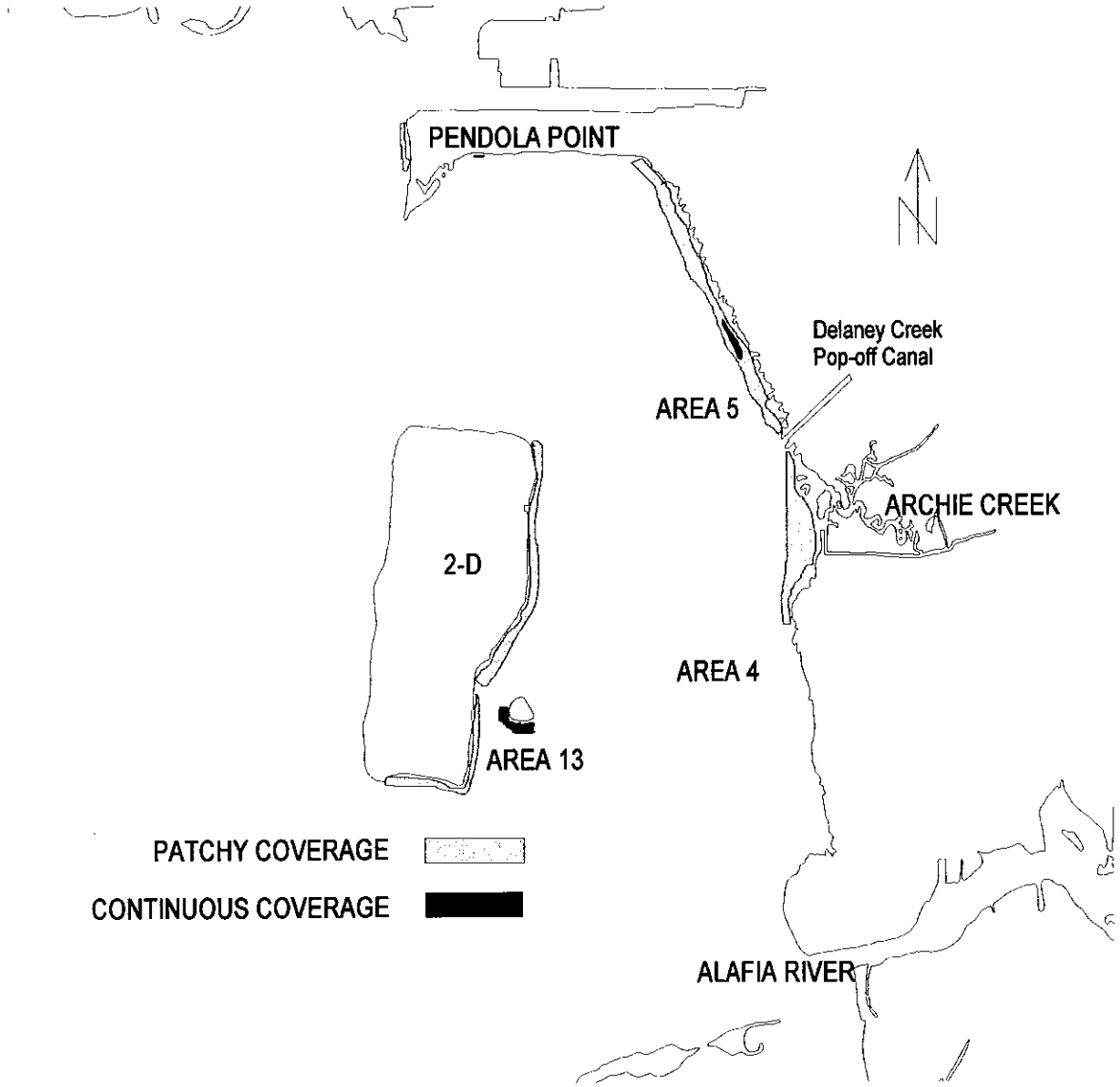


Figure 6. Distribution of *Halodule wrightii* in northeastern Hillsborough Bay (Areas 4, 5, and 13) in 2001.

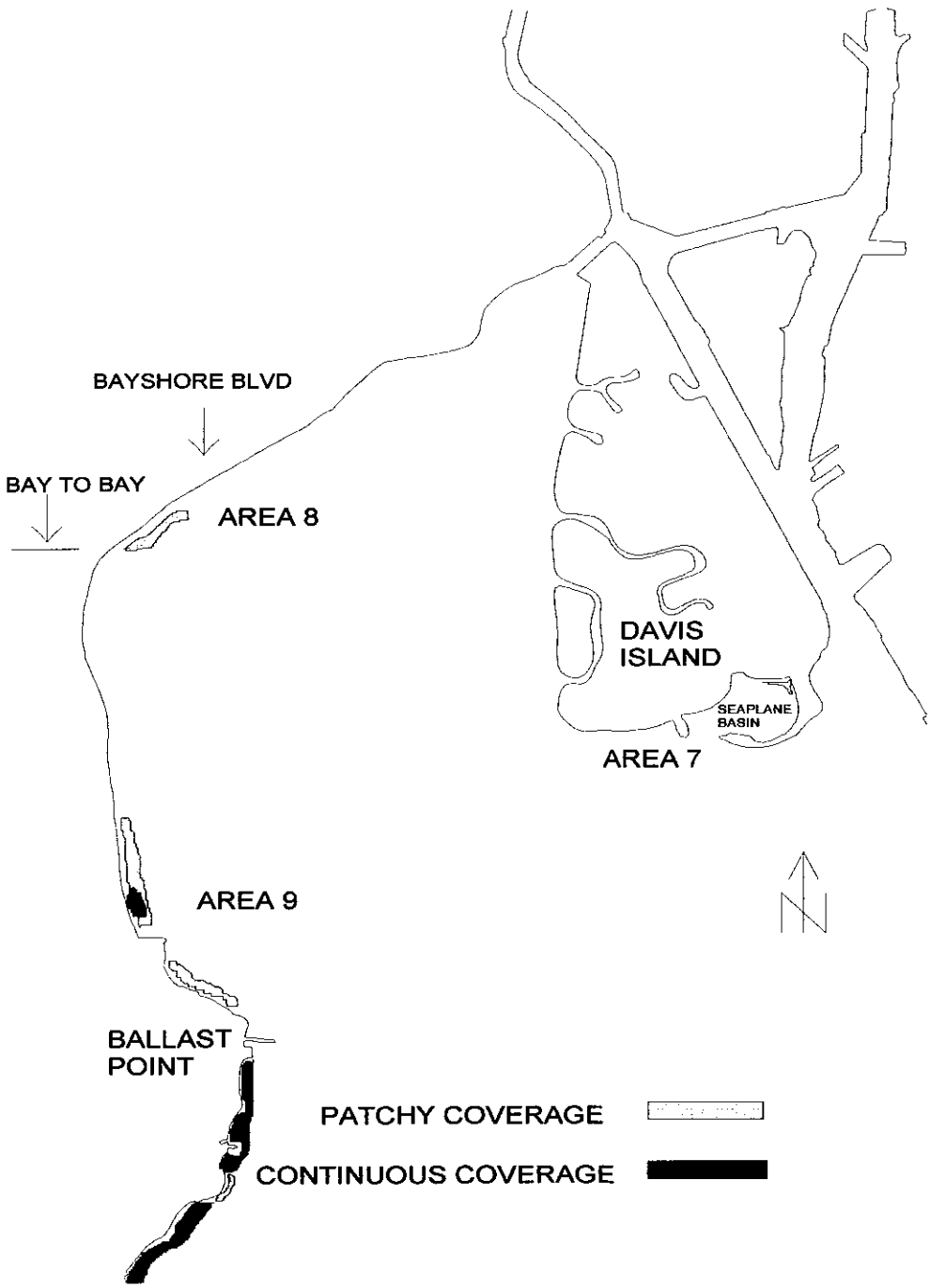


Figure 7. Distribution of *Halodule wrightii* in northwestern Hillsborough Bay (Areas 7, 8, and 9) in 2001.

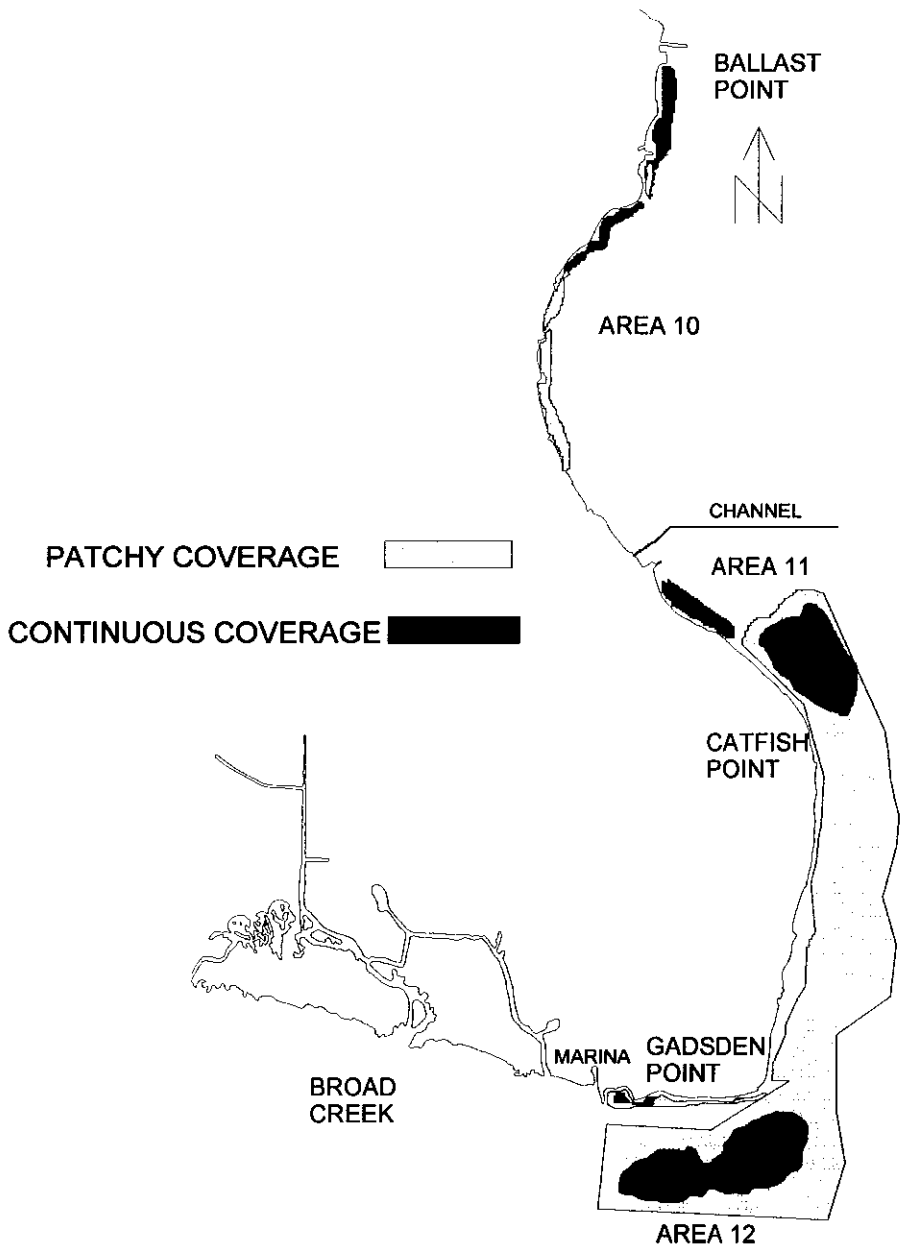


Figure 8. Distribution of *Halodule wrightii* in southwestern Hillsborough Bay (Areas 10, 11, and 12) in 2001.

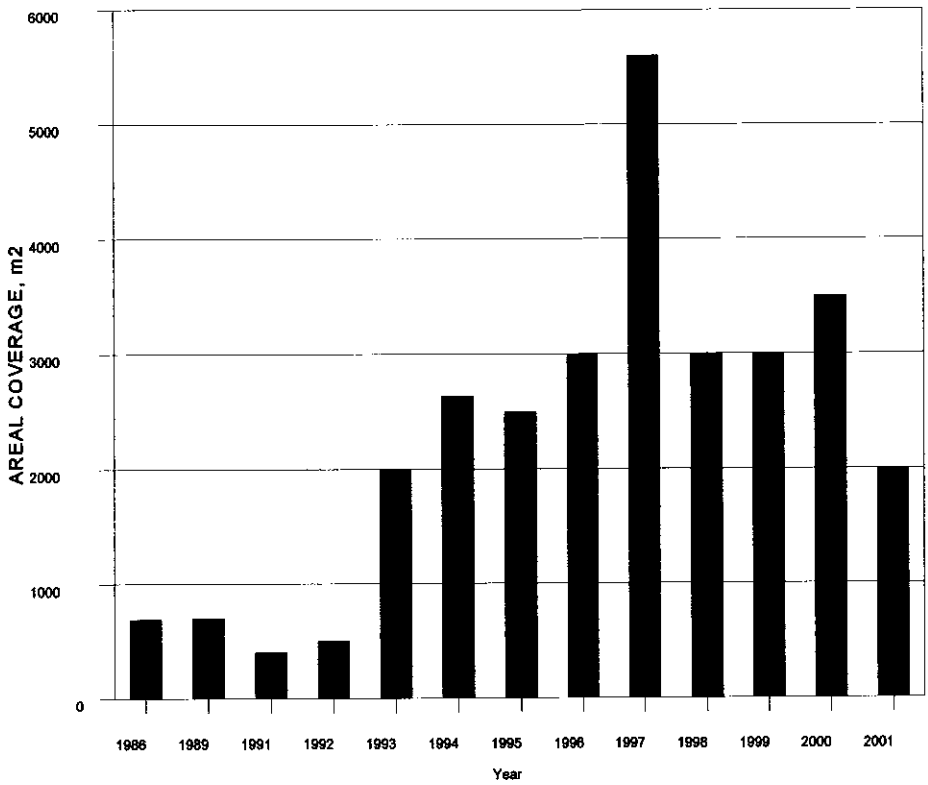


Figure 9. *Halodule wrightii* coverage in Area 1 from 1986-2001.

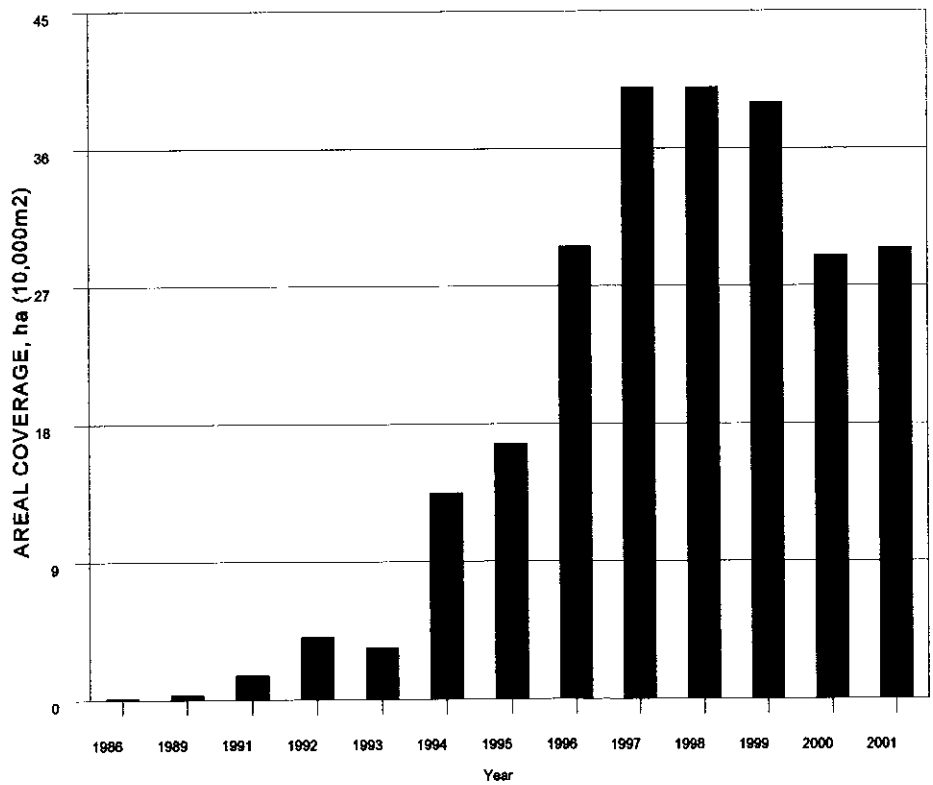


Figure 10. *Halodule wrightii* coverage in Area 2 from 1986-2001.

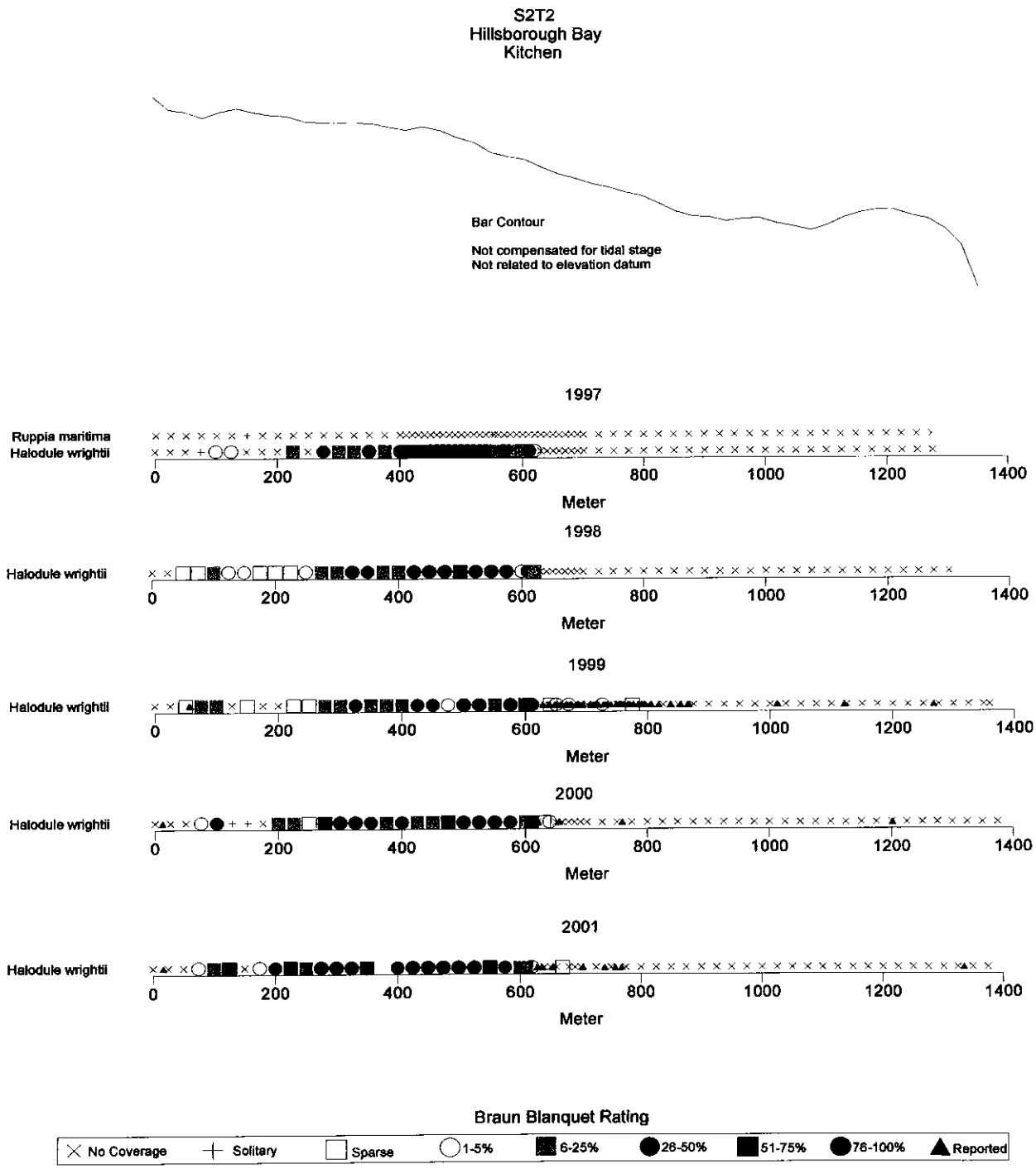


Figure 11. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S2T2 from 1997-2001.

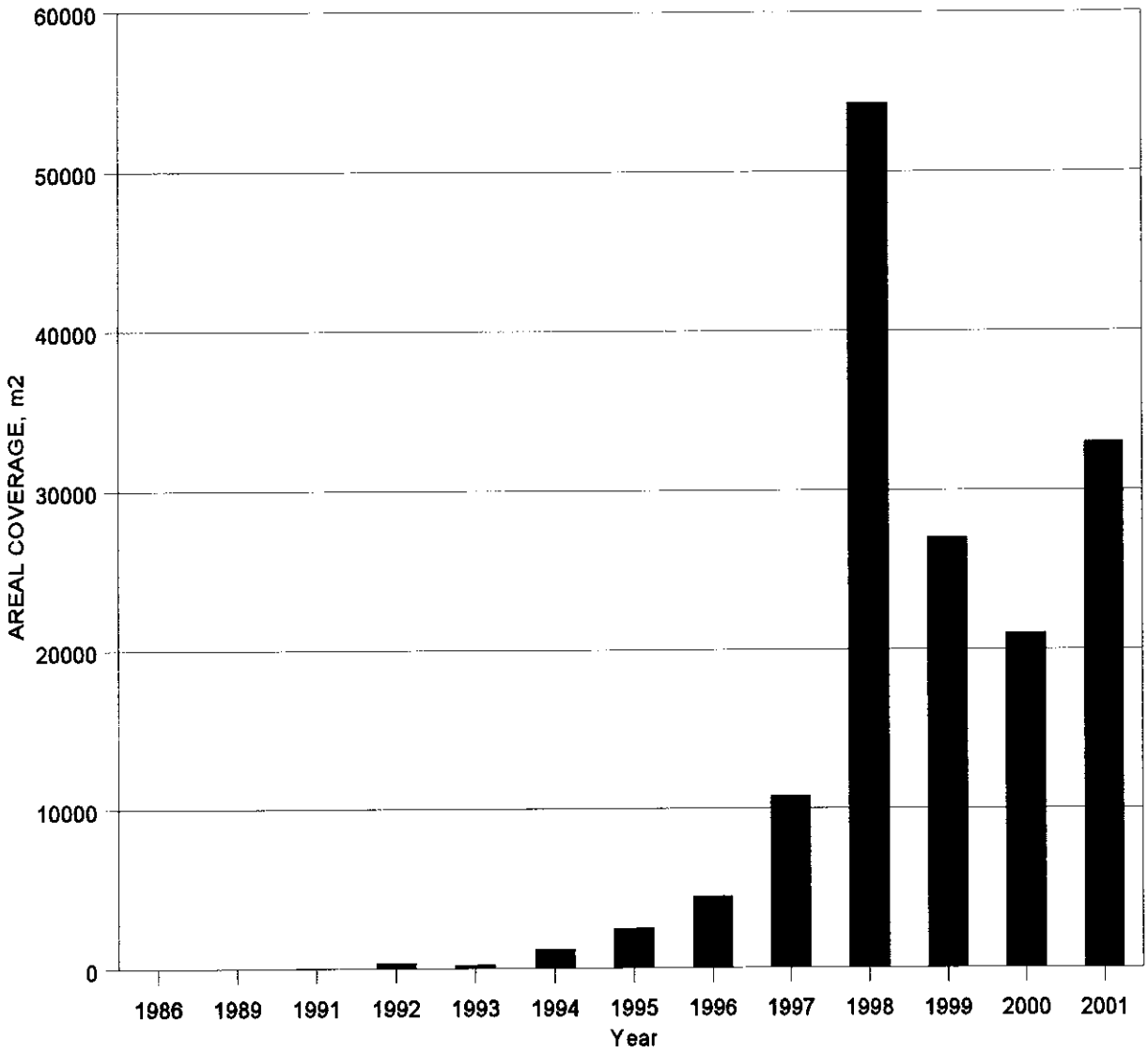


Figure 12. *Halodule wrightii* coverage in Area 3 from 1986-2001.

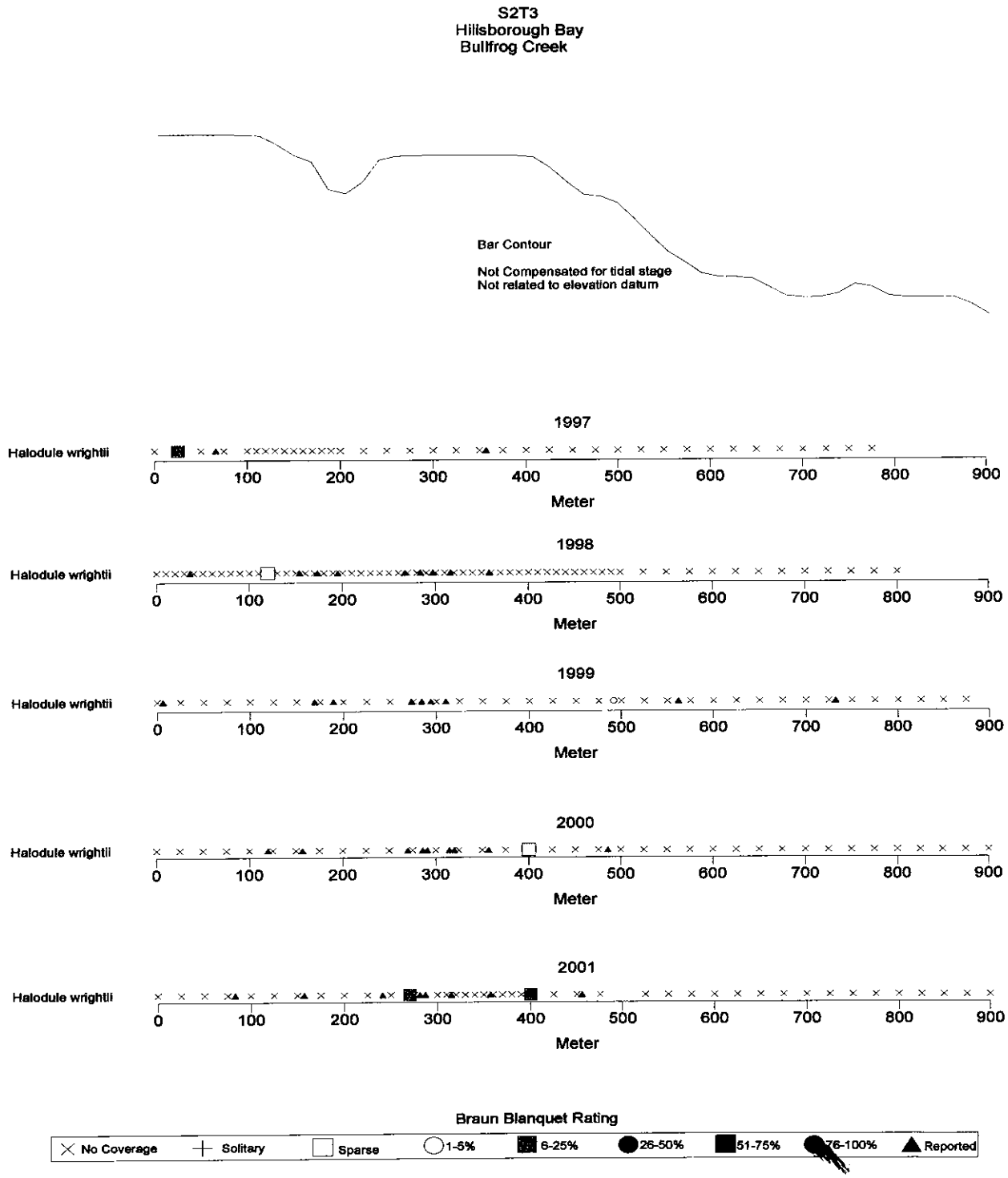


Figure 13. Distribution and abundanc of *Halodule wrightii* along Transect S2T3 from 1997-2001.

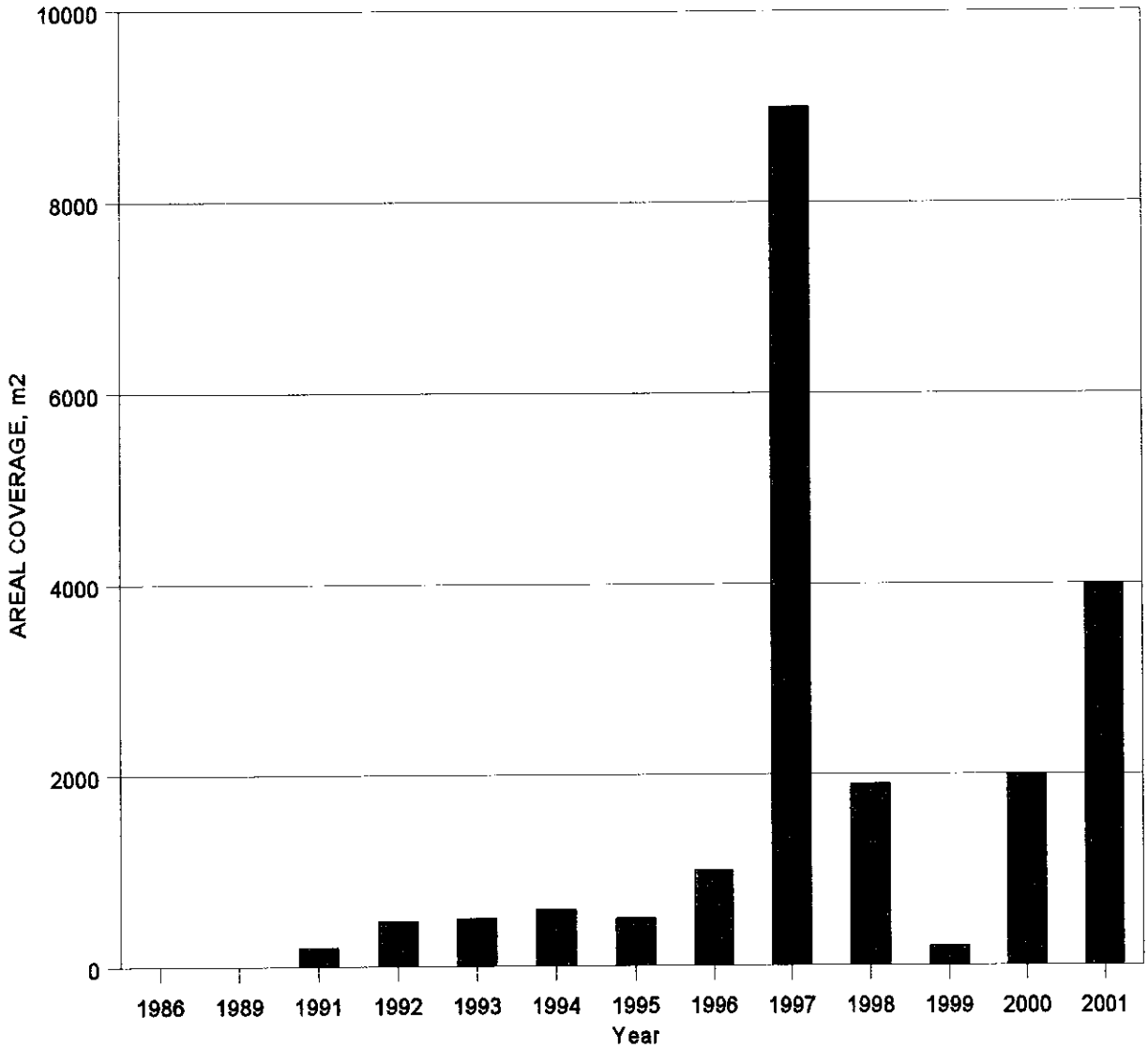
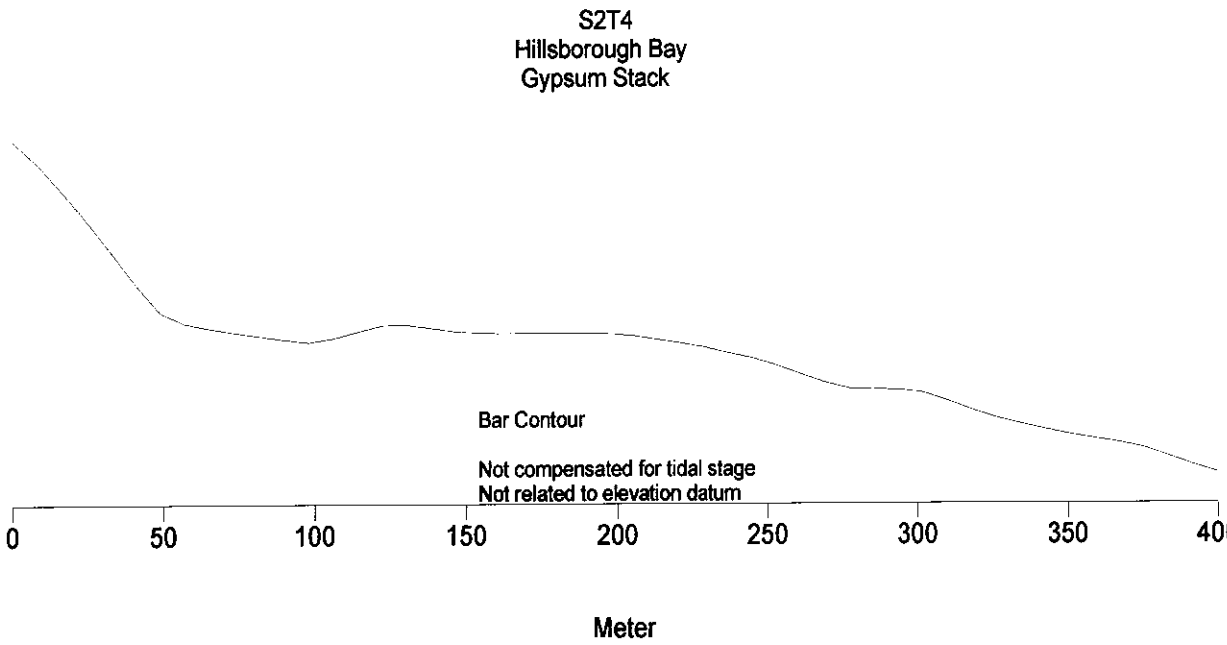


Figure 14. *Halodule wrightii* coverage in Area 4 from 1986-2001.



No SAV reported in 1997, 1998, 1999, 2000, or 2001.

Figure 15. Distribution and abundance of submerged aquatic vegetation along Transect S2T4 from 1997-2001.

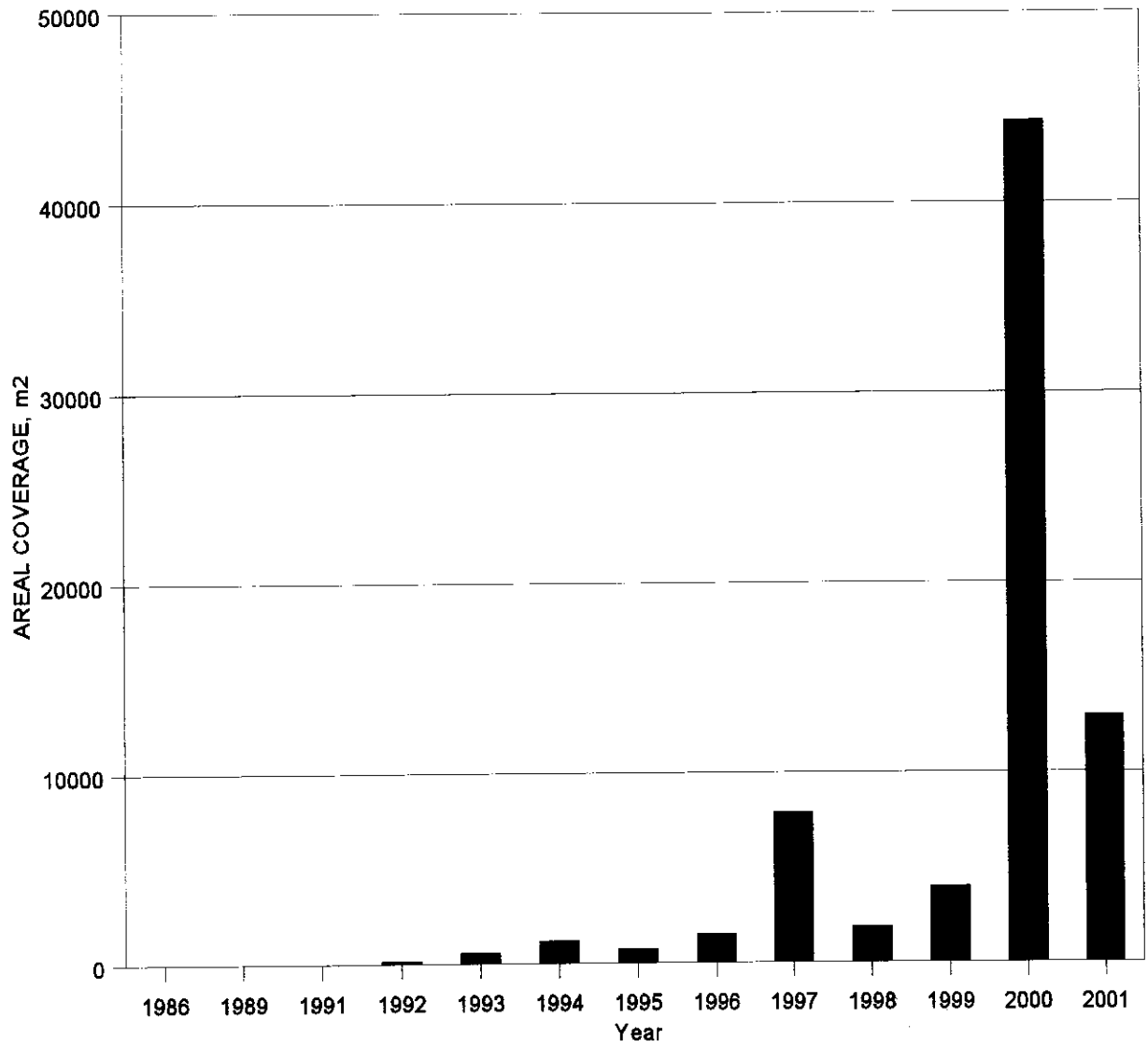


Figure 16. *Halodule wrightii* coverage in Area 5 from 1986-2001.

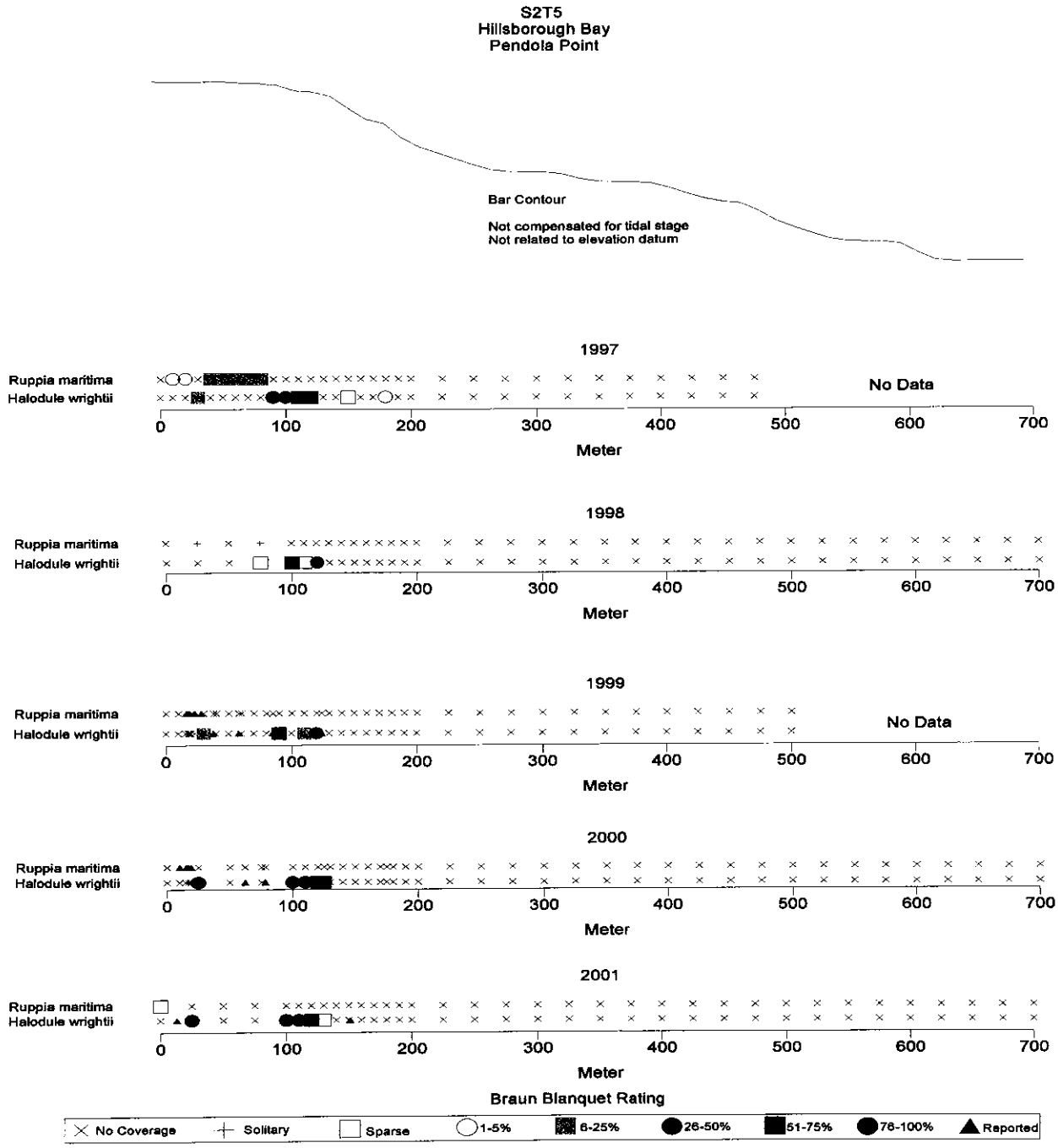


Figure 17. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S2T5 from 1997-2001.

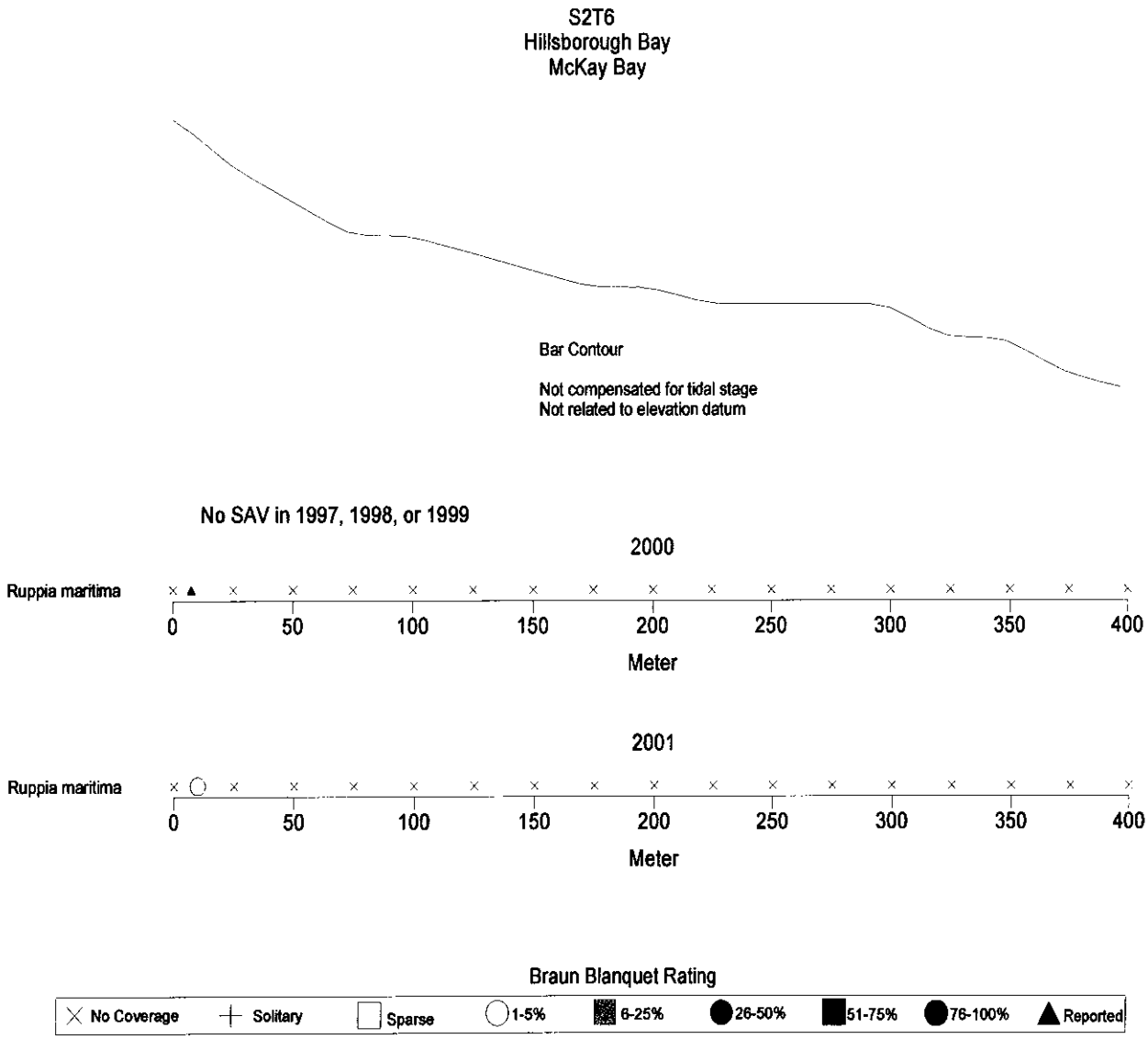


Figure 18. Distribution and abundance of *Ruppia maritima* along Transect S2T6 from 1997-2001.

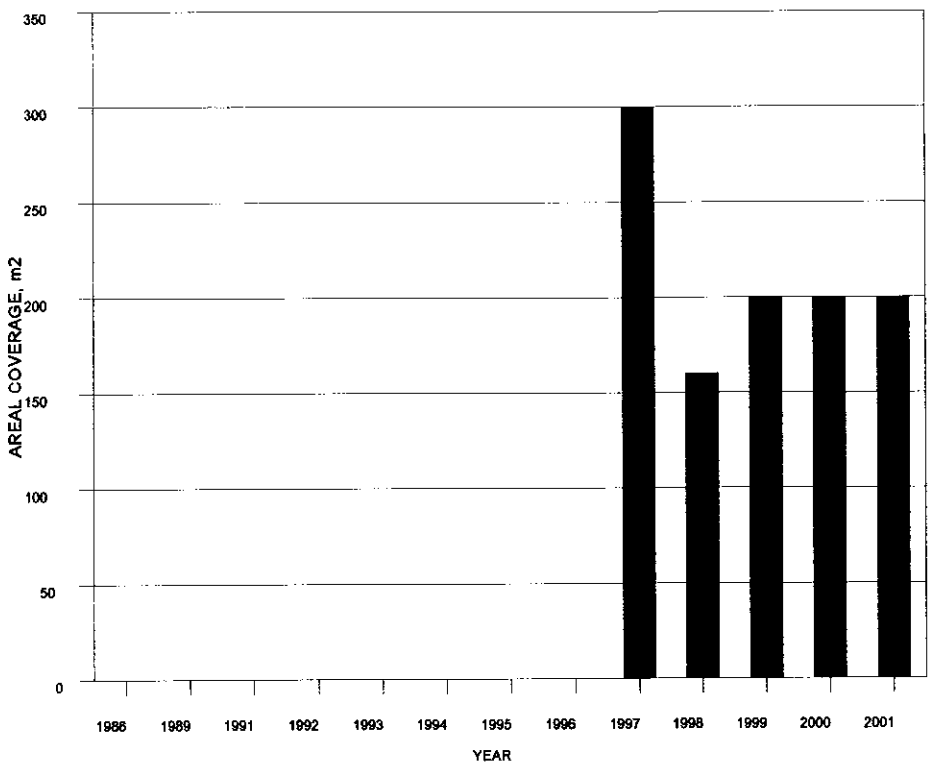


Figure 19. *Halodue wrightii* coverage in Area 7 from 1986-2001.

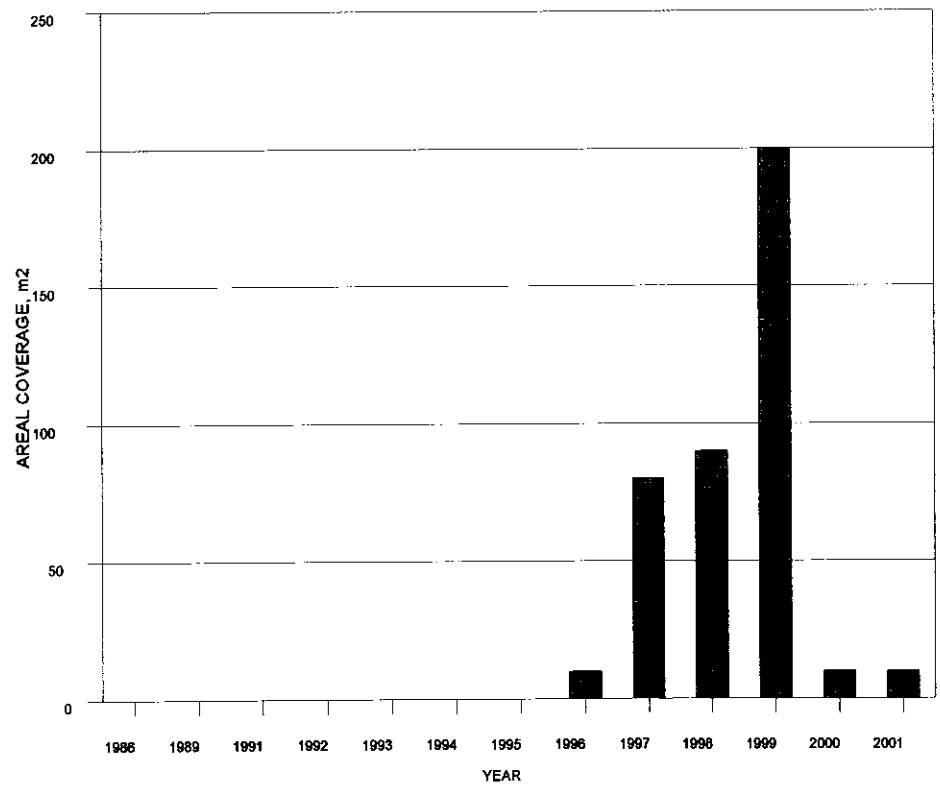


Figure 20. *Halodule wrightii* coverage in Area 8 from 1986-2001.

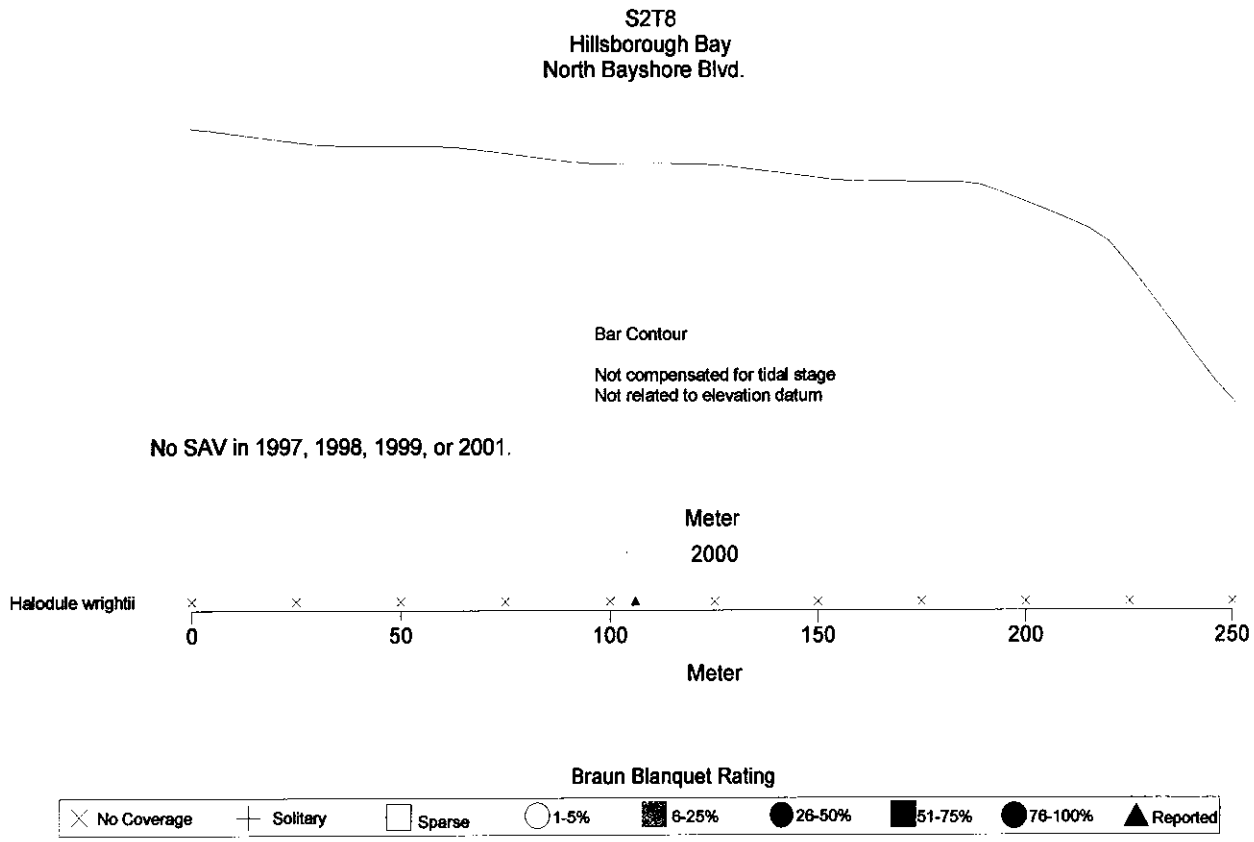


Figure 21. Distribution and abundance of *Halodule wrightii* along Transect S2T8 from 1997-2001.

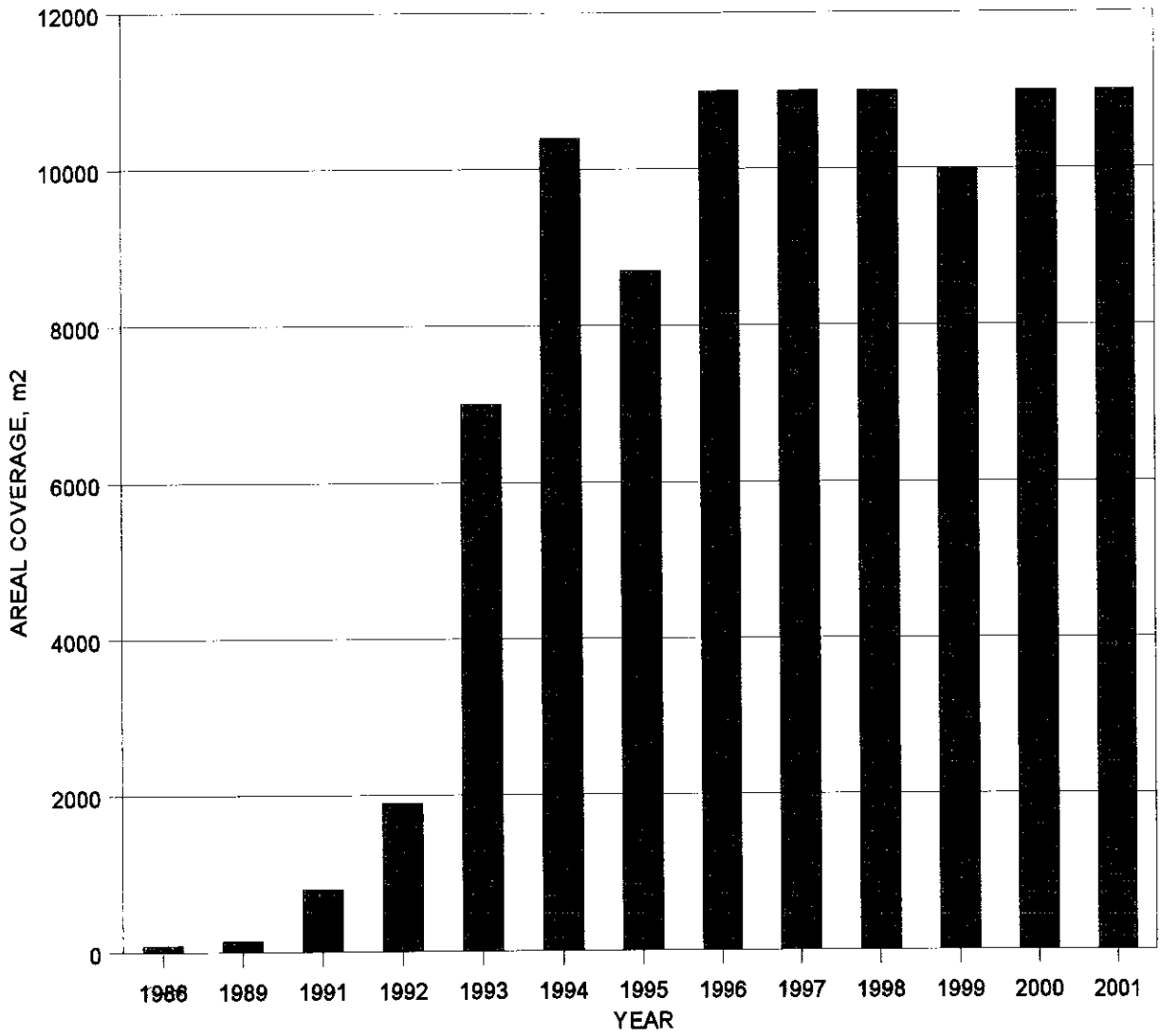


Figure 22. *Halodule wrightii* coverage in Area 9 from 1986-2001.

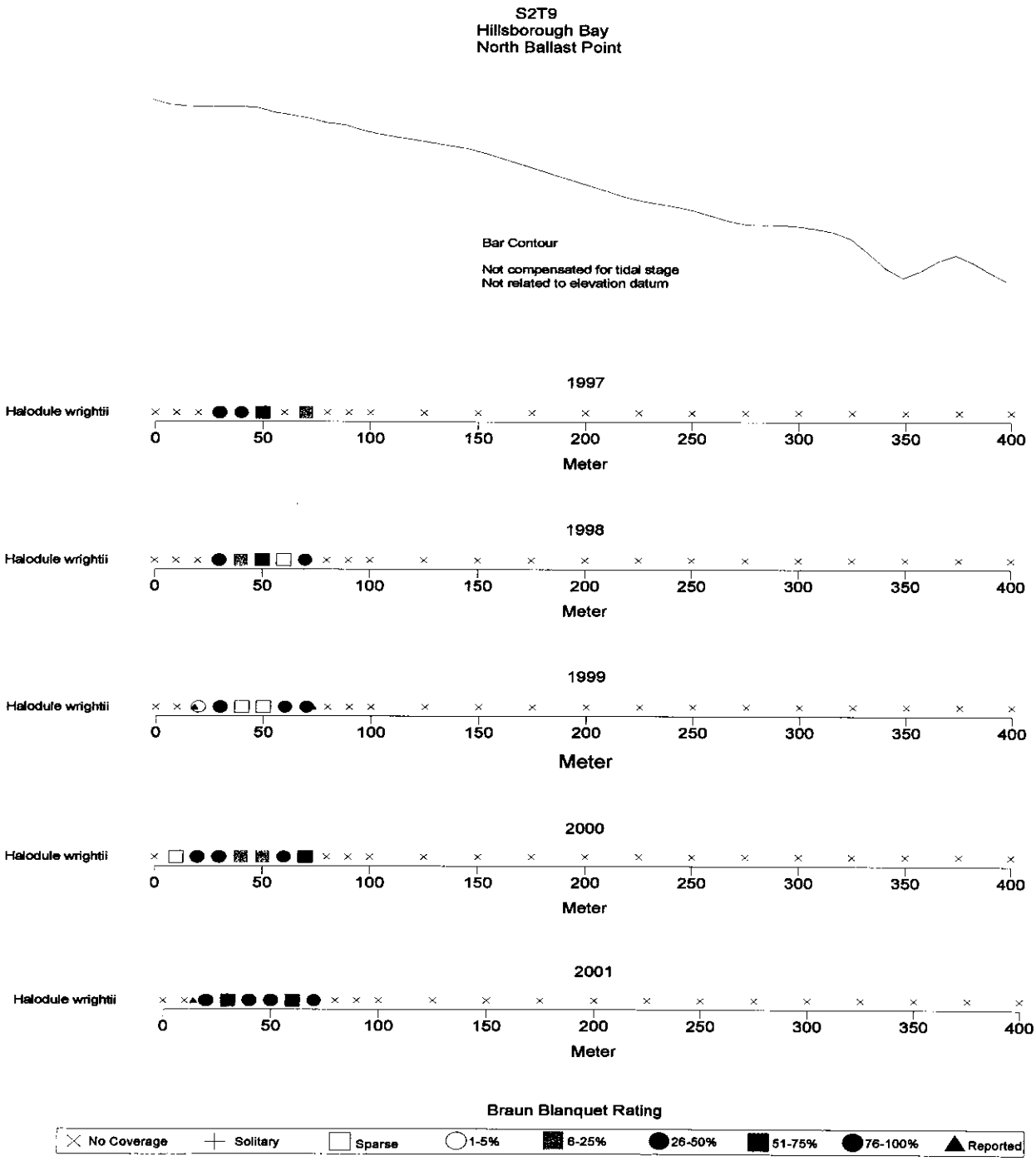


Figure 23. Distribution and abundance of *Halodule wrightii* along Transect S2T9 from 1997-2001.

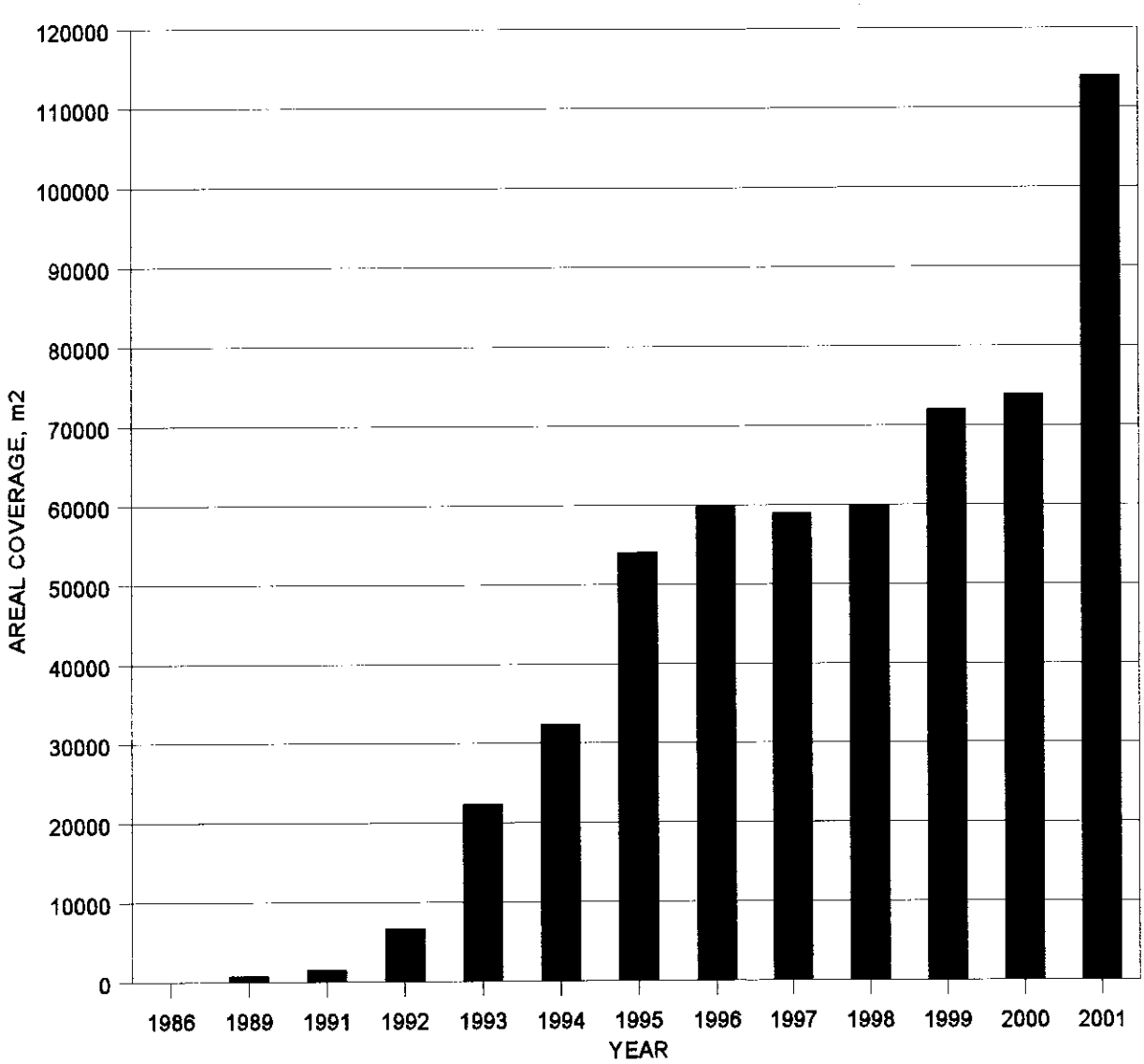


Figure 24. *Halodule wrightii* coverage in Area 10 from 1986-2001.

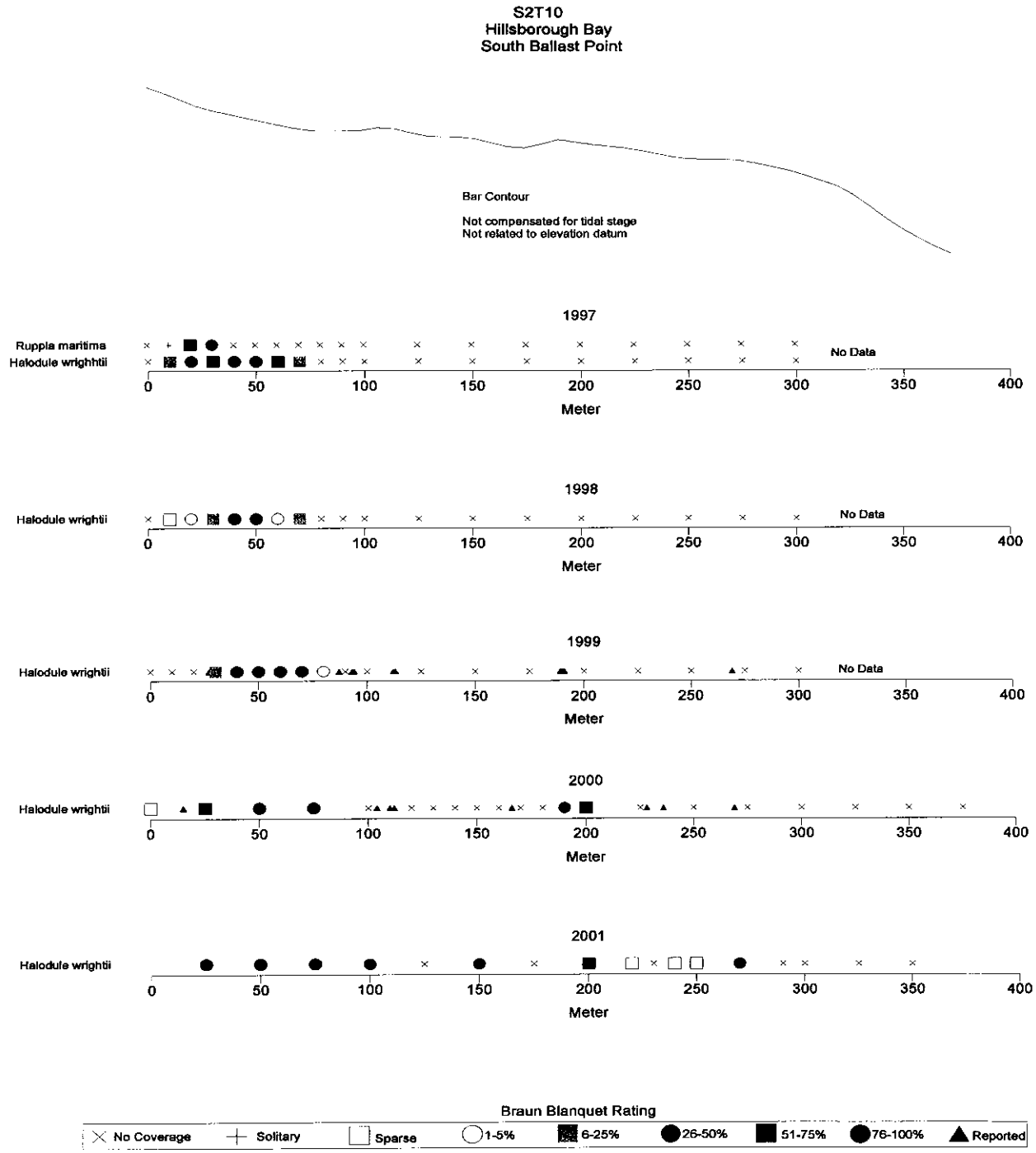


Figure 25. Distribution and abundance of *Halodule wrightii* along Transect S2T10 from 1997-2001.

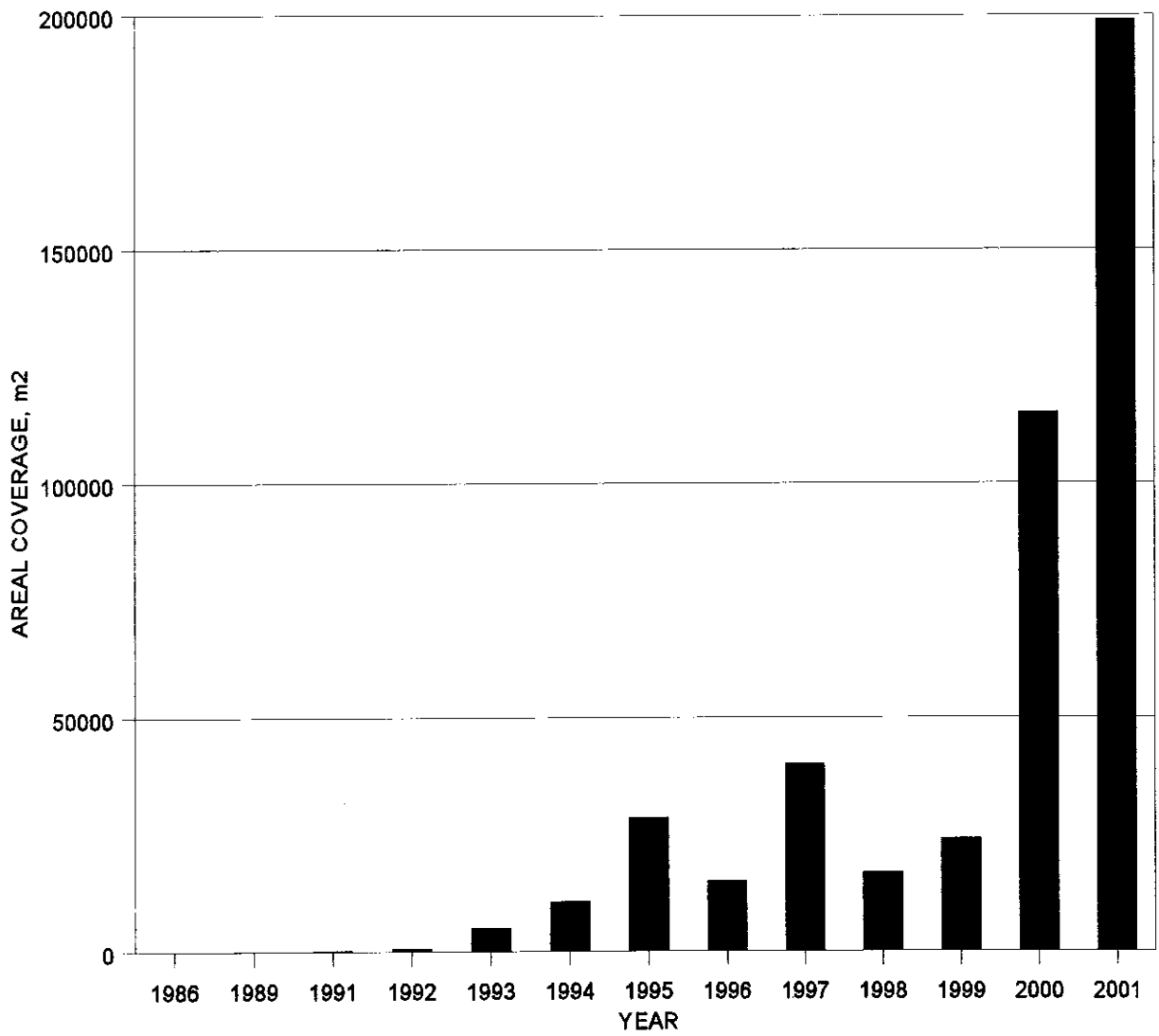


Figure 26. *Halodule wrightii* coverage in Area 11 from 1986-2001.

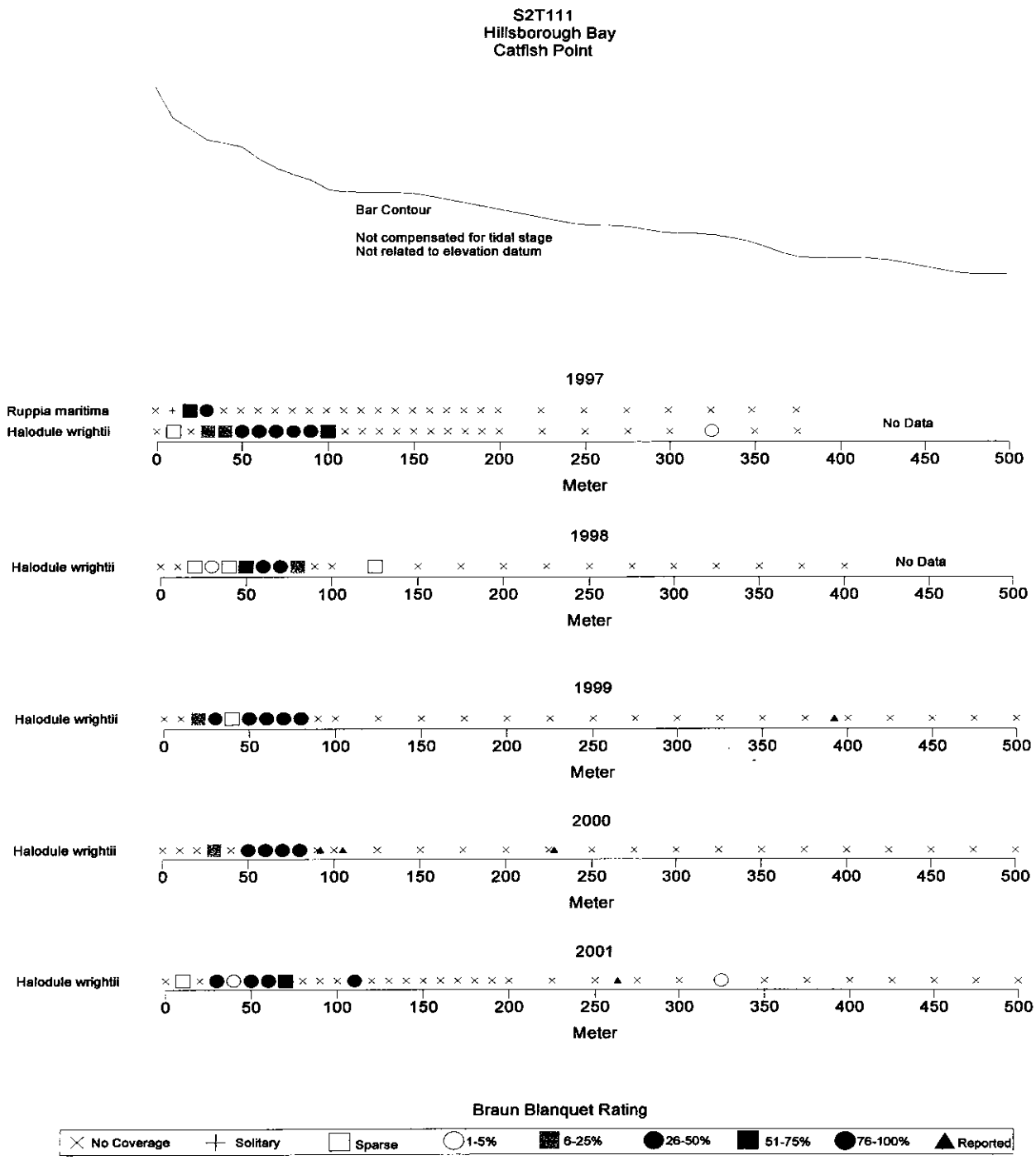


Figure 27. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S2T111 from 1997-2001.

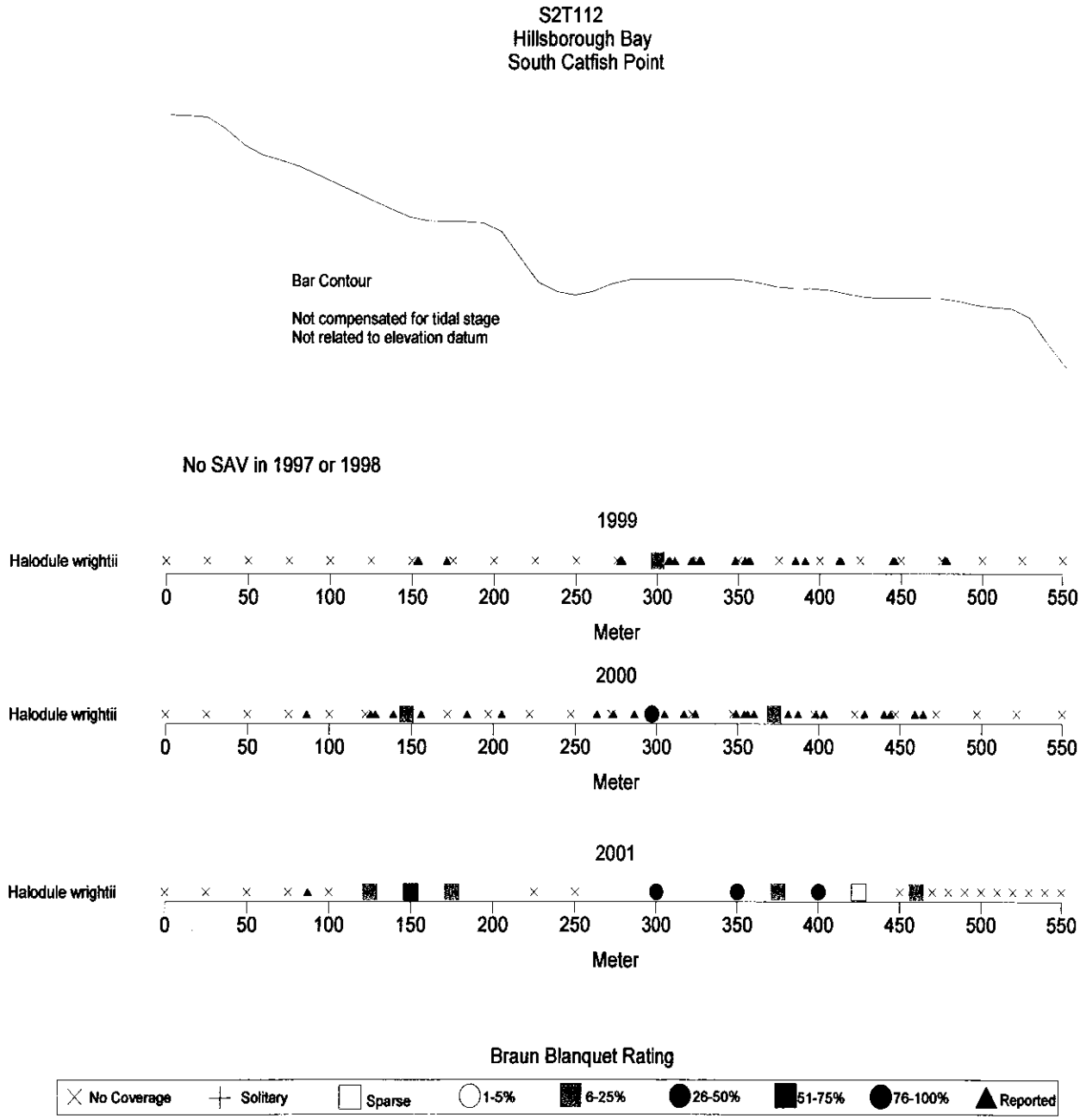


Figure 28. Distribution and abundance of *Halodule wrightii* along Transect S2T112 from 1997-2001.

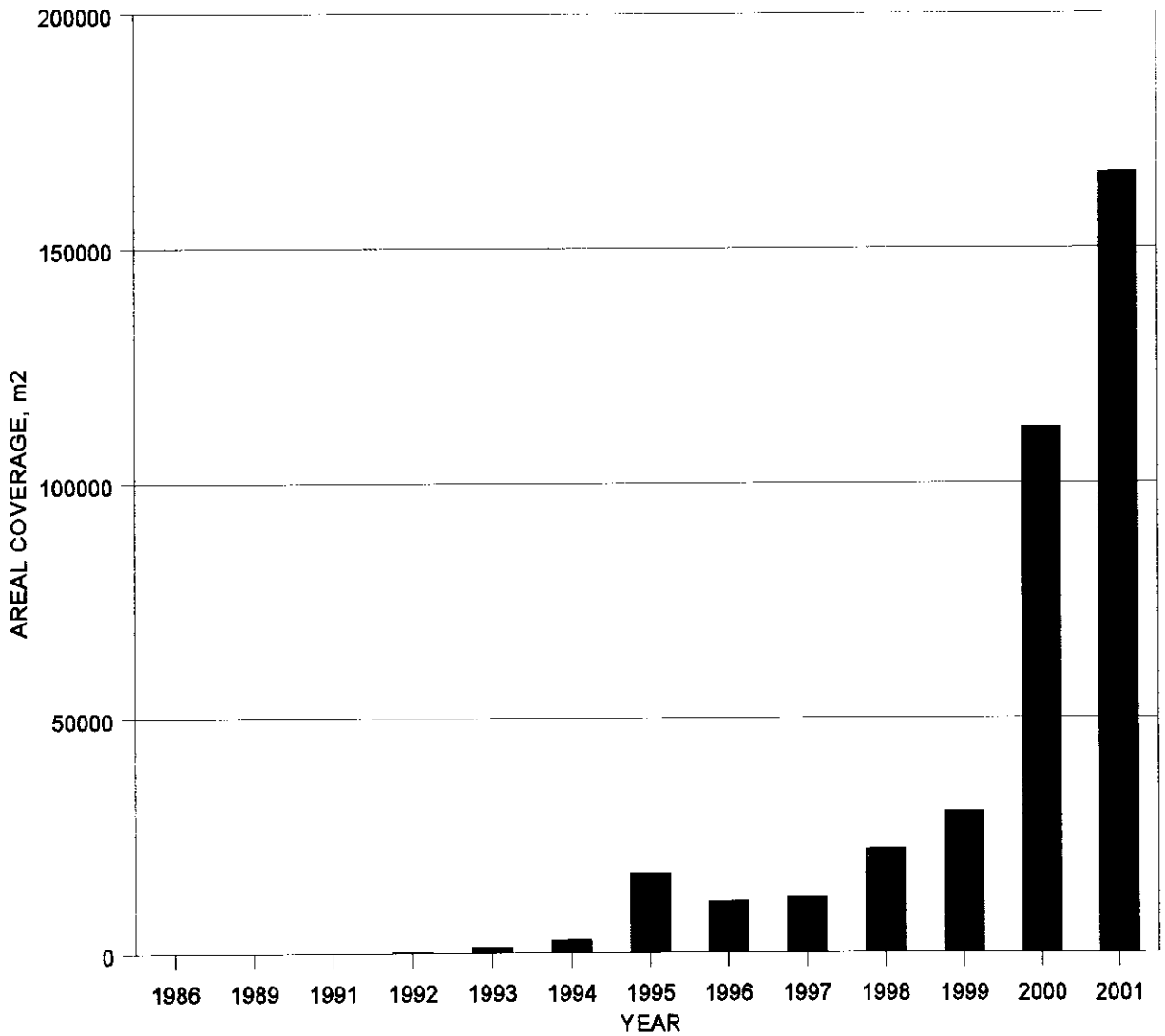


Figure 29. *Halodule wrightii* coverage in Area 12 from 1986-2001.

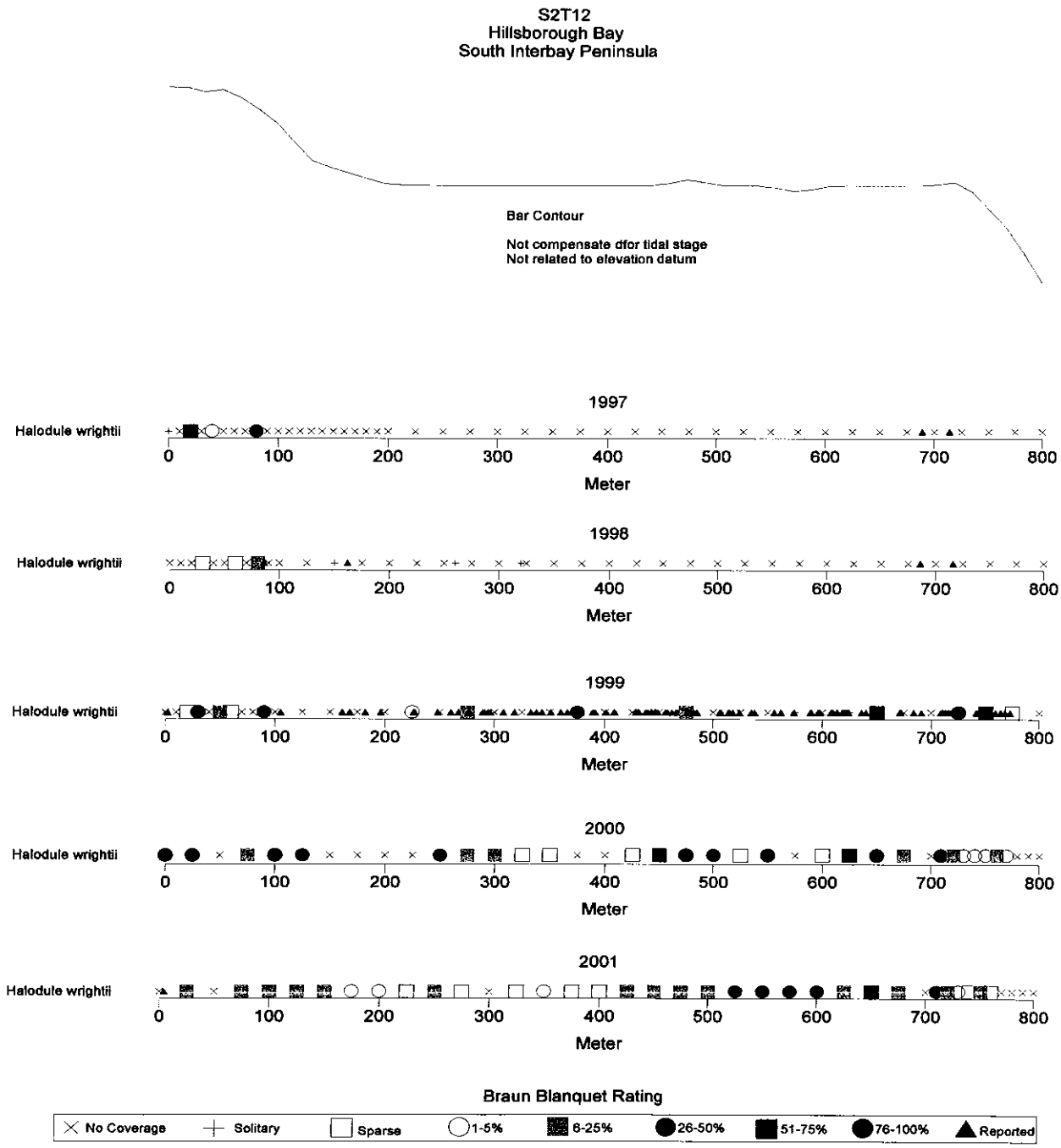


Figure 30 . Distribution and abundance of *Halodule wrightii* along Transect S2T12 from 1997-2001.

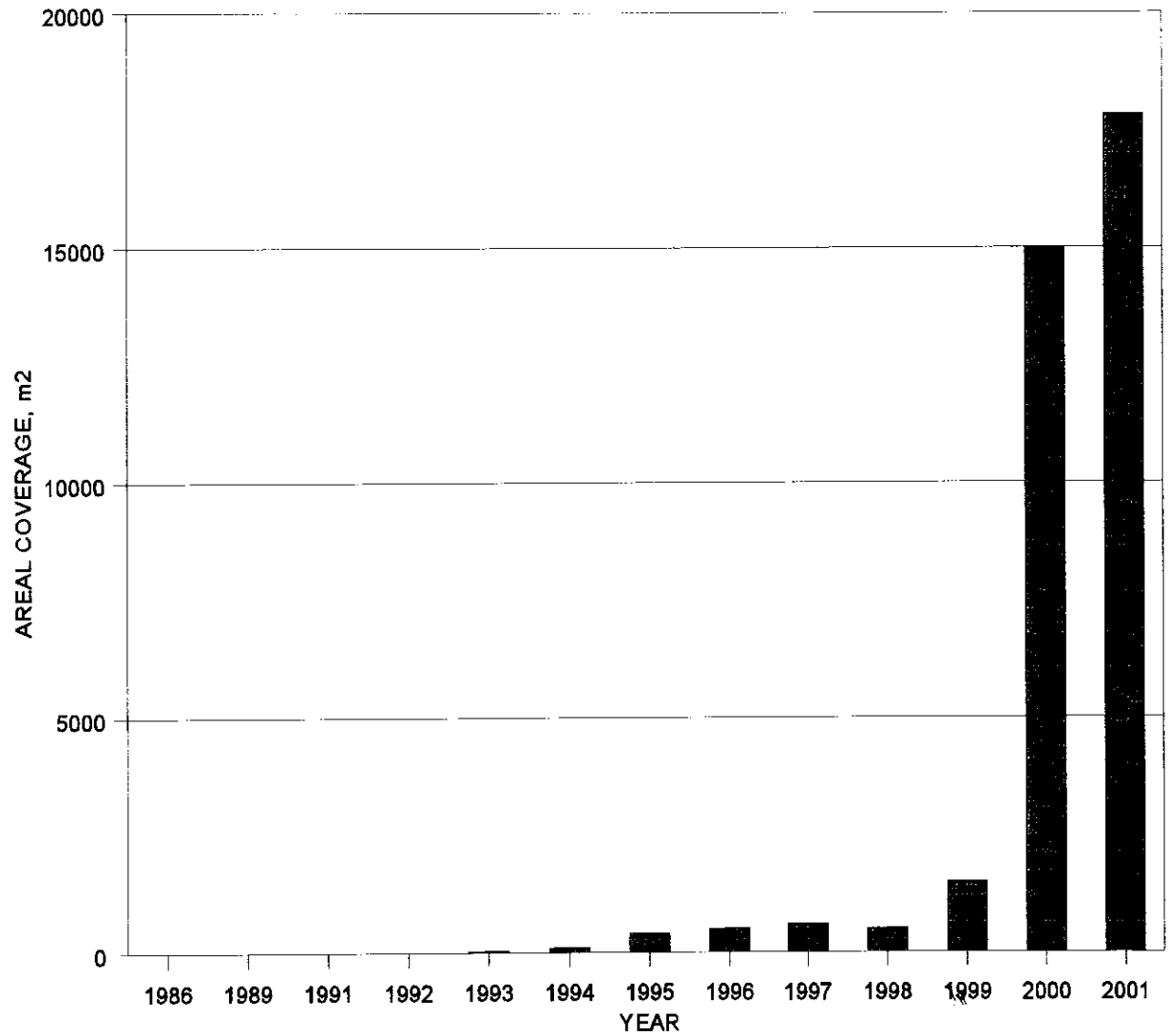


Figure 31. *Halodule wrightii* coverage in Area 13 from 1986-2001.

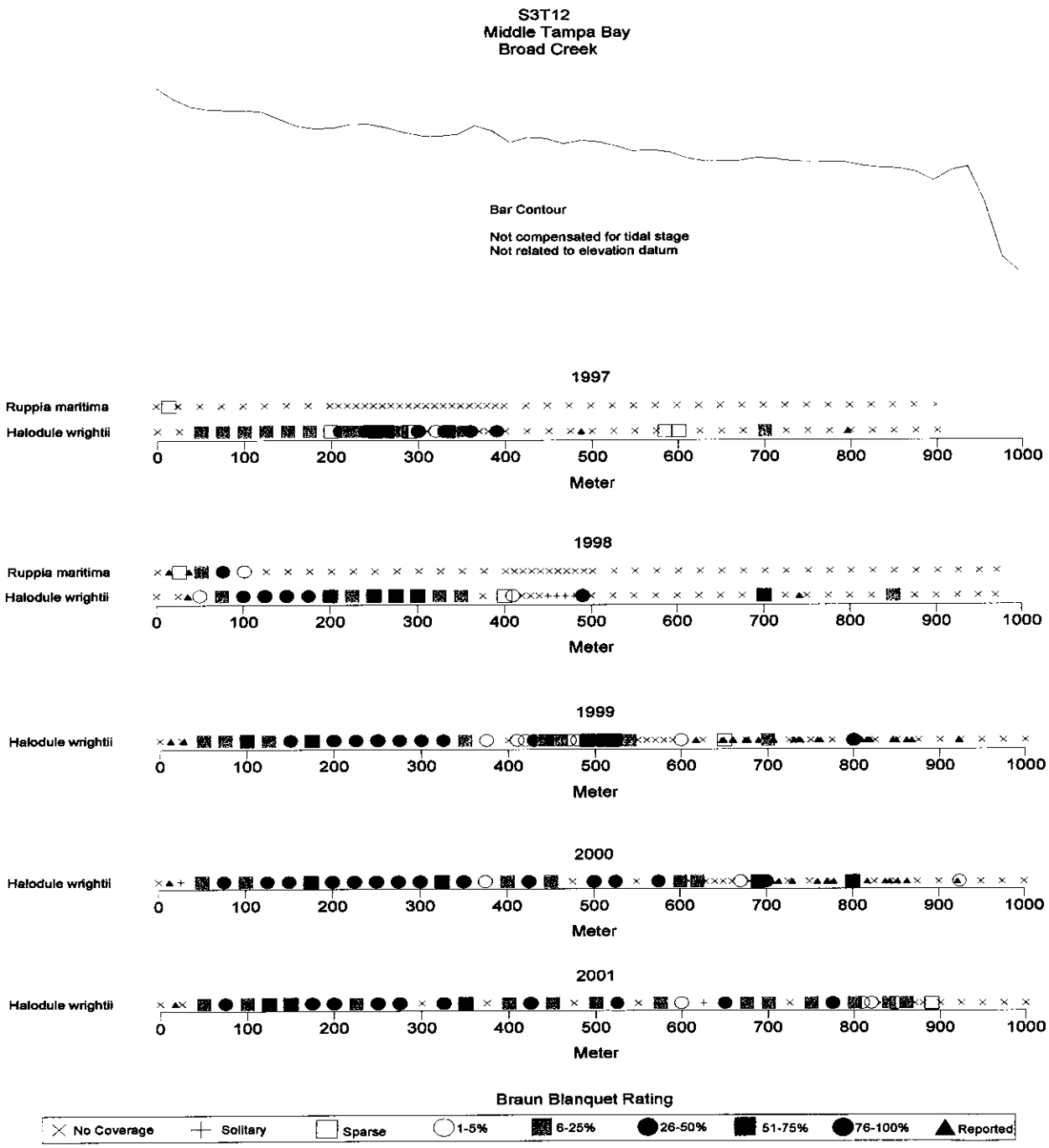


Figure 32. Distribution of *Ruppia maritima* and *Halodule wrightii* along Transect S3T12 from 1997-2001.

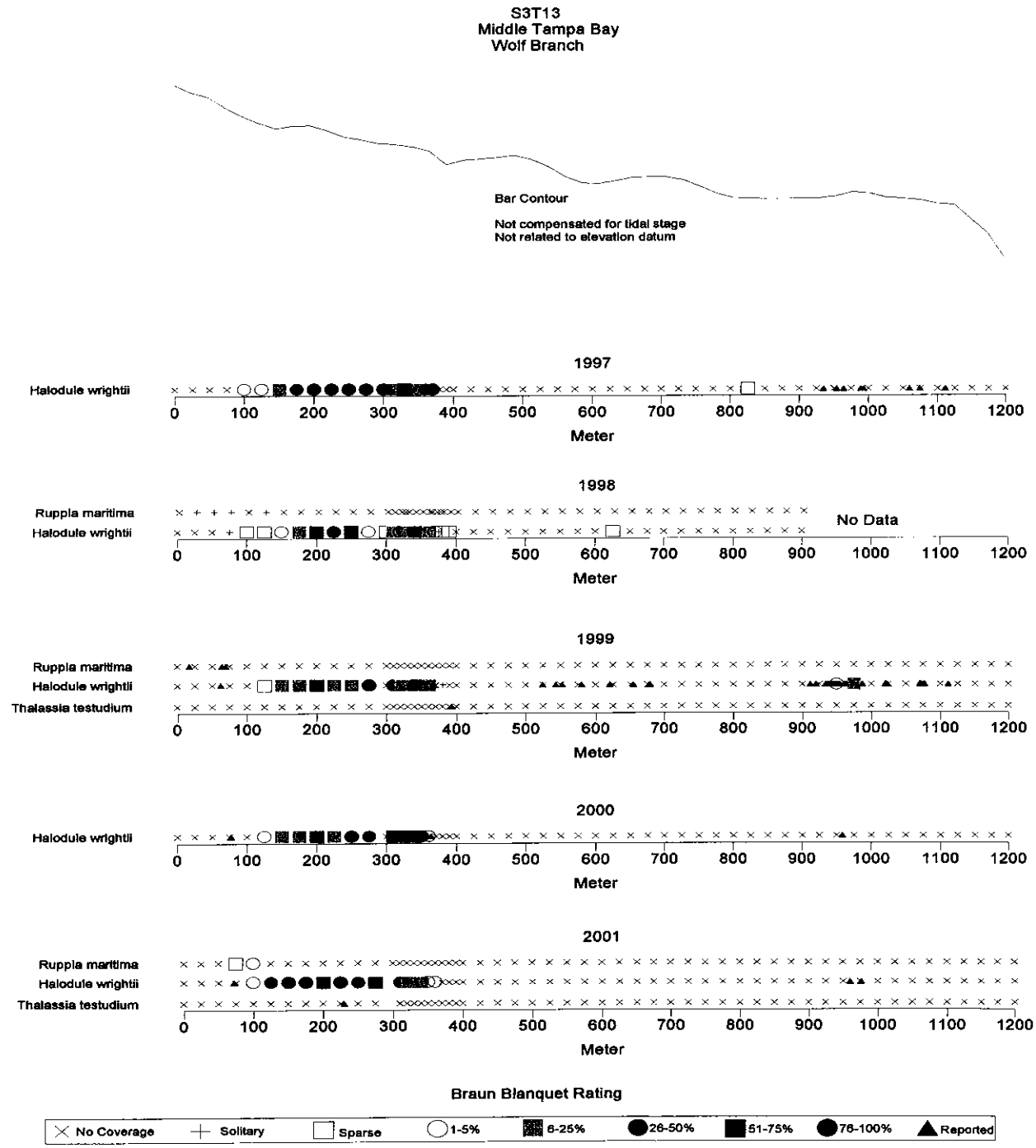


Figure 33. Distribution and abundance of *Ruppia maritima*, *Halodule wrightii*, and *Thalassia testudinum* along Transect S3T13 from 1997-2001.

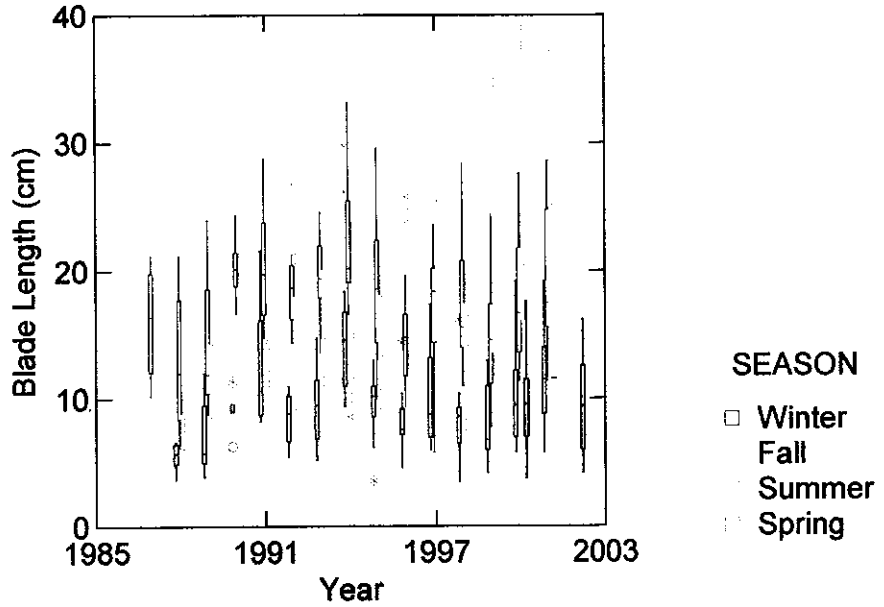


Figure 34. Box plot of seasonal *Halodule wrightii* blade length in Hillsborough Bay from 1986 through 2001.

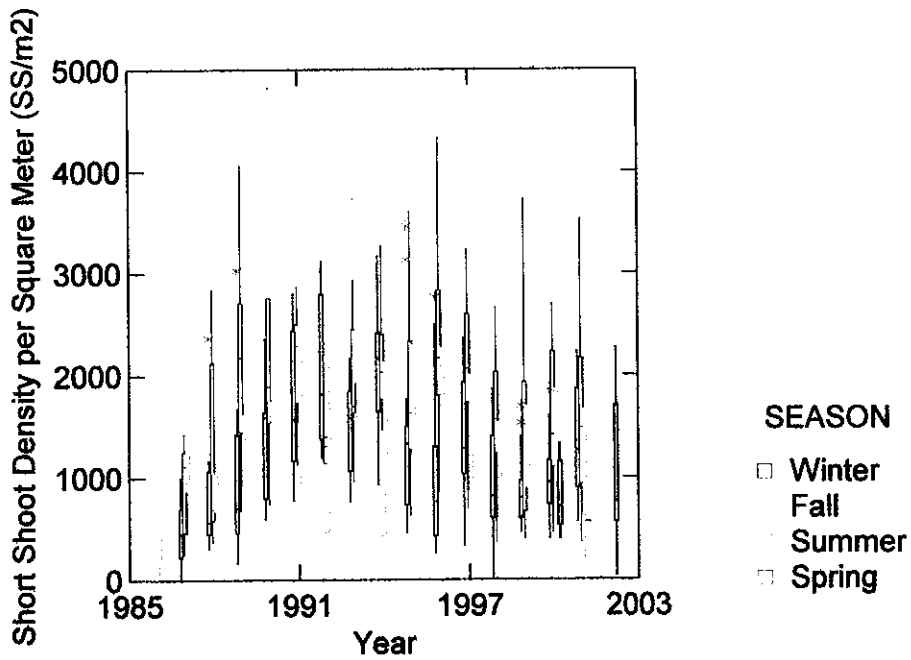


Figure 35. Box plot of seasonal *Halodule wrightii* short shoot density in Hillsborough Bay from 1986 through 2001.

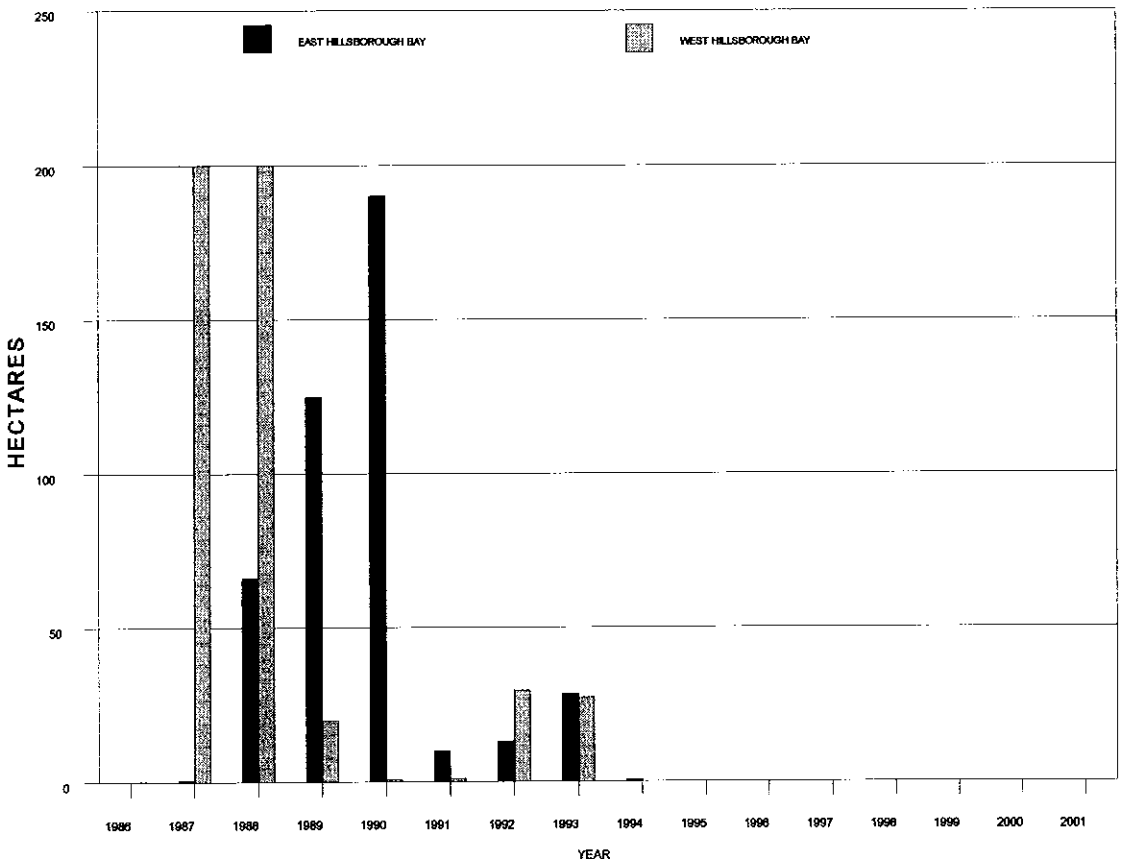


Figure 36. Areal coverage of *Caulerpa prolifera* in Hillsborough Bay from 1986-2001.