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Seagrass and Caulerpa monitoring in Hillsborough Bay Fourteenth Annual Report

City of Tampa Department of Sanitary Sewers

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

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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 were followed by the emergence of shoalgrass, *Halodule wrightii*, in many 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.

During the course of the study, *H. wrightii* baywide areal coverage has ranged between nearly 2000m^2 in the initial survey in 1986 to about 85.5ha in 2001. *H. wrightii* coverage for 2002 was estimated at 84.7ha. Coverage for *R. maritima* fluctuated between 2000m^2 in 1986 to 40ha in 1996. However, following the maximum reported in 1996, *R. maritima* coverage has declined to about 3ha in 2002. *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. *C. prolifera* was present in Hillsborough Bay through 1996. There was no *C. prolifera* reported in Hillsborough Bay between 1997 and 2001, however, about 4.3ha was noted in southwestern Hillsborough Bay in 2002.

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 that 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 annual reports submitted to the Florida Department of Environmental Protection (FDEP) 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 fourteenth annual report submitted to the 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.

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 2). 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 did not fall within meter square placements. Generally, the “reported” category is used for noting seagrass in areas that 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 measurement) is collected where each transect traverses the mid and edge portion of the seagrass bed, and at the two meter water depth contour. In addition, water samples 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 that 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 delineate large areas. 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 an area to be measured and automatically recording positions every five seconds. Subsequently, the data are downloaded into a PC using the Trimble Pathfinder Office software. In this software, the delineated areas are 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 defined as less than twenty-five percent coverage within a given area with none of the patches exceeding $2000m^2$. Seagrass areas exceeding either or both of these parameters would be defined as continuous.

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:

C. prolifera in Hillsborough Bay was documented seasonally using transects through the fall of 1994. However, due to the paucity of *C. prolifera* in Hillsborough Bay in 1995, the BSG discontinued these transects. Results for transect coverage through 1994 may be found in the 1995 annual report.

Currently, *C. prolifera* abundance is estimated within the eleven TBEP transects established in Hillsborough Bay. Areal coverage is estimated from vertical aerial photography and measured using the Trimble GPS system.

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. In contrast, *C. prolifera* has exemplified an ephemeral presence and, in 2002, was noted in Hillsborough Bay for the first time since 1997.

Hillsborough Bay Seagrass Coverage 2002

H. wrightii and *R. maritima*, have been observed during the 2002 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. In 2002, however, coverage decreased less than one percent to about 84.7ha (Figure 3). *R. maritima* coverage was estimated to be about 2ha in 2002, similar to the coverage found in 2001. 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), while most of the *R. maritima* coverage was found between the Alafia River and Pendola Point (Areas 4 and 5). *H. wrightii* coverage in McKay Bay (Area 6) is possibly due to transplant efforts permitted by the FDEP. *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 4, 5, 6, and 7, respectively. These figures are intended to present the general areal extent for *H. wrightii* and do not illustrate precise areal coverage or geographic location.

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 S2T12 and S2T13 are outside the boundaries of Hillsborough Bay and the results for these transects will be presented without a discussion of areal coverage.

Seagrass Study Area 1:

After a substantial decline in 2001, *H. wrightii* coverage in Area 1, near the Tampa Electric Company Big Bend power generating plant, increased to about 3600m^2, similar to the coverage found in 2000 (Figure 8). Most of the gain occurred along the east side of Fishhook spoil. There was no *R. maritima* reported in this area.

Seagrass Study Area 2:

Both *H. wrightii* and *R. maritima* have been documented in Area 2, which includes the Kitchen in southeastern Hillsborough Bay (Figure 4). *H. wrightii* coverage in this area did not change appreciably between 2000-2002 (Figure 9). The bulk of the meadow has been situated between Green Key and Hog and Hominy peninsula. Also, a band of *H. wrightii* has persisted approximately one kilometer west of Green Key since 1999. Further, a small area developed along Adamsville peninsula (just north of Port Redwing) in 2002.

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, in 1996, 29ha was documented. The 1996 *R. maritima* coverage rapidly diminished to 1000m^2 by 2000. Sparse patchy *R. maritima* was observed in the Kitchen in 2002.

Figure 10 illustrates the distribution and Braun Blanquet coverage rating of seagrass along Transect S2T2. Along this transect, *H. wrightii* presence has been recorded each year, however, *R. maritima* was seen only in 1997. Through 2001, *H. wrightii* coverage had been stable with the exception of some minor recolonization between 600-850m in 1999. This coverage was not present in 2000. In 2002, the seaward edge of the *H. wrightii* meadow retreated about 20m from the location of the edge

seen in 2001. Further, *H. wrightii* abundance appears to be increasing from that found in 1999-2001, especially in the 200-400m segment.

Seagrass Study Area 3:

In Area 3 (Figure 4), between the Kitchen and the Alafia River, *H. wrightii* coverage has vacillated between 2.1ha and 3.3ha since reaching peak coverage of 5.4ha in 1998 (Figure 11). *H. wrightii* was estimated at nearly 2.7ha in 2002 and the only seagrass species noted in this area.

Braun Blanquet data from Transect S2T3 (Figure 12), 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, only a few of the meter square placements consistently contained any seagrass between each survey.

Seagrass Study Area 4:

After reaching 9000m^2 in 1997, *H. wrightii* coverage between the Alafia River and Archie Creek (Figure 5) declined to 200m^2 in 1999 (Figure 13). However, *H. wrightii* coverage increased to about 4000m^2 in 2001, approximately the coverage found in 2002.

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 0.5ha of *R. maritima* was present in Area 4 during 2002.

Transect S2T4 has been devoid of seagrass (Figure 14), however, this transect is located to the south of most of the *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 minor meadows developed and then fragmented into small patches. In 1997, a 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 5). This meadow became very patchy in 2001 that resulted in an overall decrease in coverage for Area 5 to about 1.3ha. Areal coverage in 2002 was similar to that found in 2001 (Figure 15).

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 Area 5 has been about 2ha since 1999.

On Transect S2T5, there was a mixture of *H. wrightii* and *R. maritima* along the first 120m of during the first five years of the study (Figure 16). *H. wrightii* coverage did not change significantly between 1998 and 2001 along the transect. In 2002, *H. wrightii* abundance appears to have decreased slightly, although the seaward edge of the bed expanded about 10m. *R. maritima* was not

present on this transect in 2002.
Seagrass Study Area 6:

Between 1986 and 2001, *H. wrightii* had not been observed in McKay Bay (Figure 5). However, a transplant effort conducted under the guidance of FDEP, has introduced about $5m^2$ of *H. wrightii* into the eastern area of the bay (Figure 17). Since 1986, there have been scattered ephemeral patches of *R. maritima* in northwest and southeast McKay Bay.

Along Transect S2T6, patchy *R. maritima* coverage has been recorded within the first 50m of the transect 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 6) 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 6). Since 1999, however, *H. wrightii* coverage has been reduced from $200m^2$ to about $10m^2$ (Figure 20). Further, small patches of *R. maritima* that were noted during 1997 have been absent from this area since 1998.

Along Transect S2T8, some very sparse *H. wrightii* coverage was documented in 2000 (Figure 21). There was no *H. wrightii* seen on this transect in 2001 and 2002.

Seagrass Study Area 9:

H. wrightii was the only seagrass species reported in Area 9 since 1998. Coverage in this area remained near 1ha between 1994 and 2001 (Figure 22). However, in 2002, coverage increased to about 1.6ha. Most of the *H. wrightii* was found just north of Ballast Point along Bayshore Boulevard (Figure 6). *R. maritima* was not found in this area during 2002.

Along Transect S2T9, seagrass distribution and abundance has not changed appreciably since 1997. Braun Blanquet data from this transect (Figure 23) indicate a band of continuous to patchy *H. wrightii* coverage beginning approximately 20m from the seawall and ending at 70m.

Seagrass Study Area 10:

H. wrightii coverage in Area 10 increased between 1997 and 2001 (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 7) as *H. wrightii* has

begun

to recolonize the flats within 300m of the shoreline. In 2002, the areal coverage in Area 10 was estimated to be 10.8ha, which is slightly less than that found in 2001 (Figure 24).

Between 1986 and 1999, several areas of *R. maritima* were documented between Macdill Air Force Base and Ballast Point. *R. maritima* was not noted in Area 10 between 2000 and 2002.

Transect S2T10 included H. *wrightii* and *R. maritima* in 1997 (Figure 25), however, only *H. wrightii* has been observed since 1998. *H. wrightii* coverage increased between the 100m-300m sections of the transect through 2001, however there was little change in distribution or abundance in 2002.

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 7). In addition, many of these patches have coalesced to form a ca. 25ha meadow at Catfish Point. *H. wrightii* coverage in Area 11 was determined to be nearly 32ha during 2002 (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, *R. maritima* has not been noted in Area 11 since 2000.

Transects S2T111 and S2T112 are in Area 11 (Figure 1). Coverage along Transect S2T111 (Figure 27) has been comprised primarily of *H. wrightii* along the first 100m section and has changed little since 1997. *H. wrightii* noted along the 250m-400m 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 reflecting the same process of seagrass development seen on Catfish Point. The abundance seen in 2002 was similar to that found in 2001, although the seaward edge advanced about 75 meters.

Seagrass Study Area 12:

H. wrightii coverage in Area 12 expanded rapidly between 1999 and 2001. During this period, *H. wrightii* increased from about 3ha to nearly 17ha resulting in a sizable meadow between Gadsden Point and the Macdill AFB marina (Figure 7). However, in 2002, areal coverage was reduced by nearly seventy percent to just under 5ha (Figure 29).

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.

Transect S2T12 data (Figure 30) reflect the rapid *H. wrightii* expansion in this area after 1998. The

figure illustrates the formation of the *H. wrightii* meadow prior to 2002 with the more robust portion of the meadow developing in the 400-700 m range. In contrast, the loss of coverage between 300m-600m is evident during 2002.

Seagrass Study Area 13:

H. wrightii has been the only seagrass species reported in this area. The *H. wrightii* that was noted along the eastern and southern shoreline of the spoil disposal island 2-D (Figure 5) in 2000 persisted through 2002. *H. wrightii* coverage adjacent to a small spoil island just to the east of 2-D increased between 2000 and 2002. *H. wrightii* coverage in Area 13 was about 2.5ha in 2002 (Figure 31).

Seagrass Study Transect S3T12:

Transect S3T12 is located at the mouth of Broad Creek on the south end of Interbay Peninsula (Figure 1). *H. wrightii* coverage increased along the transect each year between 1997 and 2001(Figure 32). In 2001, a nearly continuous meadow was present from 50m from the shoreline seaward to the 860m placement. There was little change in *H. wrightii* abundance and distribution between 2001-2002.

The 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 (Figure 1). Data from this transect (Figure 33) indicate that the seaward edge of the *H. wrightii* meadow has receded about 65m since 1998 which includes a 15m recession between 2001-2002. In addition, the Braun-Blanquet rating from 300-350m has decreased indicating that the seaward edge thinned considerably between 2000-2002.

Throughout the study, small *Thalassia testudinum* beds have been near the transect and sparse coverage has been reported along the 200m-400m section in 1999 and 2001. In 2002, *T. testudinum* was found within two one-meter square placements in this section.

Except for the years 1997 and 2000, very sparse *R. maritima* has been observed along the first 100m segment of the transect.

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 mean blade lengths are shorter in the winter (9.963.9cm) and spring (10.264.3cm) as compared to the summer (17.965.7cm) and fall (17.467.1cm).

Seasonal values for *H. wrightii* short shoot density are presented in Figure 35. These data indicate that mean short shoot density per square meter is less in the winter (9496545ss/m^2) as compared to spring, summer, and fall. Spring shoot density (12946739ss/m^2) is similar to that found in the fall

(14116755ss/m^2) with peak shoot density usually found in the summer (17476896ss/m^2).

Caulerpa prolifera

Two major *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 that 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 in this area after 1994. However, these losses do not appear to be related to major rain events. *C. prolifera* had not been observed in Hillsborough Bay between 1997-2001, however, during 2002, about 4.3ha developed between Gadsden Point and the Macdill marina channel.

CONCLUSION

Recolonization of *H. wrightii* into most intertidal and shallow subtidal areas of Hillsborough Bay occurred concurrent with improving water quality. *H. wrightii* recolonization between 1999-2001 resulted in a 29ha net increase of seagrass coverage in Hillsborough Bay. For the period 2001-2002, net *H. wrightii* coverage in Hillsborough Bay remained essentially unchanged. Areas 11 and 12 had a 60 percent increase and a 70 percent decrease, respectively. The coverage gain and loss within these two areas were virtually offsetting.

Prior to 2000, most of the *H. wrightii* recolonization occurred in the Kitchen (Area 2, Transect S2T2). However, in the past three years, *H. wrightii* increased over an order of magnitude on the flats between Catfish Point and Gadsden Point (Area 11, Transect S2T112). Similarly, *H. wrightii* coverage between Gadsden Point and the Macdill AFB marina (Area 12, Transect S2T12) expanded nearly an order of magnitude between 1997-2001, but then declined about 70 percent in 2002. Also, *H. wrightii* meadows have developed between Ballast Point (Area 10, Transect S2T10) and Macdill AFB, though not as rapidly as the coverage seen along the southeastern Interbay Peninsula. From 2000 through 2002, nearly 35ha of *H. wrightii* has developed between Ballast Point (Area 10) and the Macdill AFB marina (Area 12).

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 may have decreased in recent years. Data generated by traditional water quality monitoring programs suggest that conditions appear to be adequate for continued seagrass recolonization (see the City of Tampa report submitted to the Florida Department of Environmental Protection on May 1, 2003 entitled “Results of the City of Tampa Compliance Monitoring for the Year 2002 and Examination of Long Term Water Quality and Biological Indicator Trends in Hillsborough Bay”). However, other factors such as bioturbation, wave energy, and sediment transport may also

potentially impede seagrass restoration.

Several areas of Hillsborough Bay have *R. maritima* meadows that 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 2002, *R. maritima* coverage was estimated to be about 3ha, less than 4 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 1991-2002.

	1986	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Area														
1	690	700	400	500	2000	2630	2500	3000	5600	3000	3000	3500	2000	3600
2	1125	3300	16300	40800	34000	135000	167000	296000	400000	400000	390000	290000	295000	285000
3	0	0	40	350	250	1200	2500	4500	10800	54300	27000	21000	33000	26900
4	0	0	200	475	500	600	500	1000	9000	1900	200	2000	4000	3400
5	0	0	15	150	600	1200	750	1500	7900	1900	4000	44300	13000	10800
6	0	0	0	0	0	0	0	0	0	0	0	0	0	5
7	0	0	0	0	0	0	0	0	300	160	200	200	200	200
8	0	0	0	0	0	0	0	10	80	90	200	10	10	10
9	85	140	800	1900	7000	10400	8700	11000	11000	9000	10000	11000	11000	16000
10	40	750	1600	6750	22400	32400	54000	60000	59000	60000	72000	74000	114000	108000
11	0	65	200	650	5000	10500	28500	15000	40000	16700	24000	115200	199000	318200
12	20	20	20	250	1300	2800	17000	11000	11700	22000	30000	112000	166000	49250
13	0	0	0	0	30	100	400	500	600	500	1500	15000	17850	25400
Total	1960	4975	19575	51825	73080	196830	281850	403510	555980	569550	562100	688210	855060	846765

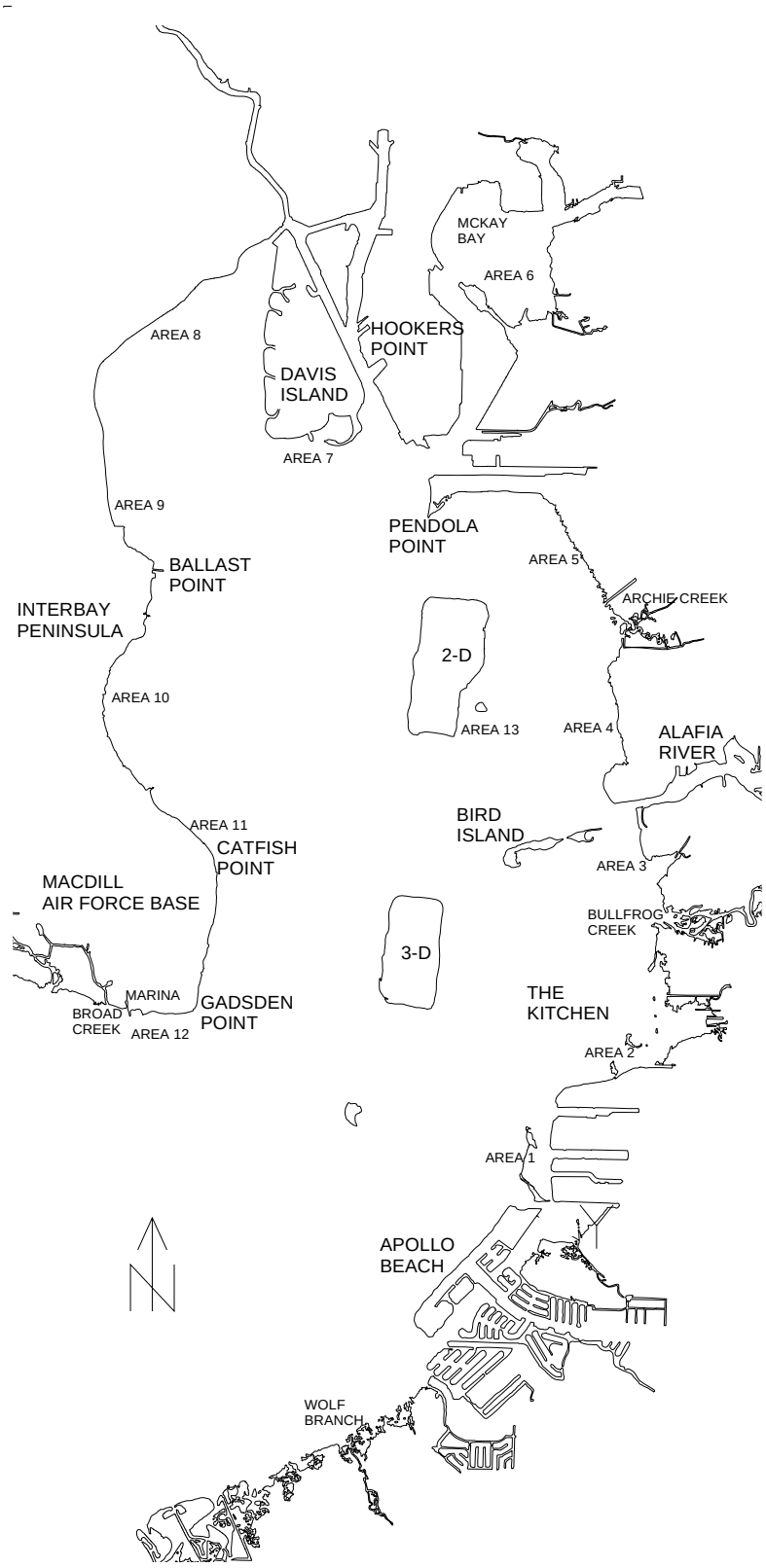
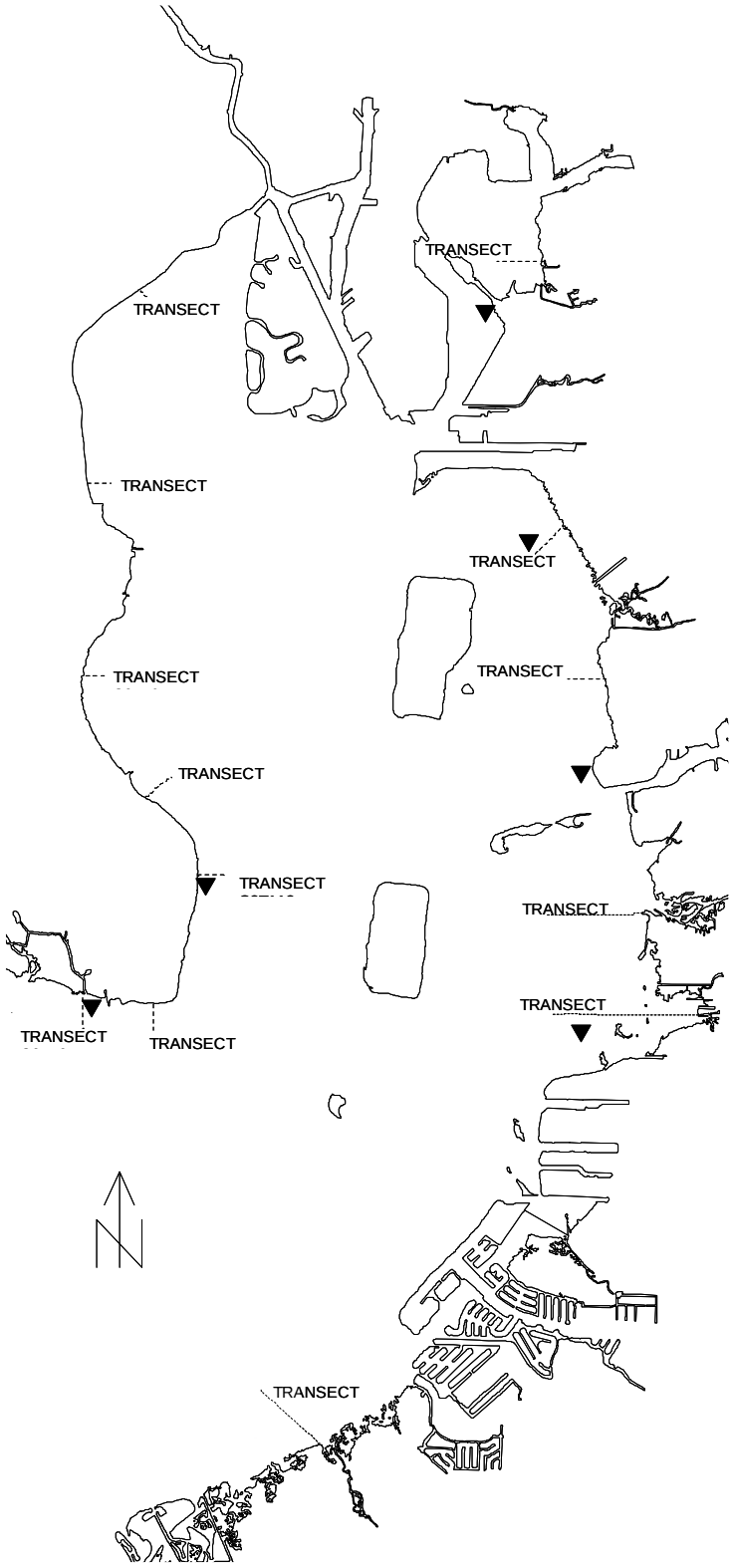


Figure 1. Location of the thirteen seagrass study areas in Hillsborough Bay.



▼)in Hillsborough Bay.

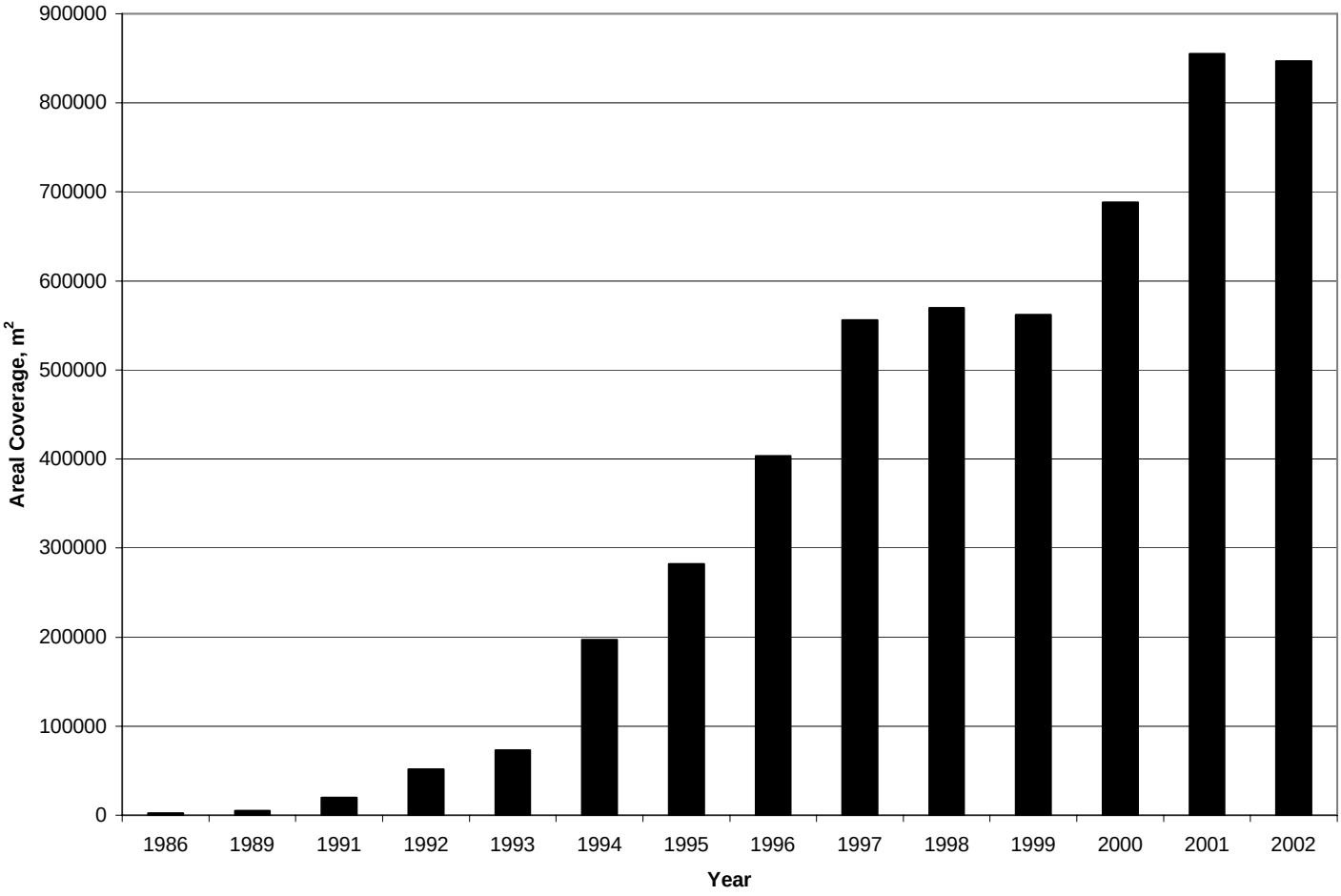


Figure 3. Total *Halodule wrightii* coverage in Hillsborough Bay from 1986-2002.

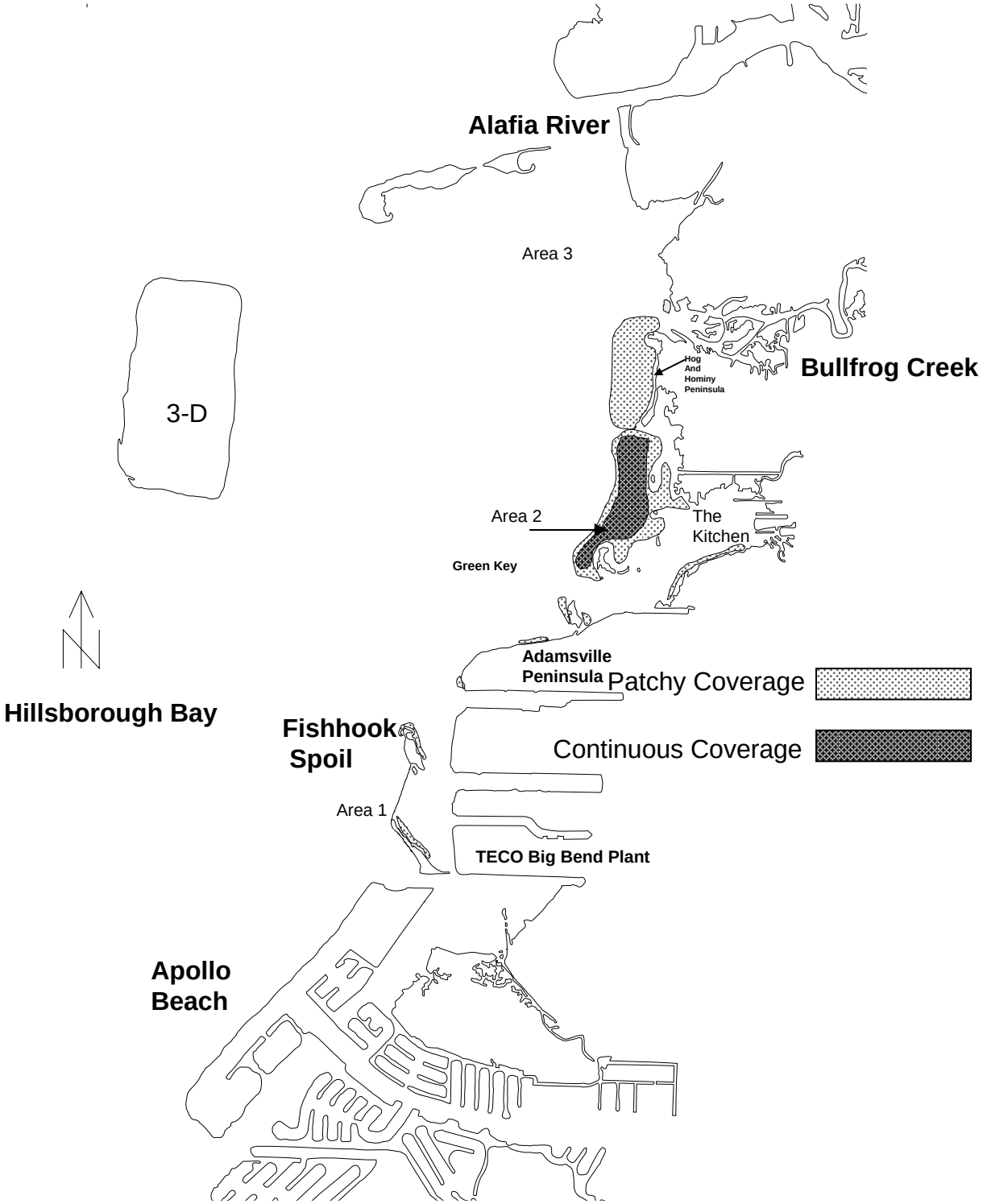


Figure 4. Distribution of *Halodule wrightii* in southeastern Hillsborough Bay (Areas 1, 2, and 3) in 2002.

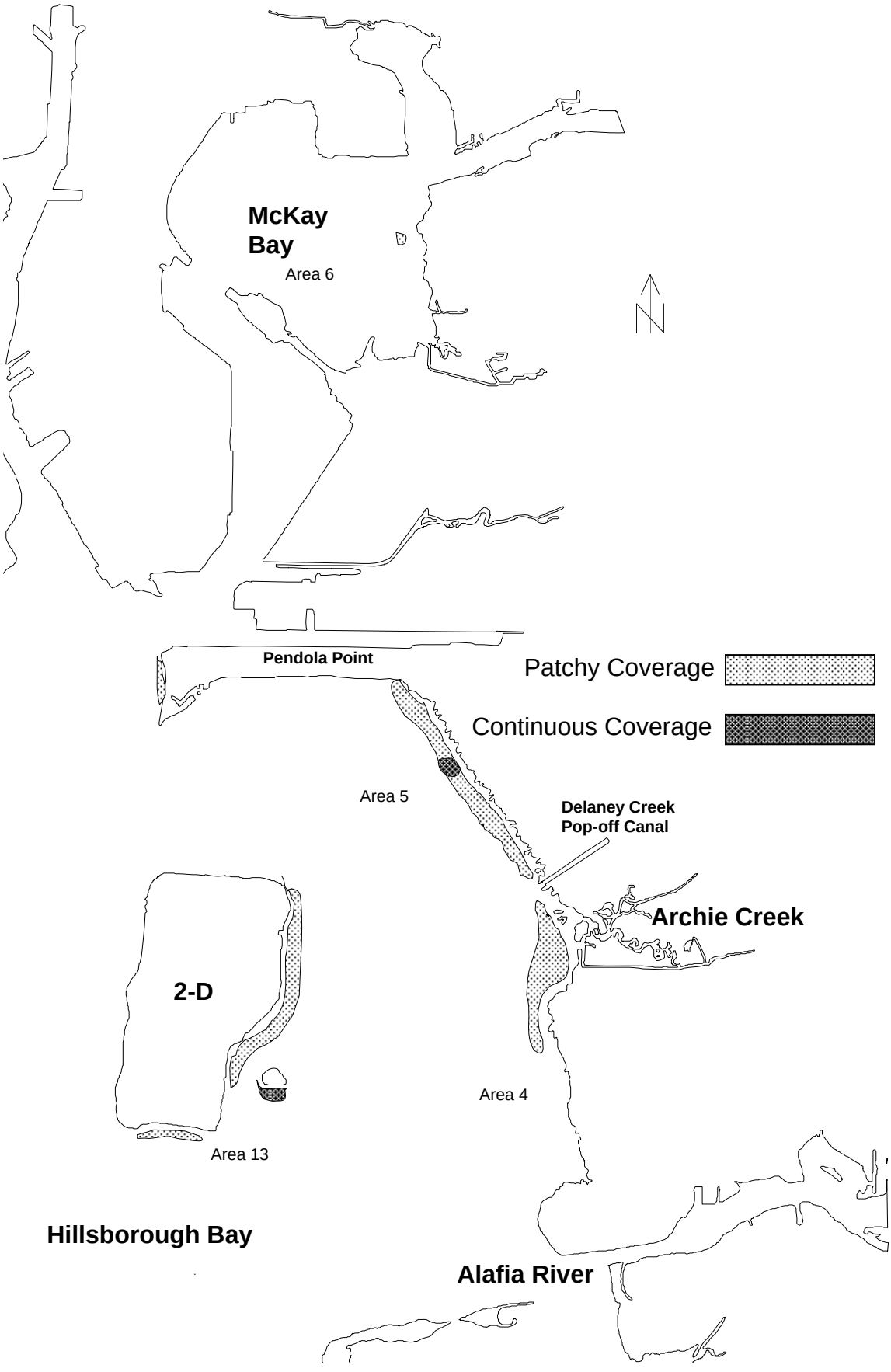


Figure 5. Distribution of *Halodule wrightii* in northeastern Hillsborough Bay (Areas 4, 5, 6, and 13) in 2002.

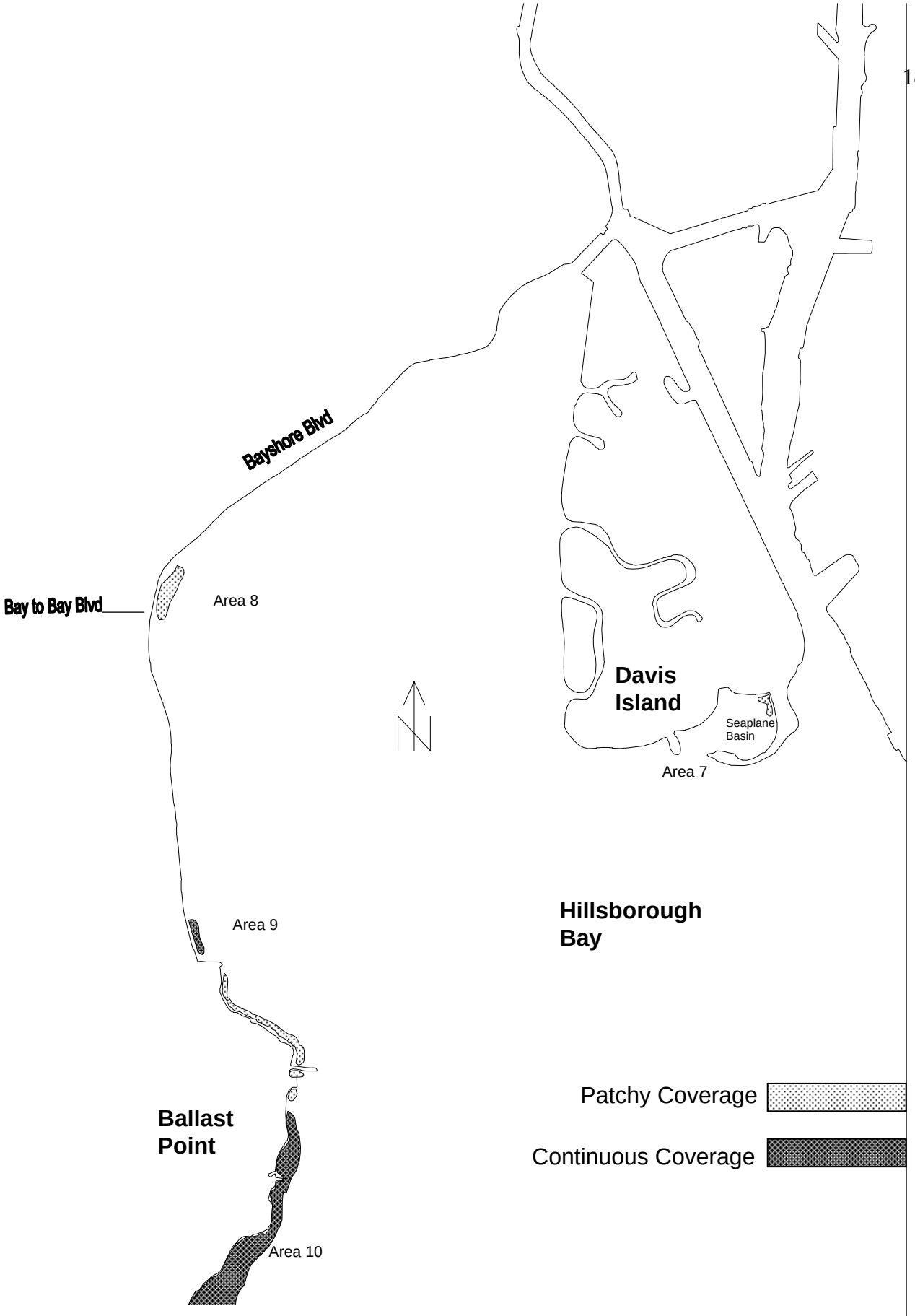


Figure 6. Distribution of *Halodule wrightii* in northwestern Hillsborough Bay (Areas 7, 8, and 9) in 2002.

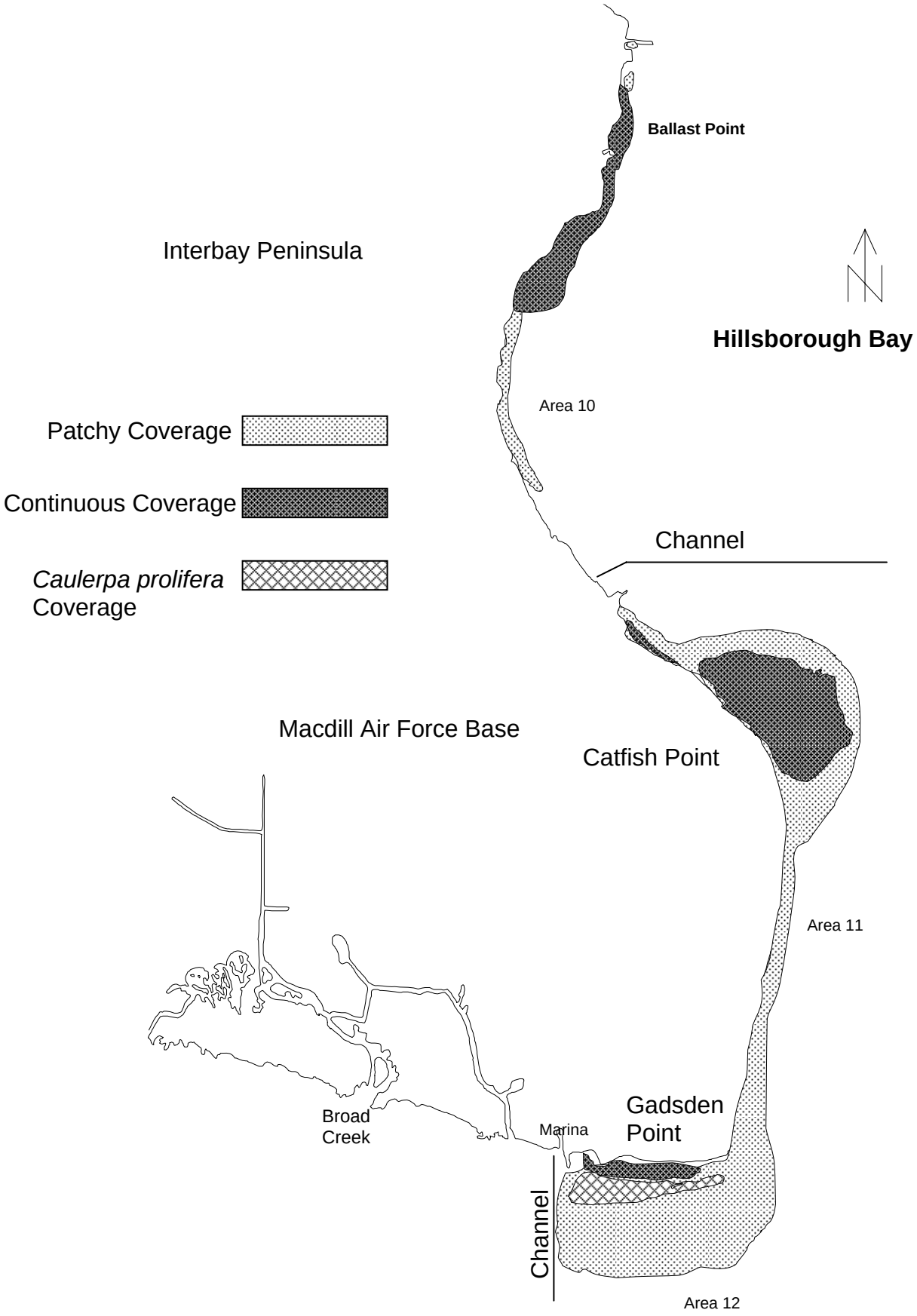


Figure 7. Distribution of *Halodule wrightii* in southwestern Hillsborough Bay (Areas 10,11, and 12) in 2002.

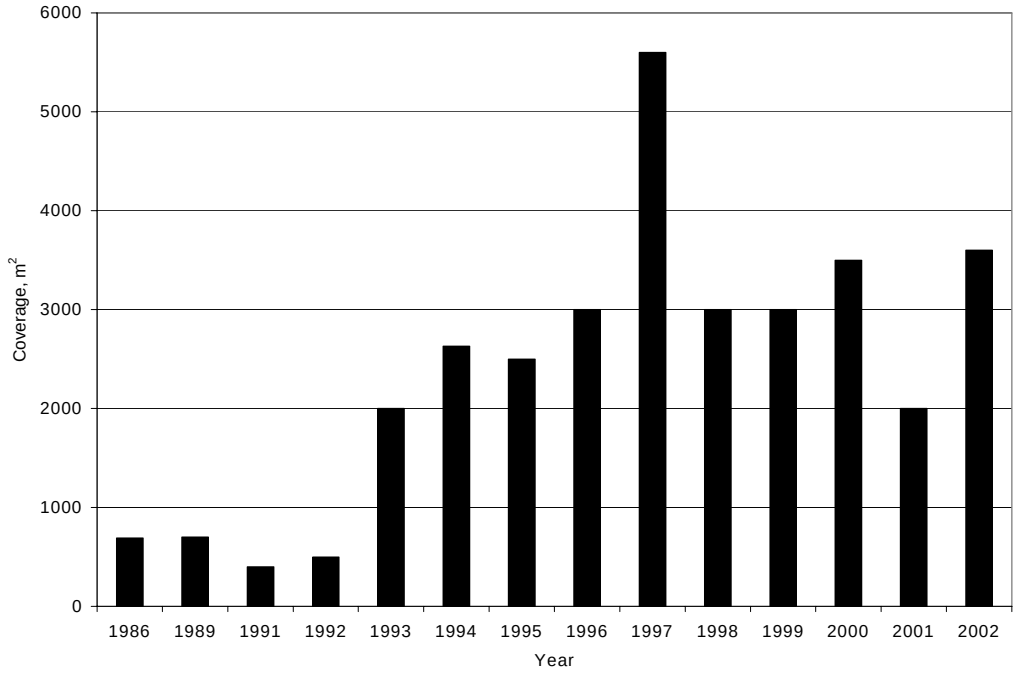


Figure 8. *Halodule wrightii* coverage in Area 1 from 1986-2002.

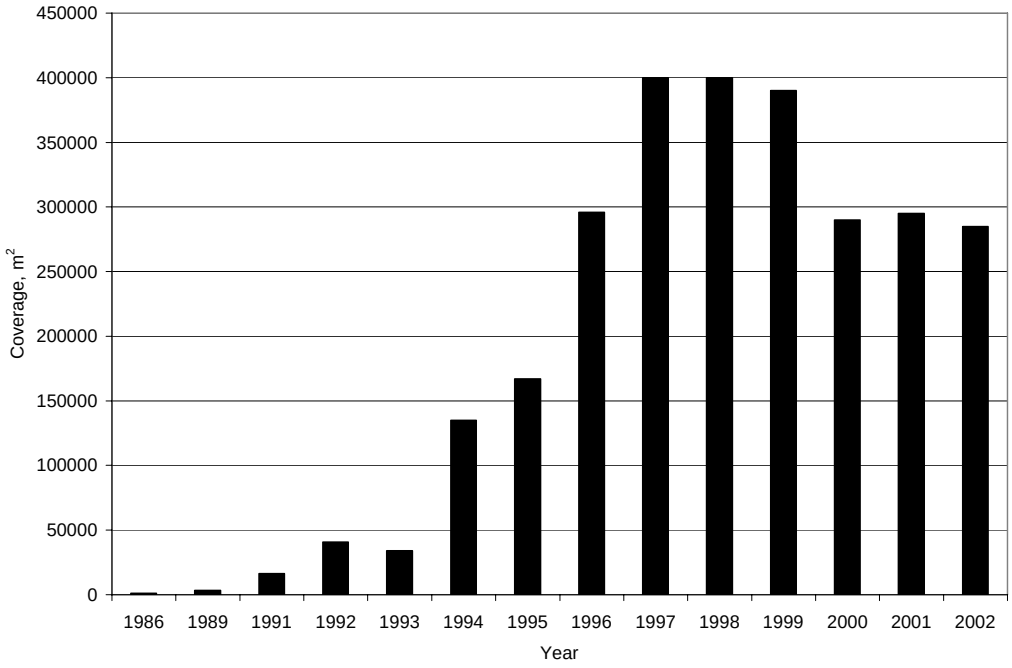


Figure 9. *Halodule wrightii* coverage in Area 2 from 1986-2002.

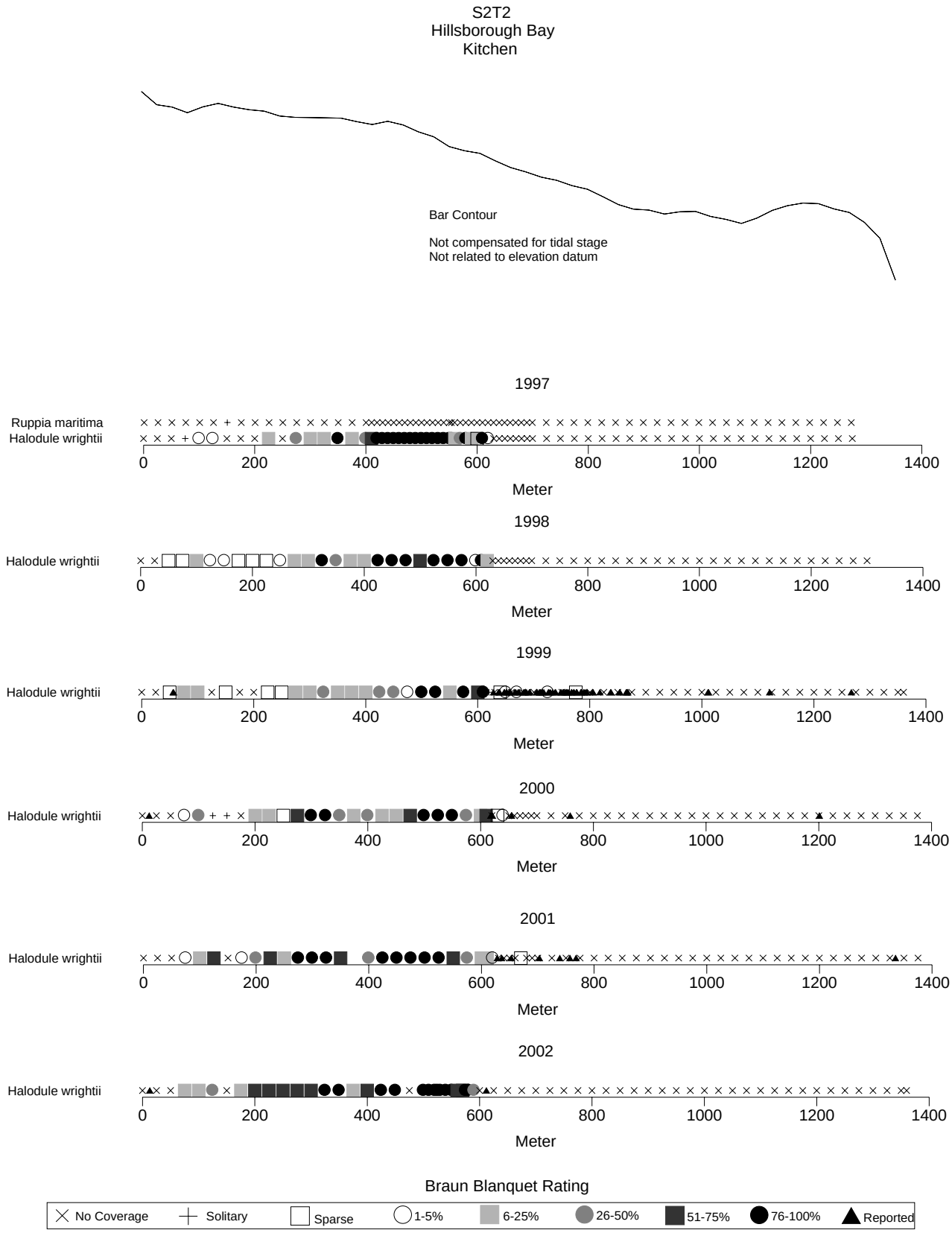


Figure 10. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S2T2 from 1997-2002.

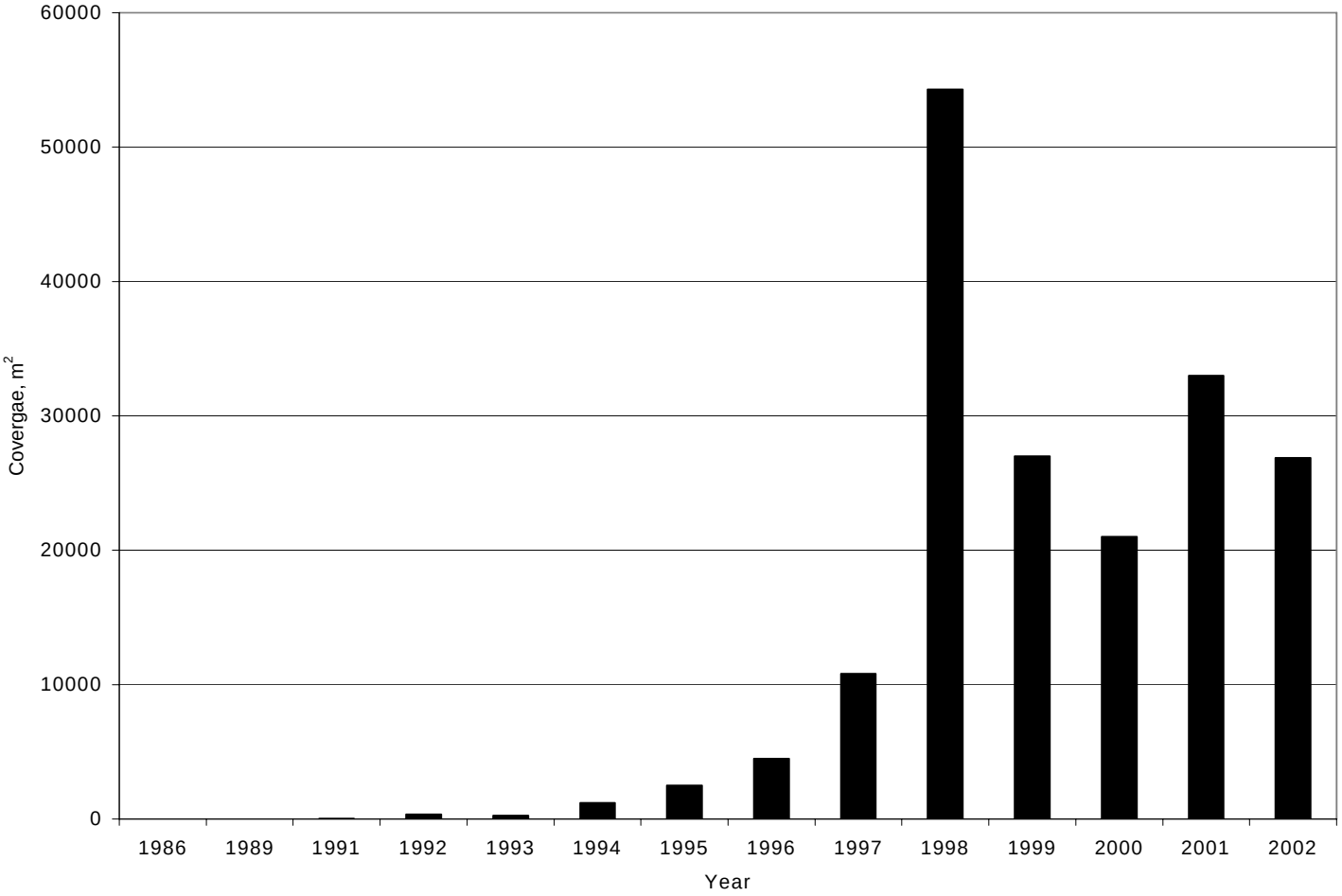


Figure 11. *Halodule wrightii* coverage in Area 3 from 1986-2002.

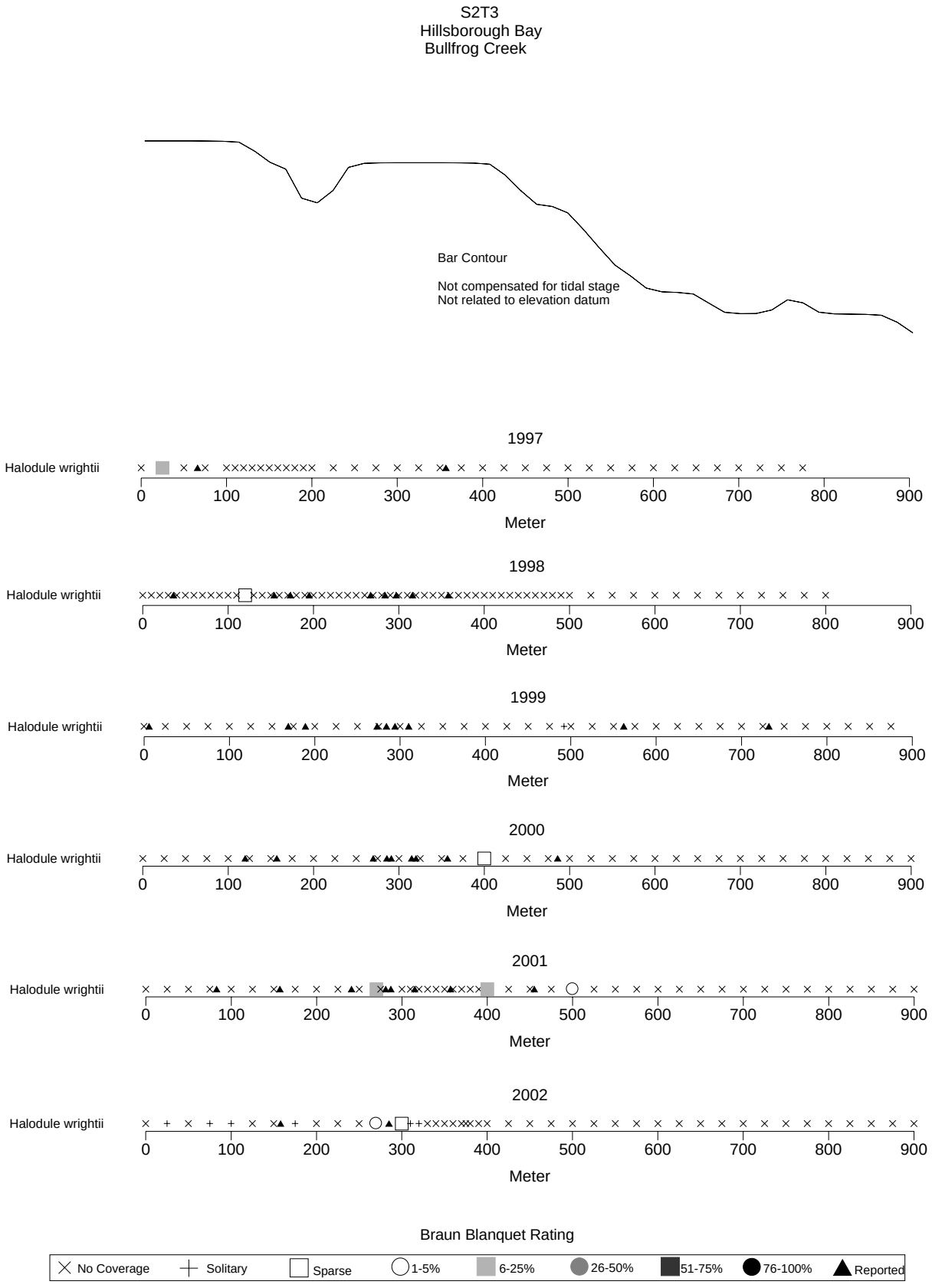


Figure 12. Distribution and abundance of *Halodule wrightii* along Transect S2T3 from 1997-2002.

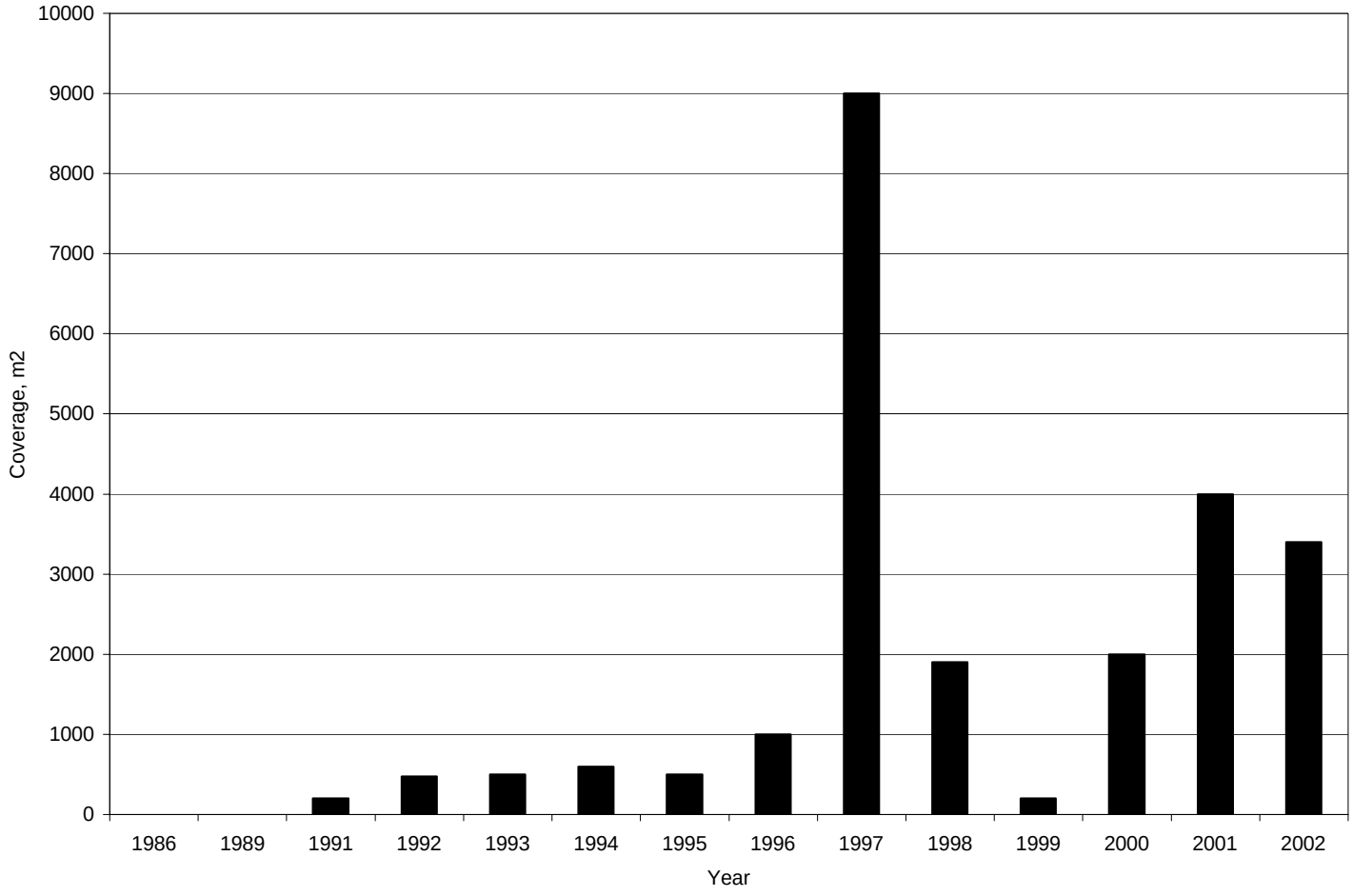


Figure 13. *Halodule wrightii* coverage in Area 4 from 1986-2002.

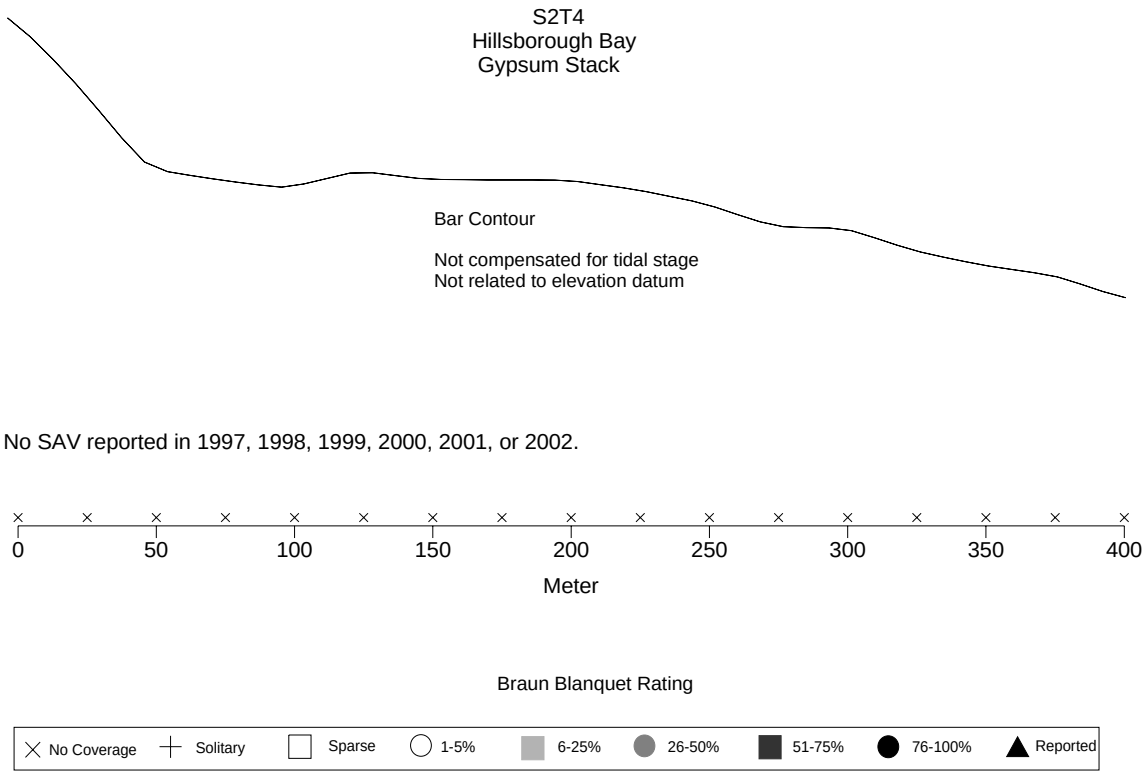


Figure 14. Distribution and abundance of submerged aquatic vegetation along Transect S2T4 from 1997-2002.

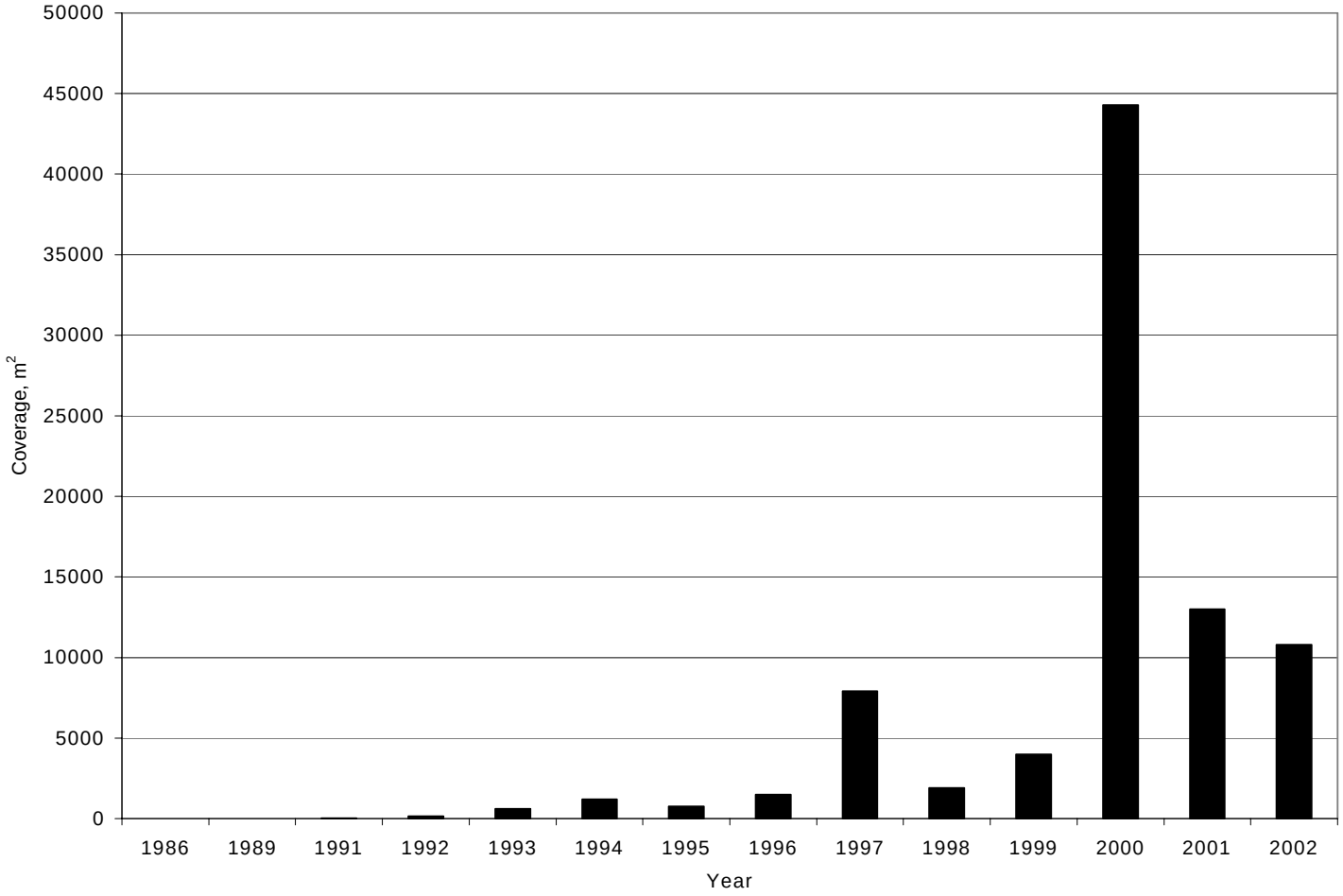


Figure 15. *Halodule wrightii* coverage in Area 5 from 1986-2002.

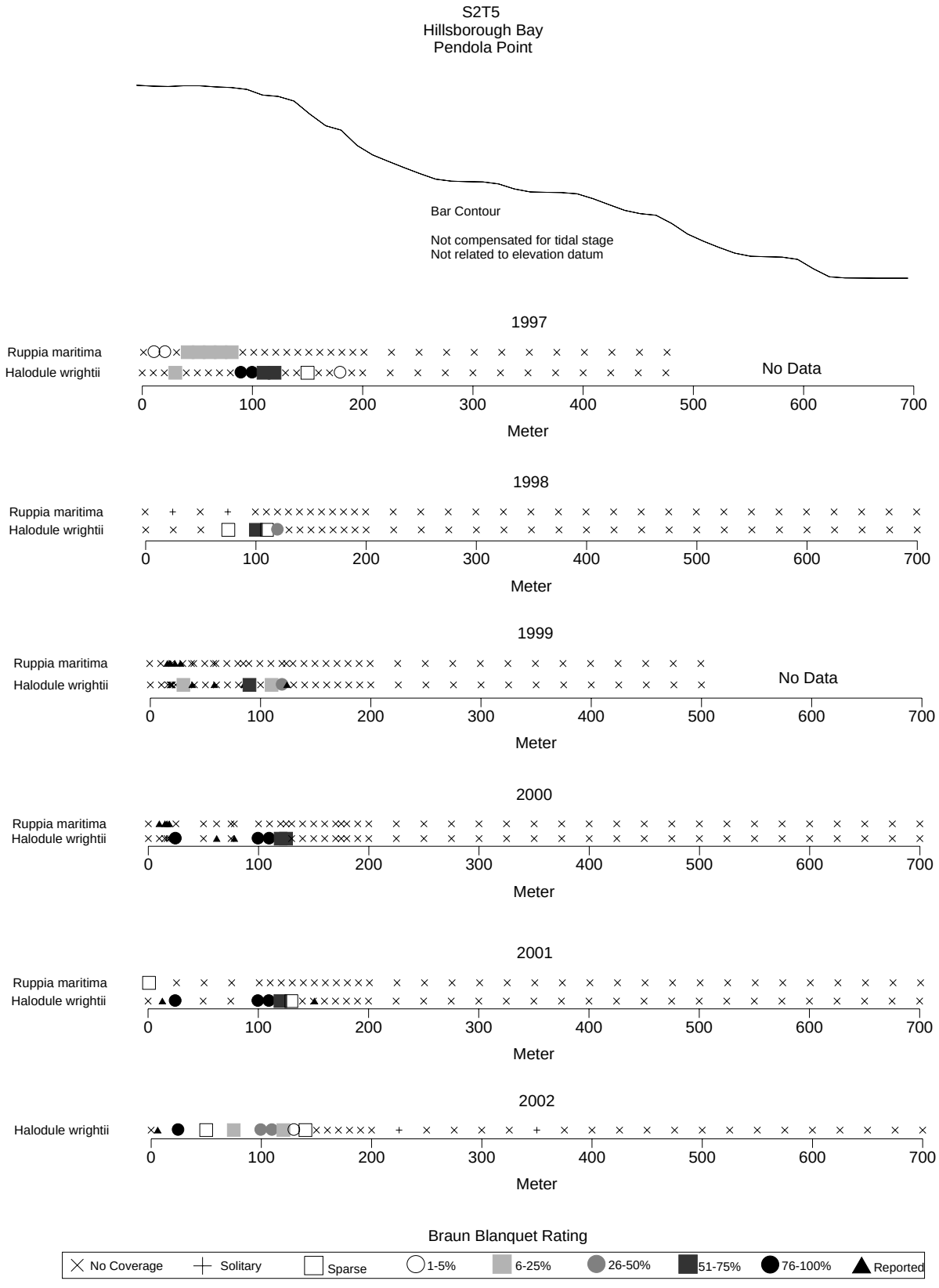


Figure 16. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S2T5 from 1997-2002.

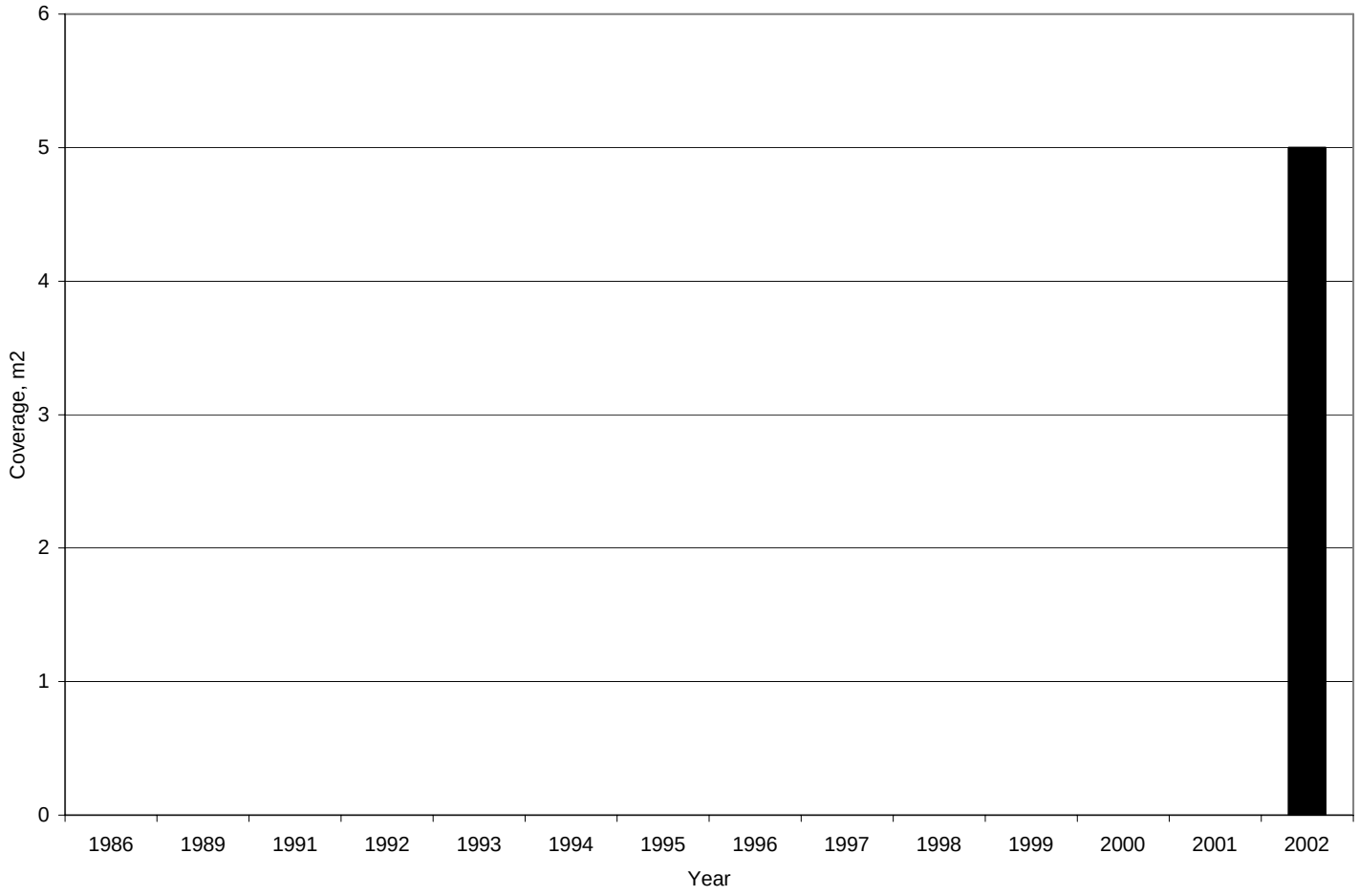


Figure 17. *Halodule wrightii* coverage in Area 6 from 1986-2002.

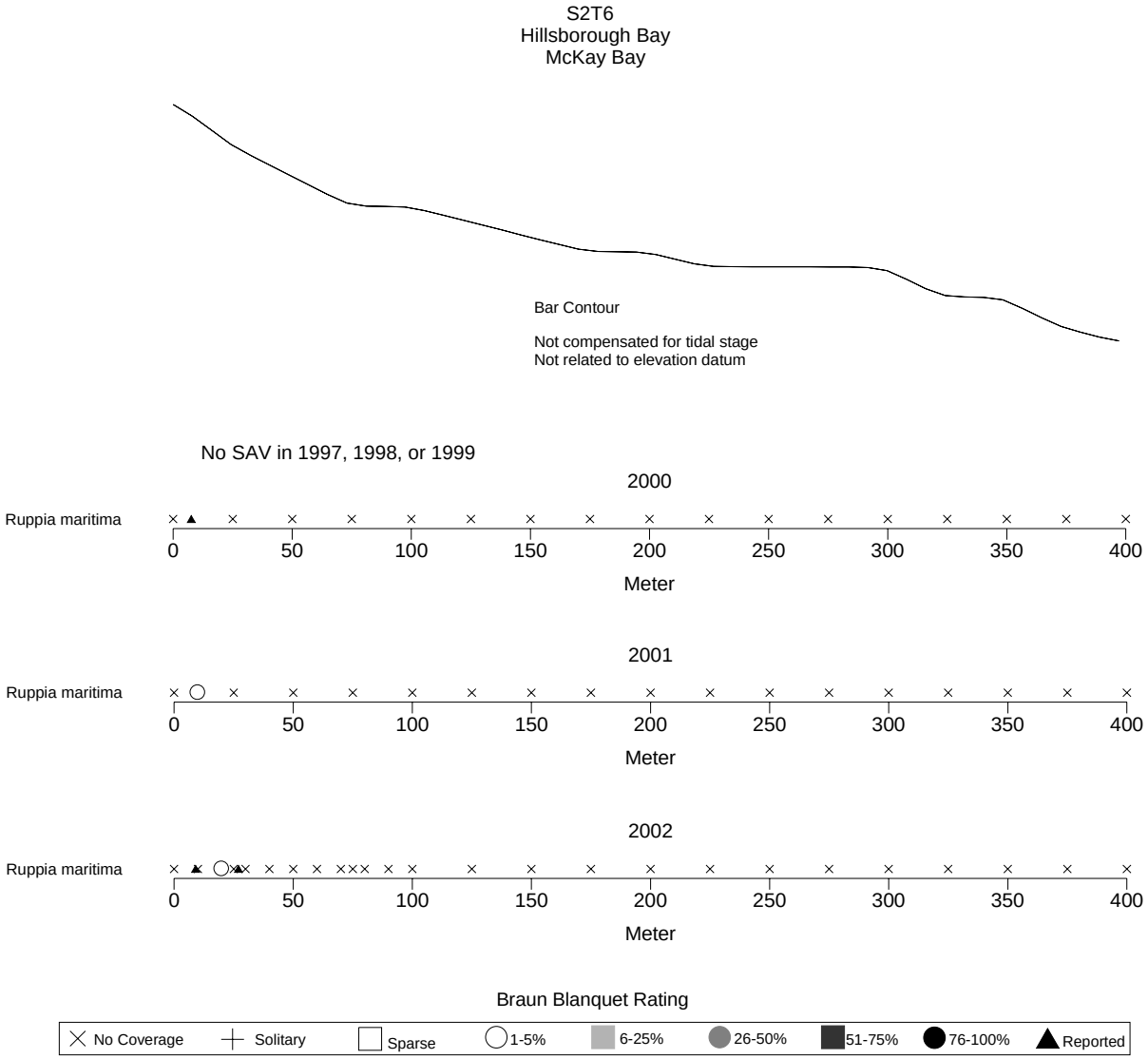


Figure 18. Distribution and abundance of *Ruppia maritima* along Transect S2T6 from 1997-2002.

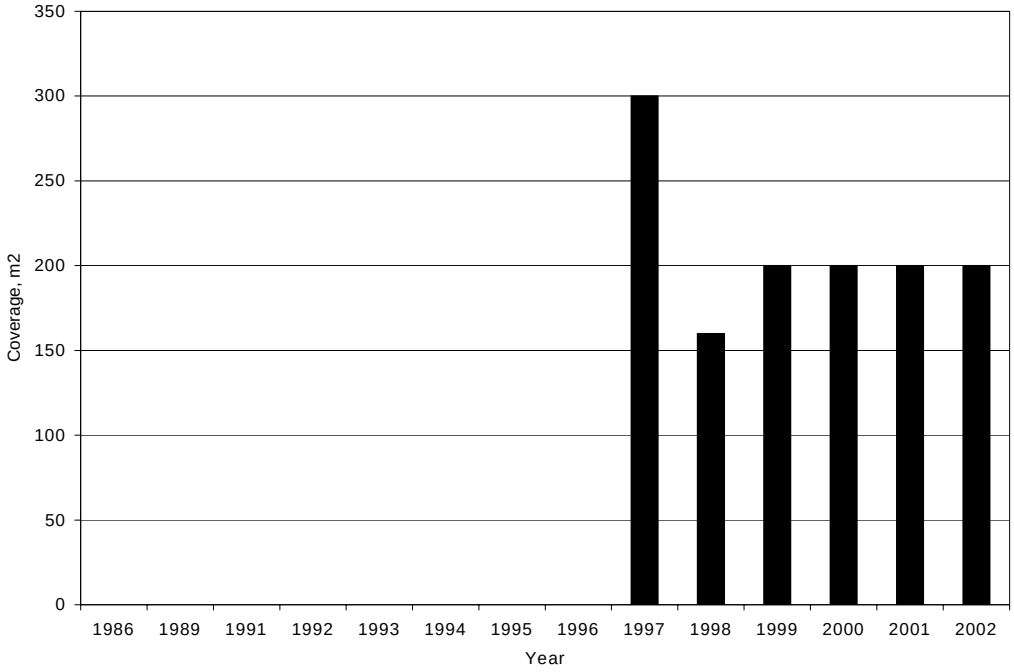


Figure 19. *Halodule wrightii* coverage in Area 7 from 1986-2002.

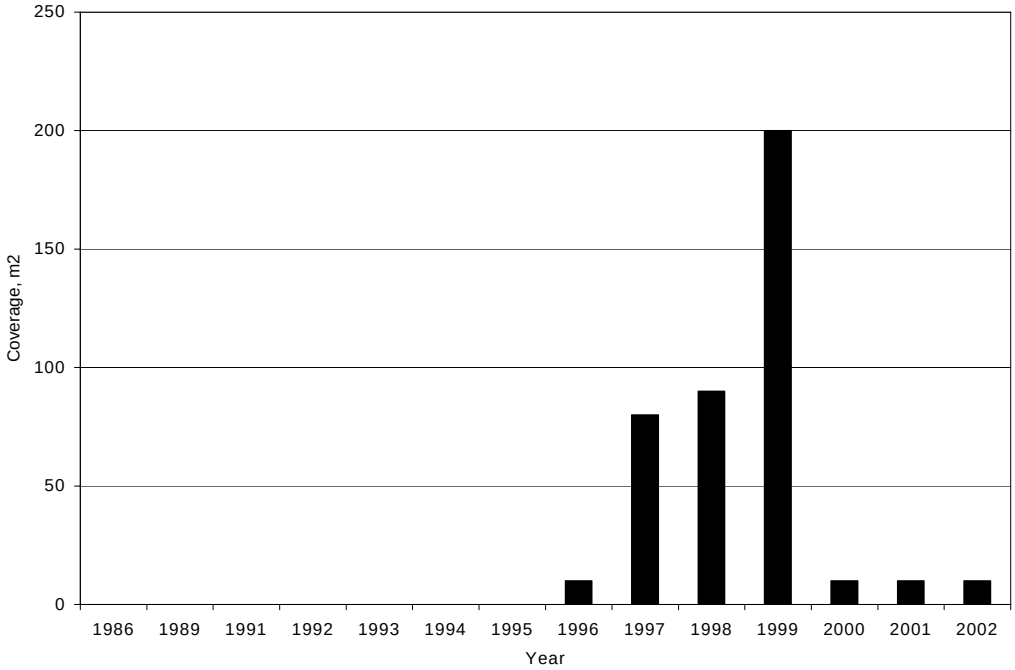


Figure 20. *Halodule wrightii* coverage in Area 8 from 1986-2002.

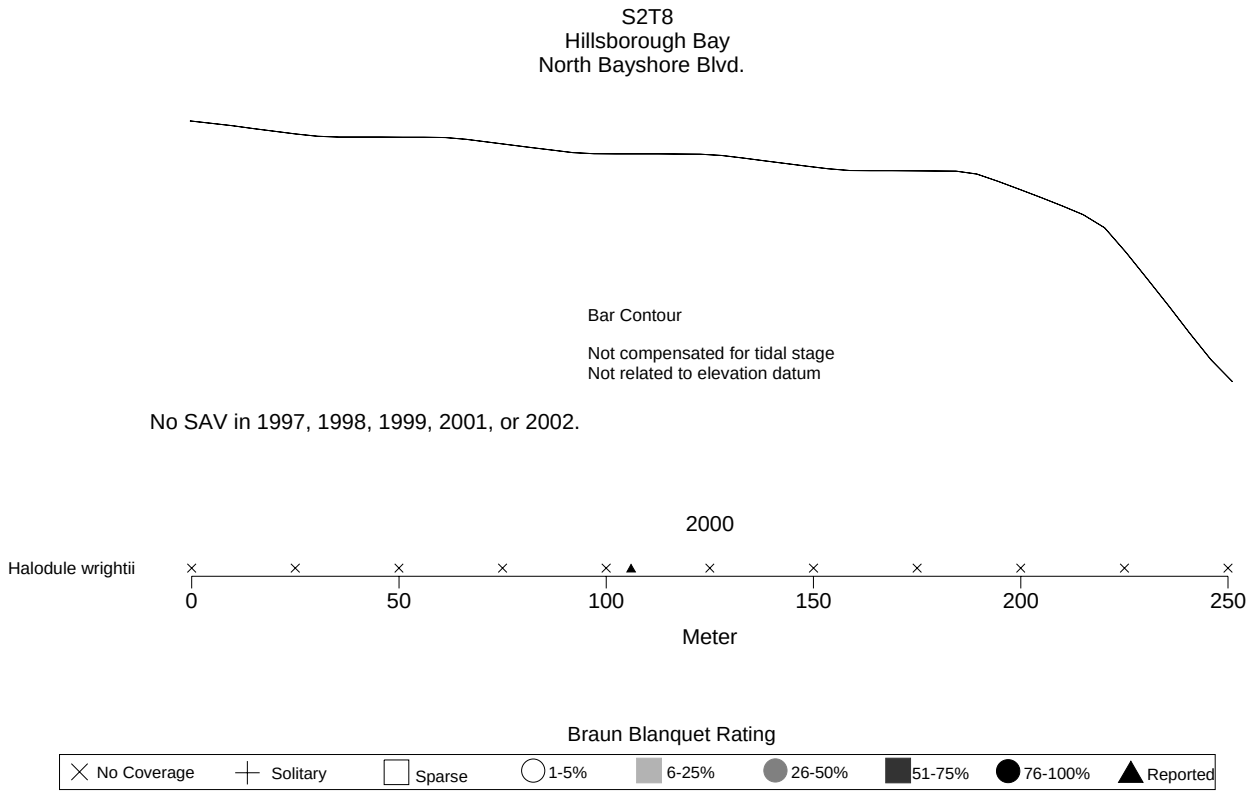


Figure 21. Distribution and abundance of *Halodule wrightii* along Transect S2T8 from 1997-2002.

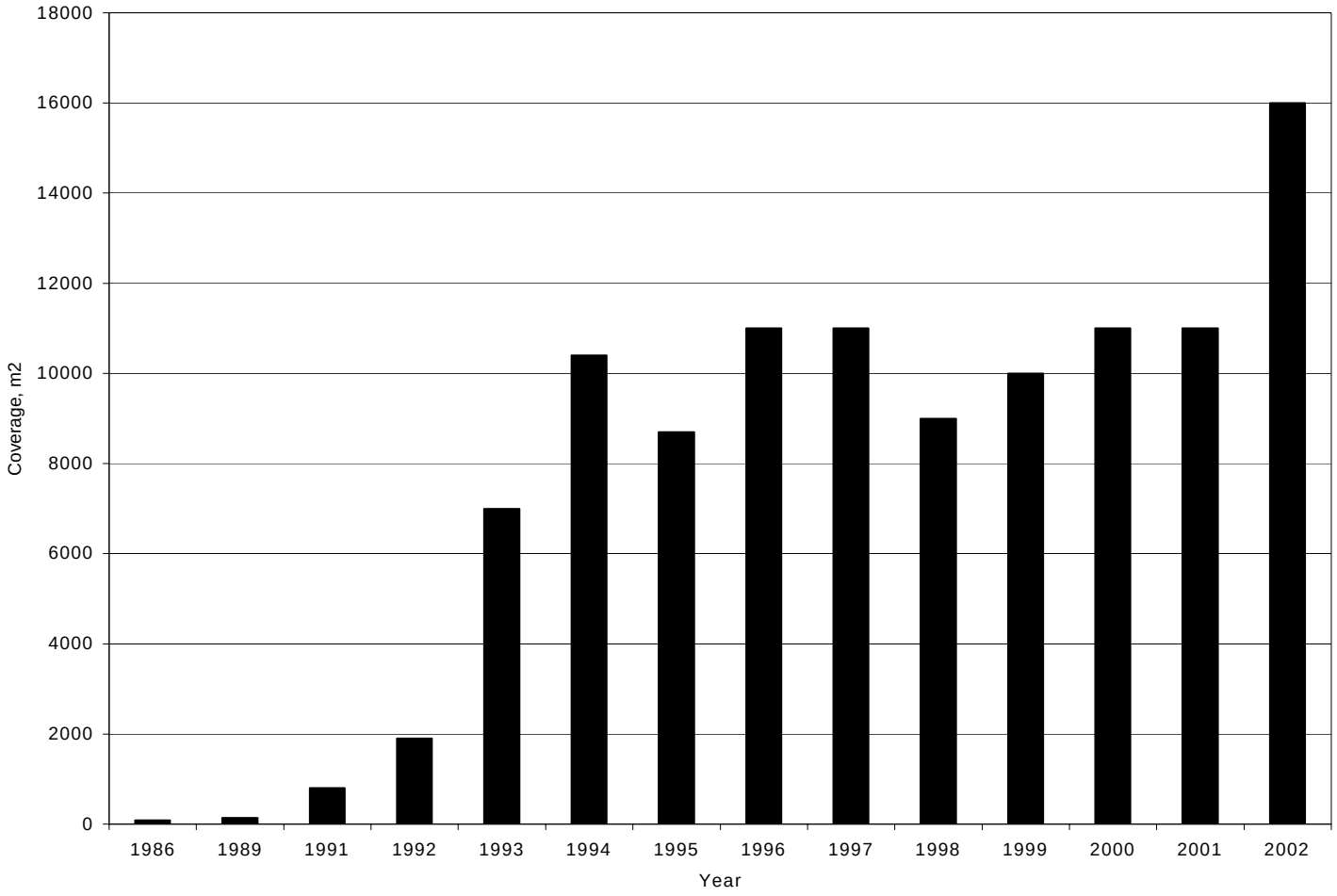


Figure 22. *Halodule wrightii* coverage in Area 9 from 1986-2002.

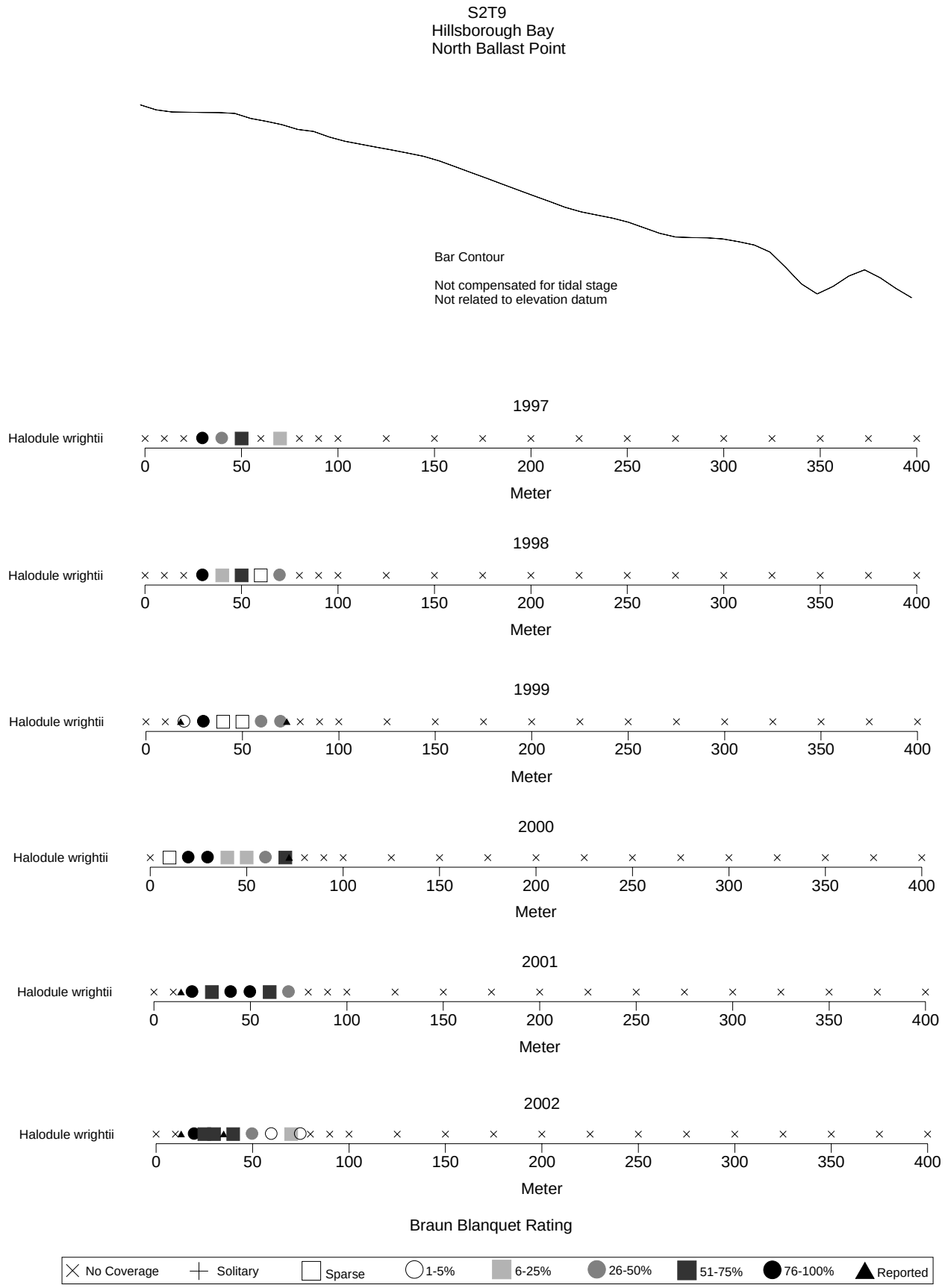


Figure 23. Distribution and abundance or *Halodule wrightii* along Transect S2T9 from 1997-2002.

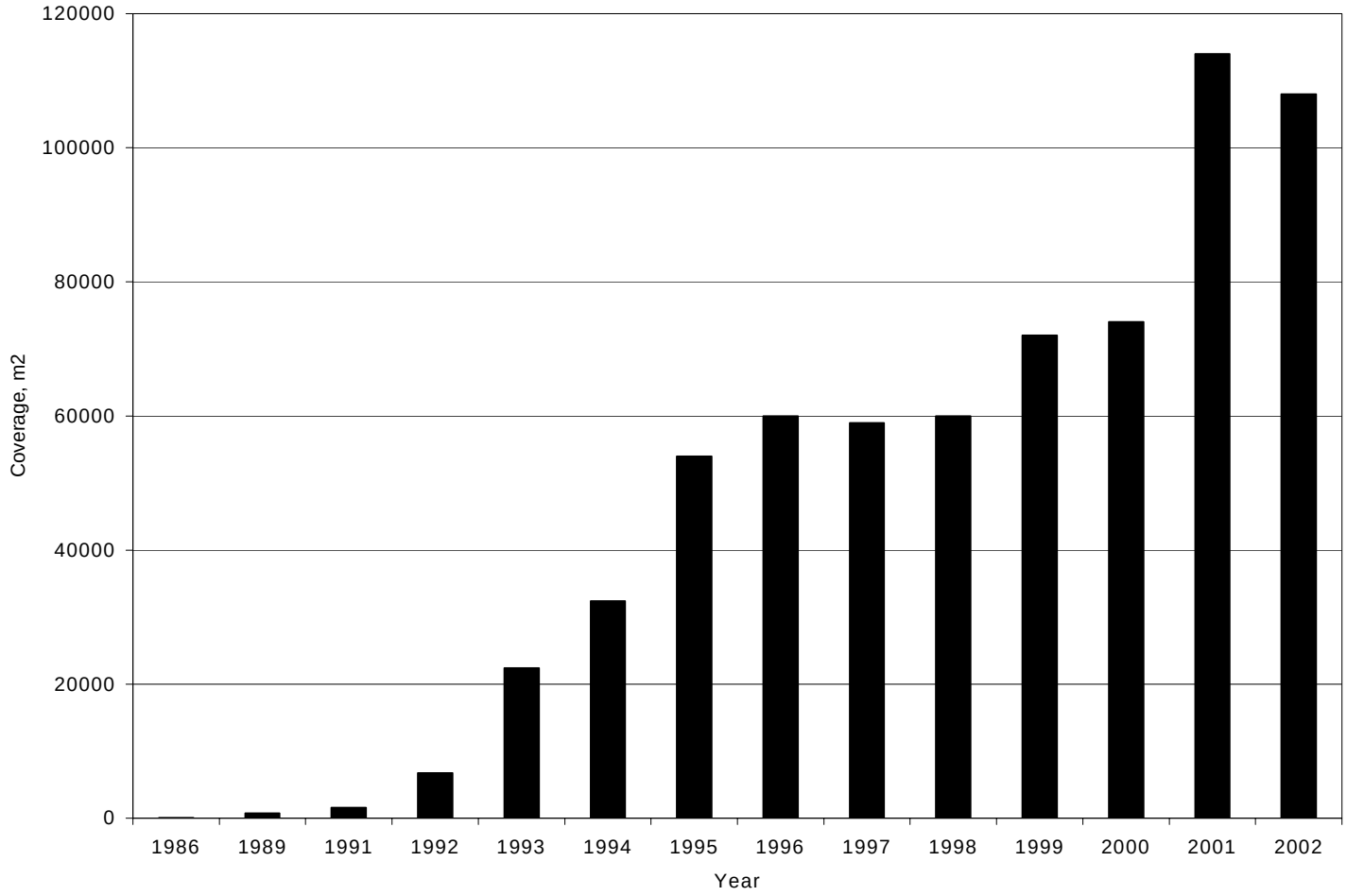


Figure 24. *Halodule wrightii* coverage in Area 10 from 1986-2002.

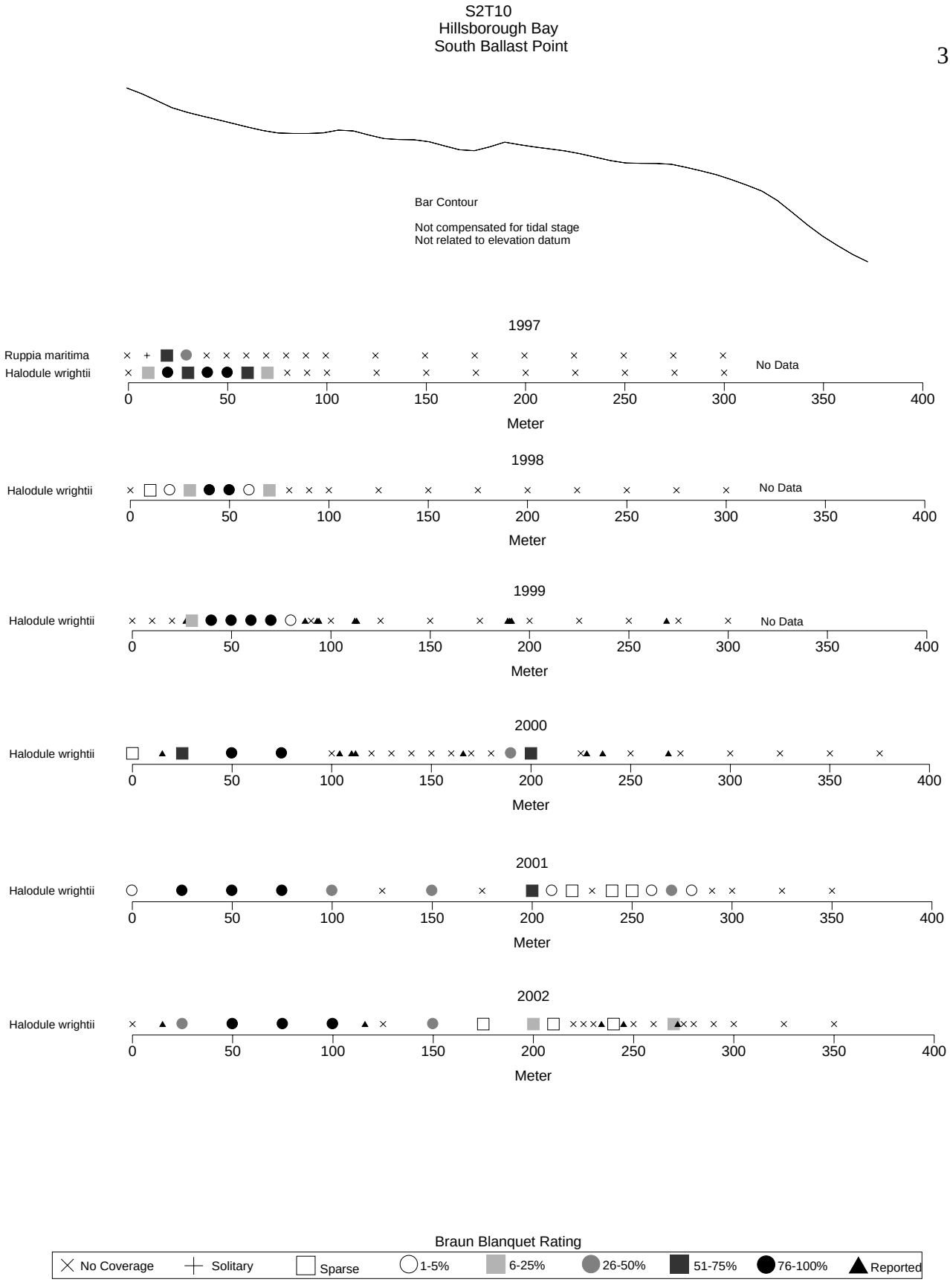


Figure 25. Distribution and abundance of *Halodule wrightii* along Transect S2T10 from 1997-2002.

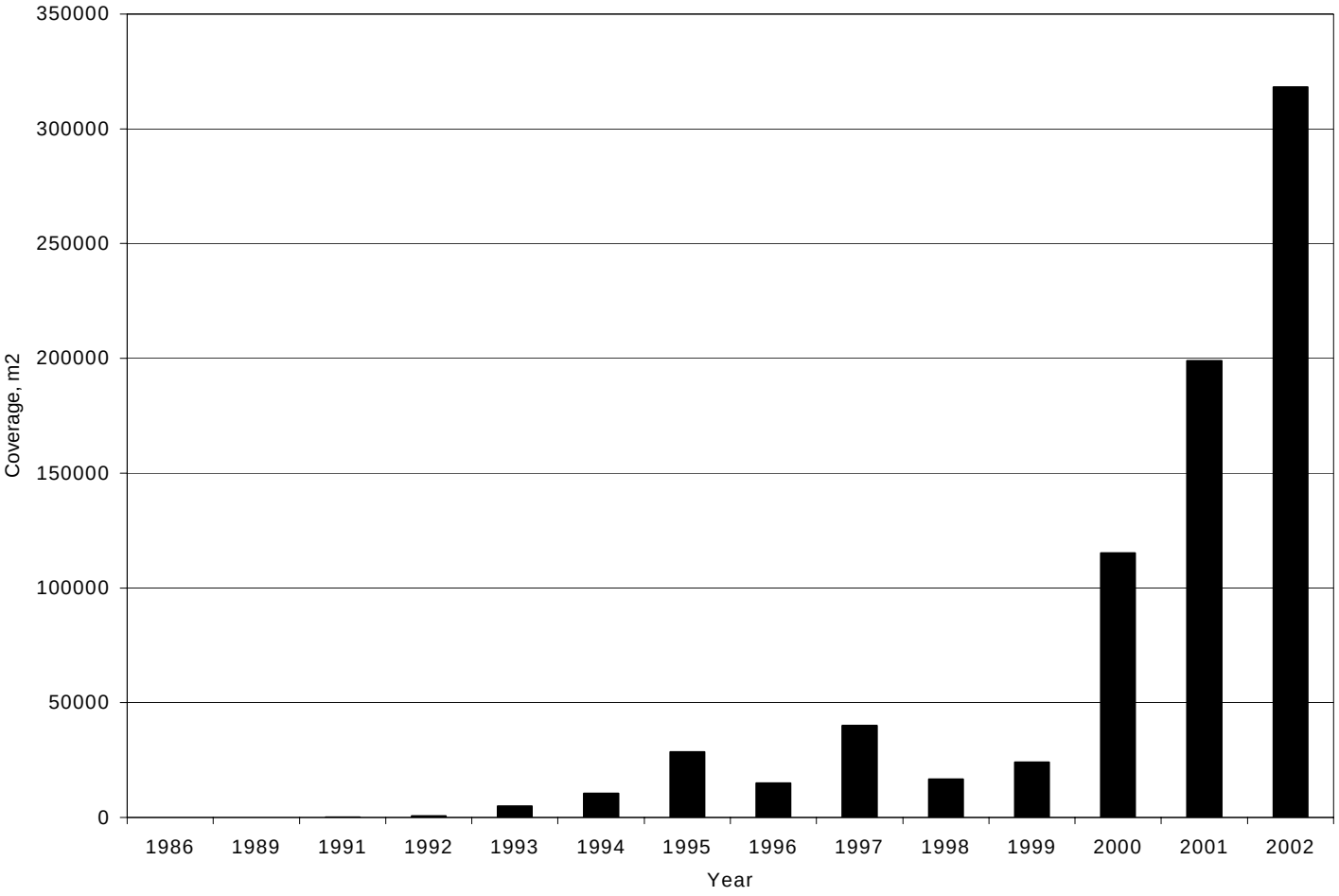


Figure 26. *Halodule wrightii* coverage in Area 11 from 1986-2002.

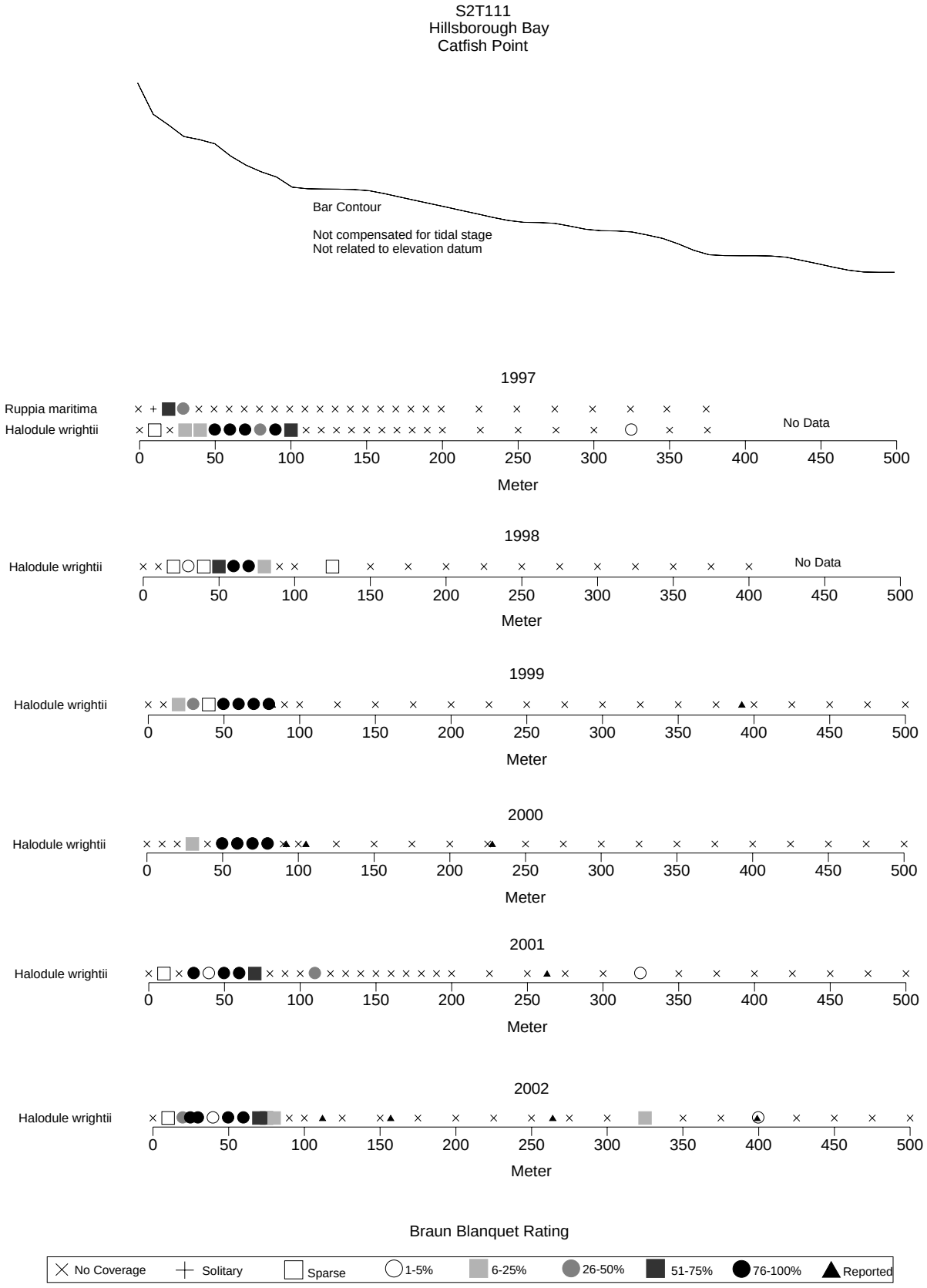


Figure 27. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S2T111 from 1997-2002.

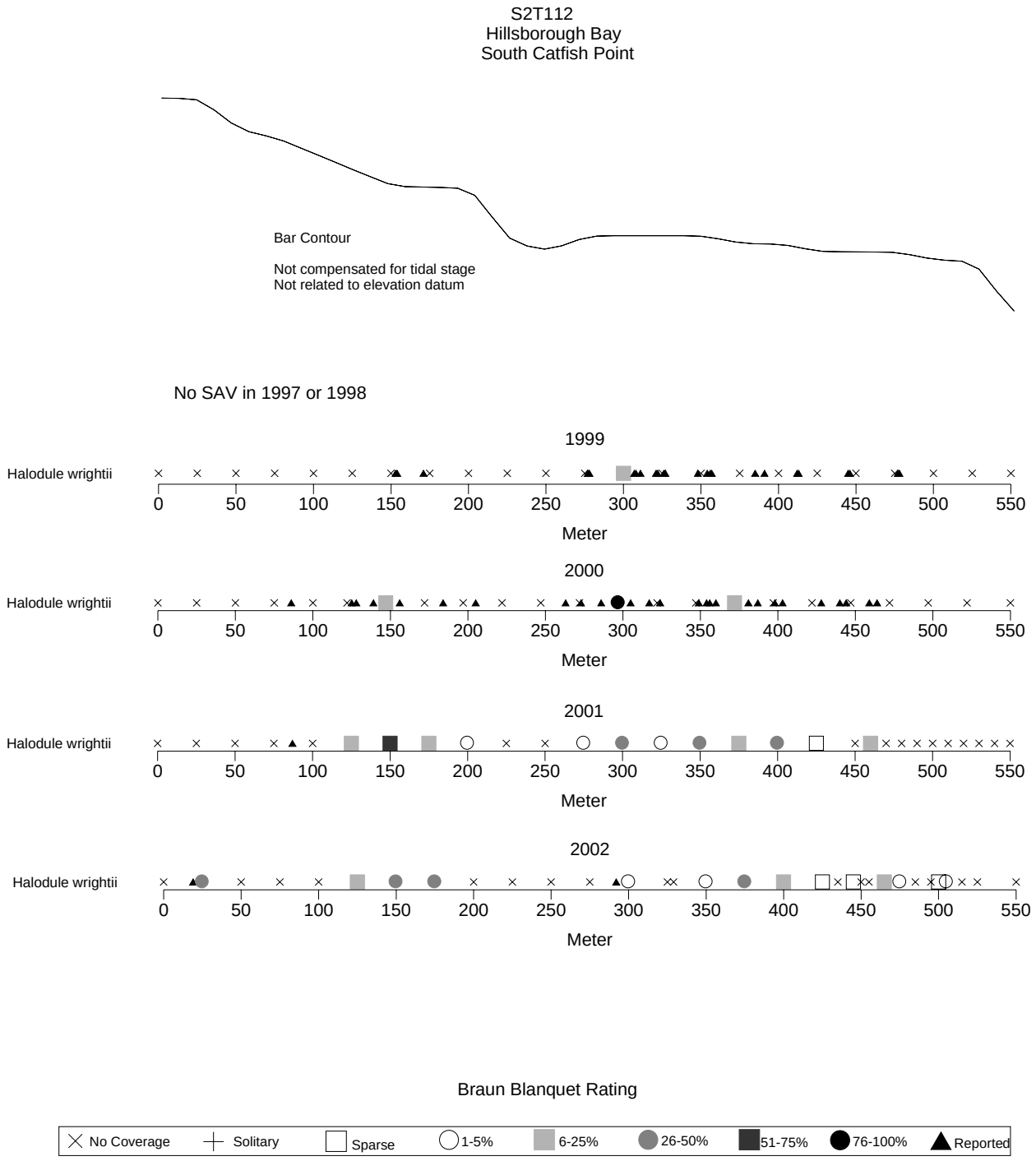


Figure 28. Distribution and abundance of *Halodule wrightii* along Transect S2T112 from 1997-2002.

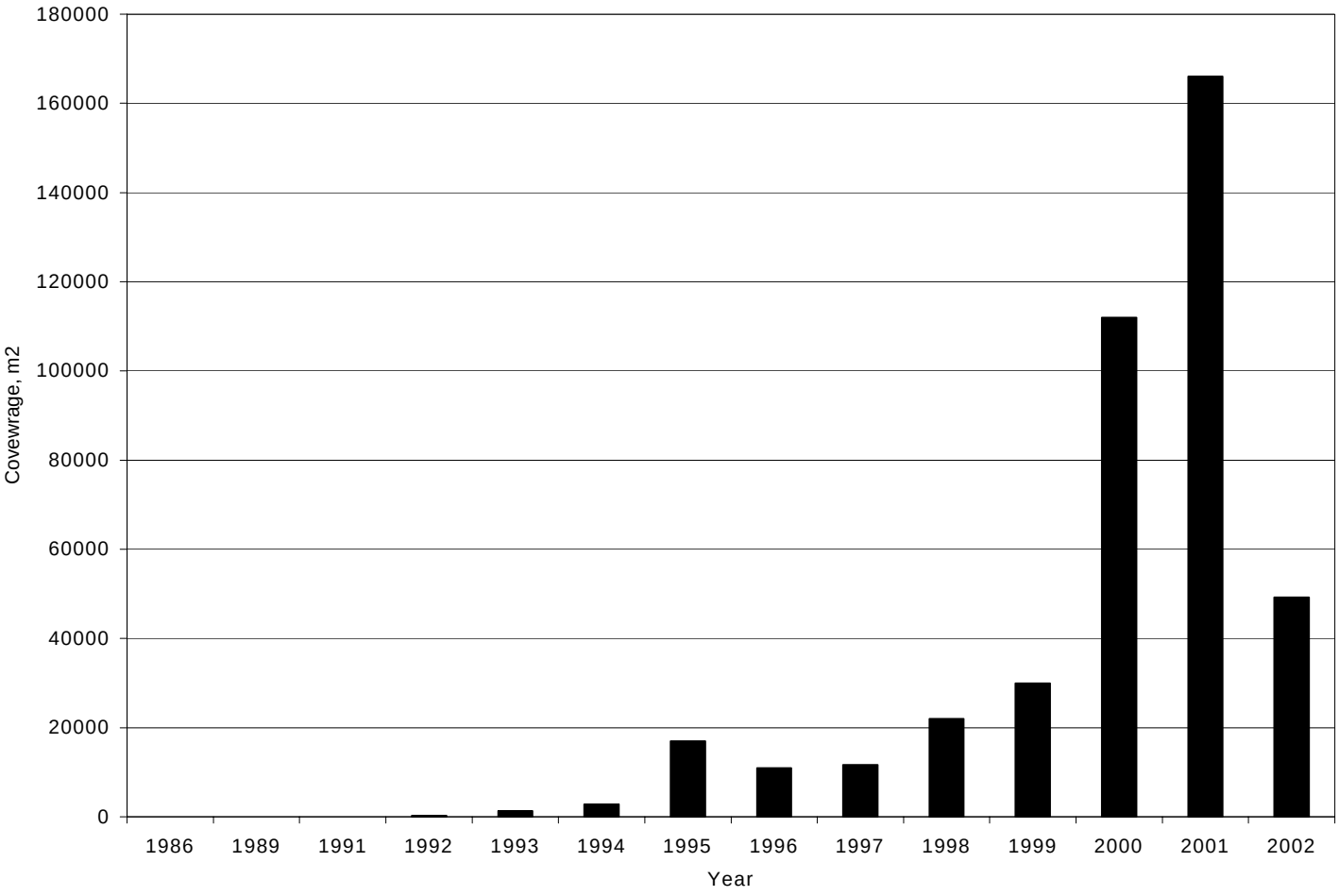


Figure 29. *Halodule wrightii* coverage in Area 12 from 1986-2002.

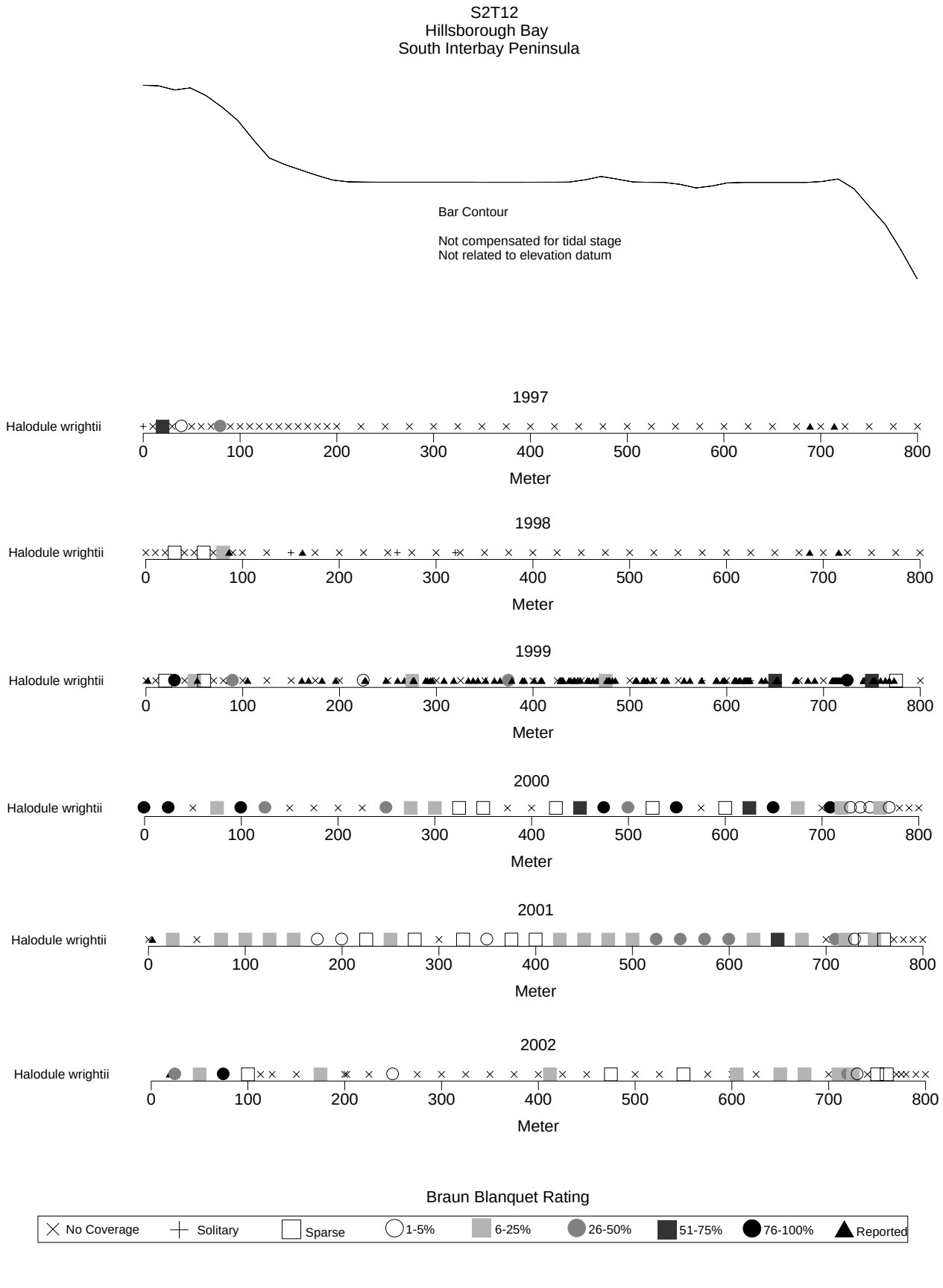


Figure 30. Distribution and abundance of *Halodule wrightii* along Transect S2T12 from 1997-2002.

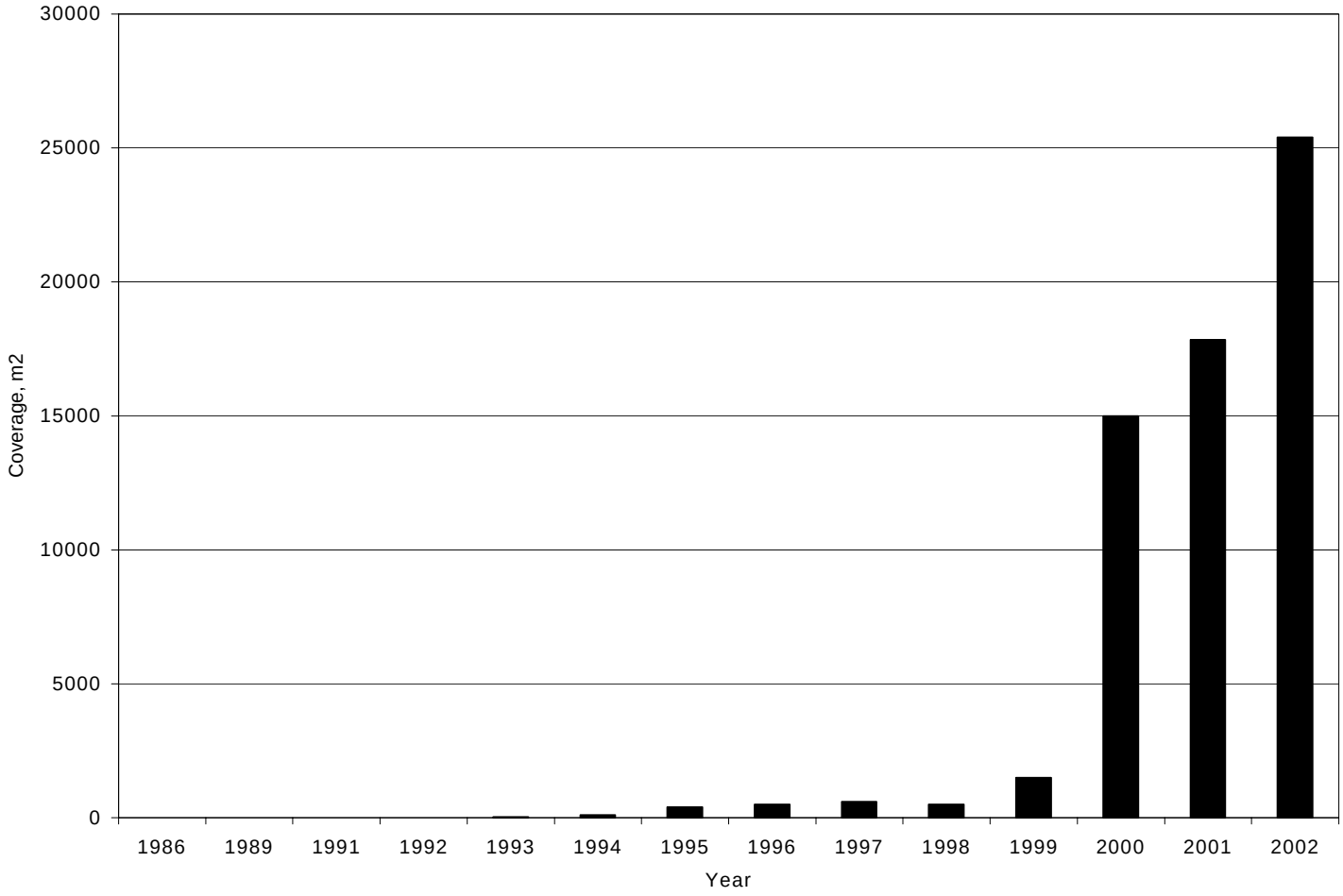


Figure 31. *Halodule wrightii* coverage in Area 13 from 1986-2002.

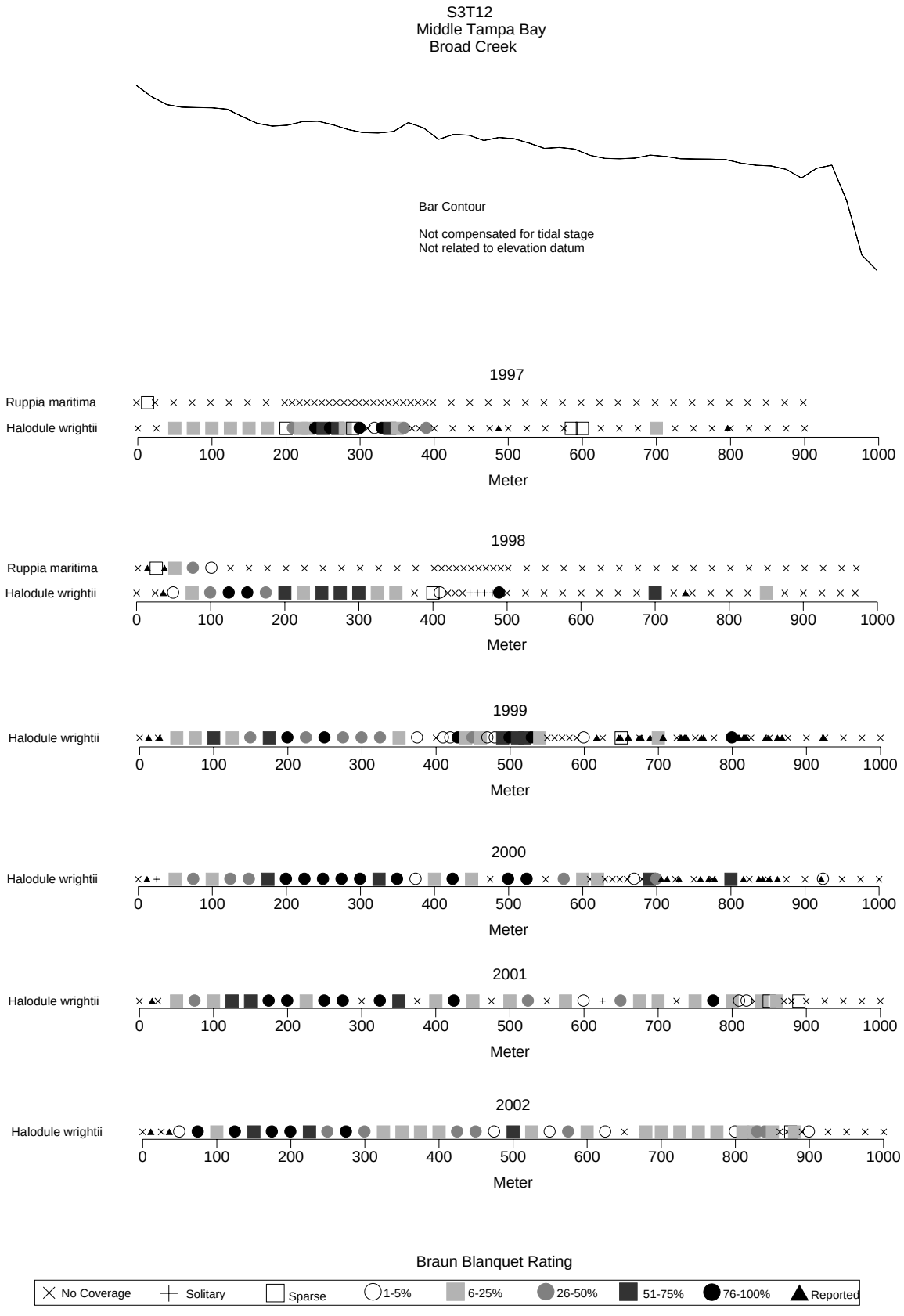


Figure 32. Distribution and abundance of *Ruppia maritima* and *Halodule wrightii* along Transect S3T12 from 1997-2002

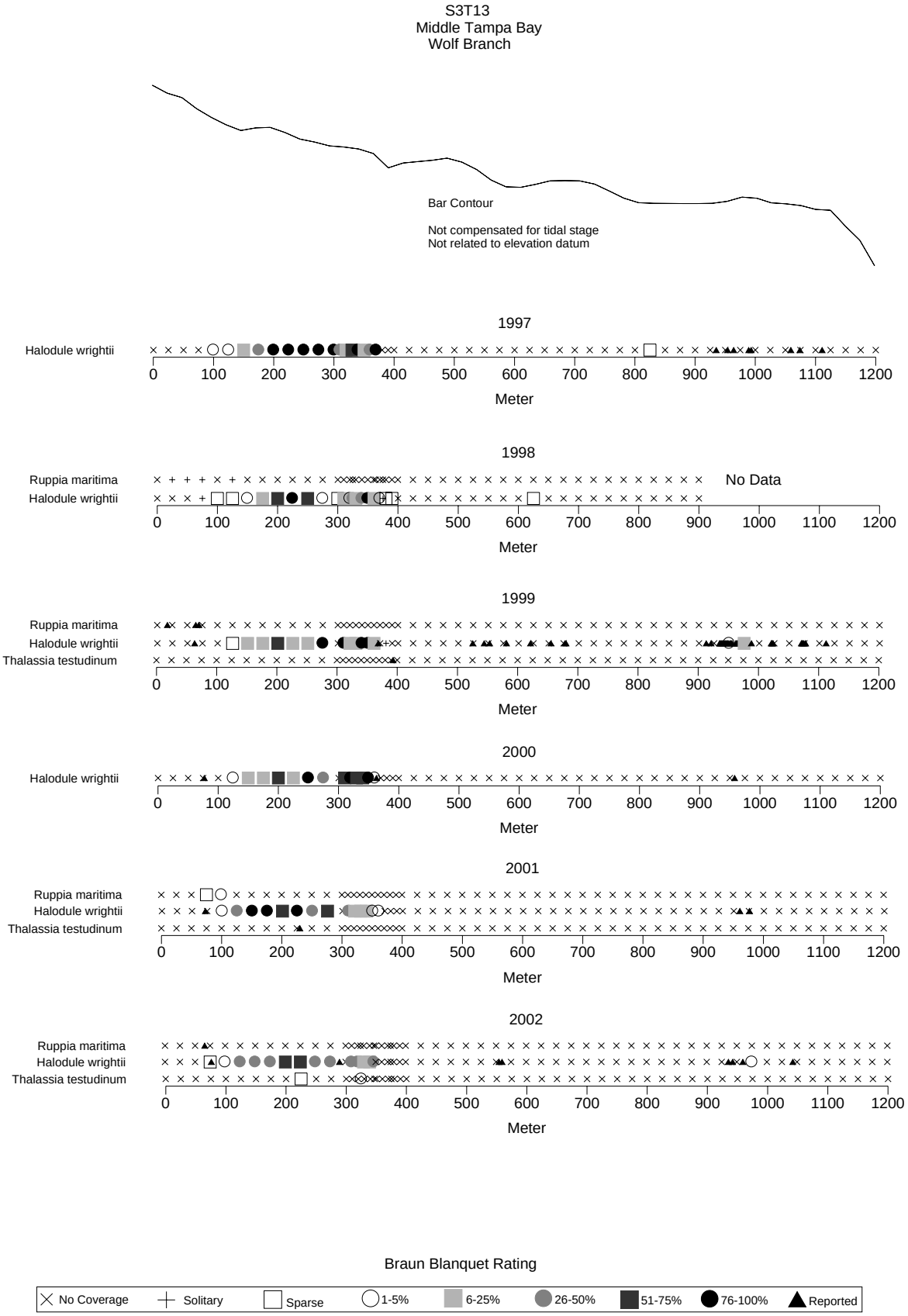


Figure 33. Distribution and abundance of *Ruppia maritima*, *Halodule wrightii*, and *Thalassia testudinum* along Transect S3T13 from 1997-2002.

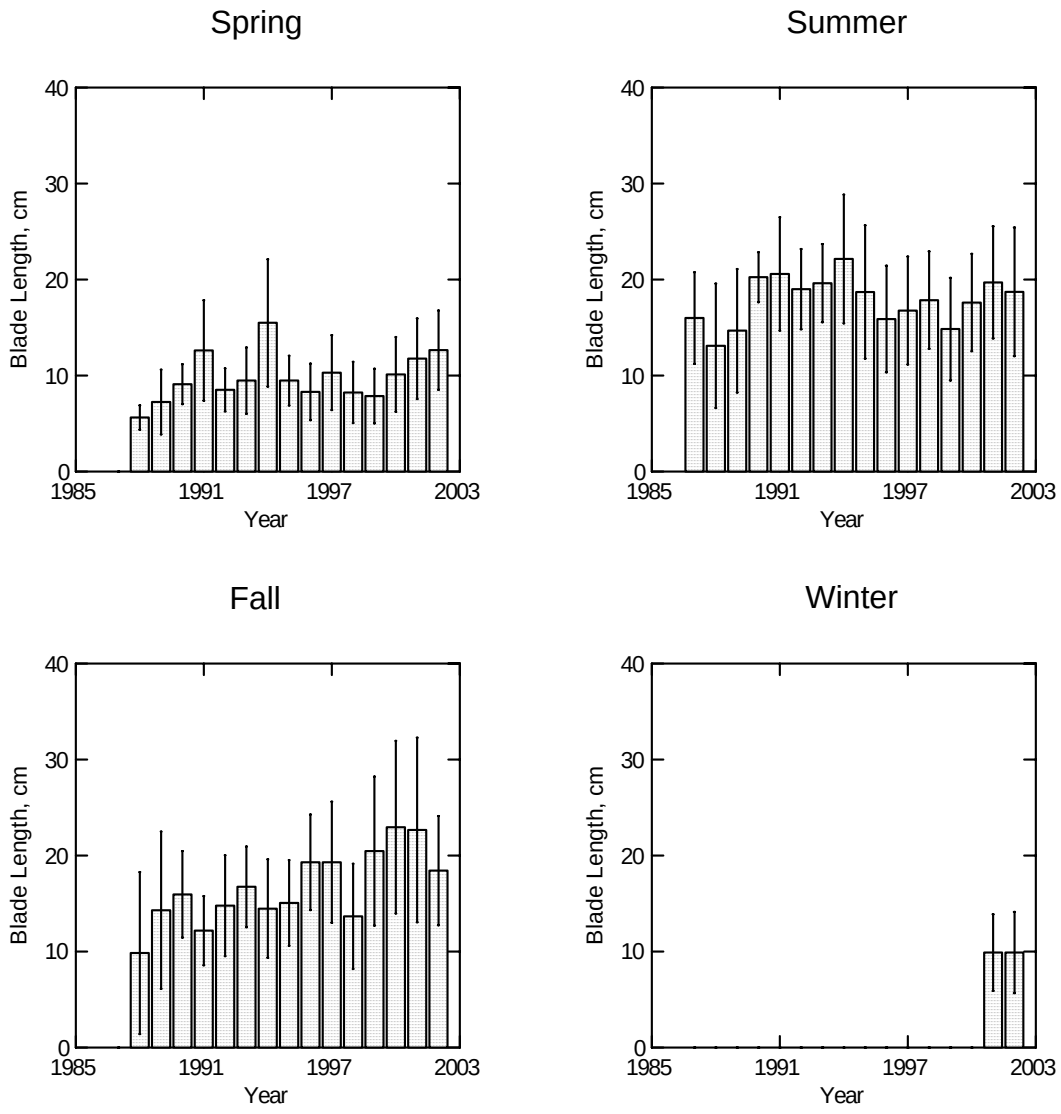


Figure 34. Mean seasonal *Halodule wrightii* blade lengths (6 1SD) in Hillsborough Bay from 1986-2002.

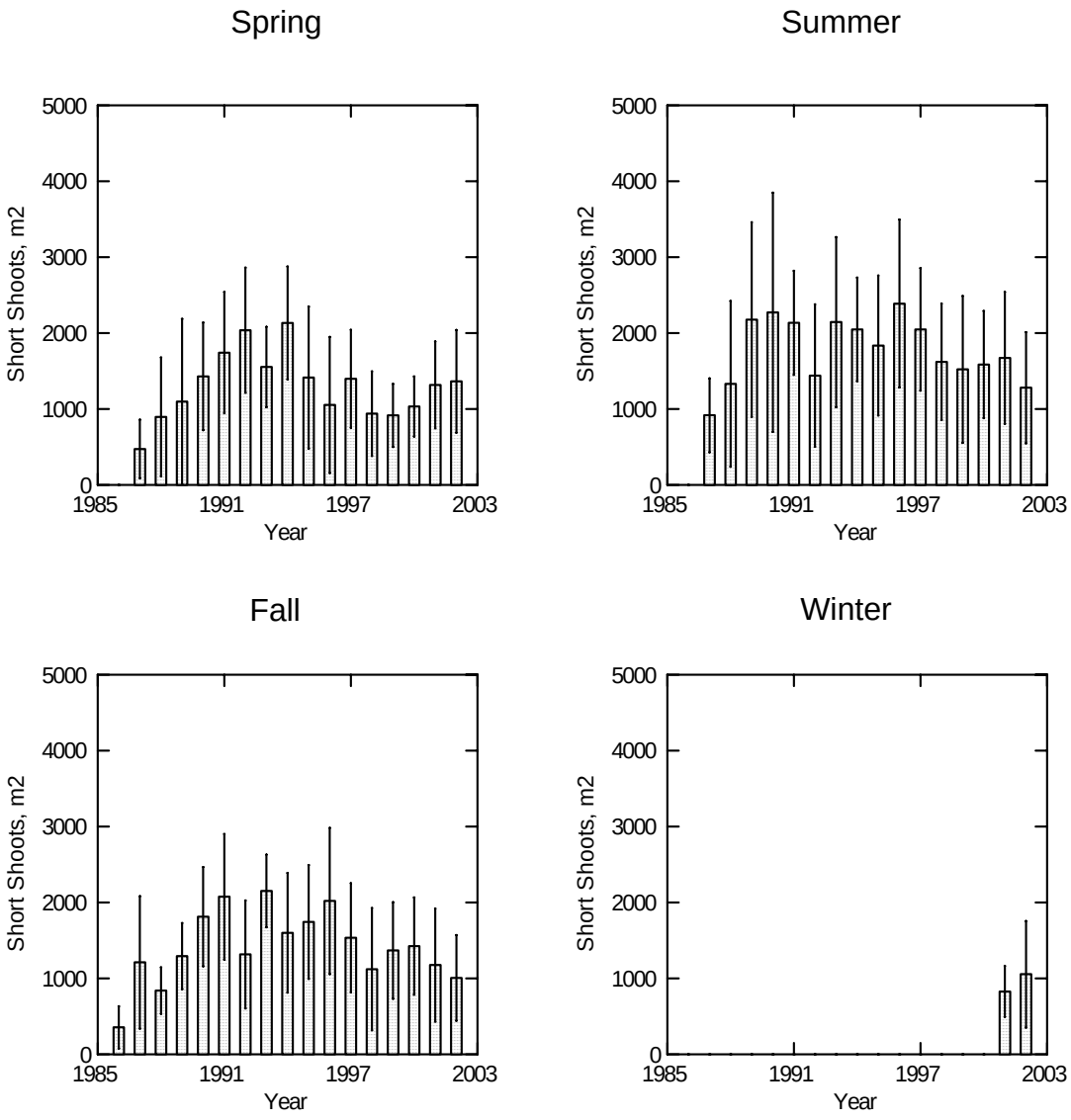


Figure 35. Mean seasonal *Halodule wrightii* short shoot density (6 1SD) in Hillsborough Bay from 1986-2002.

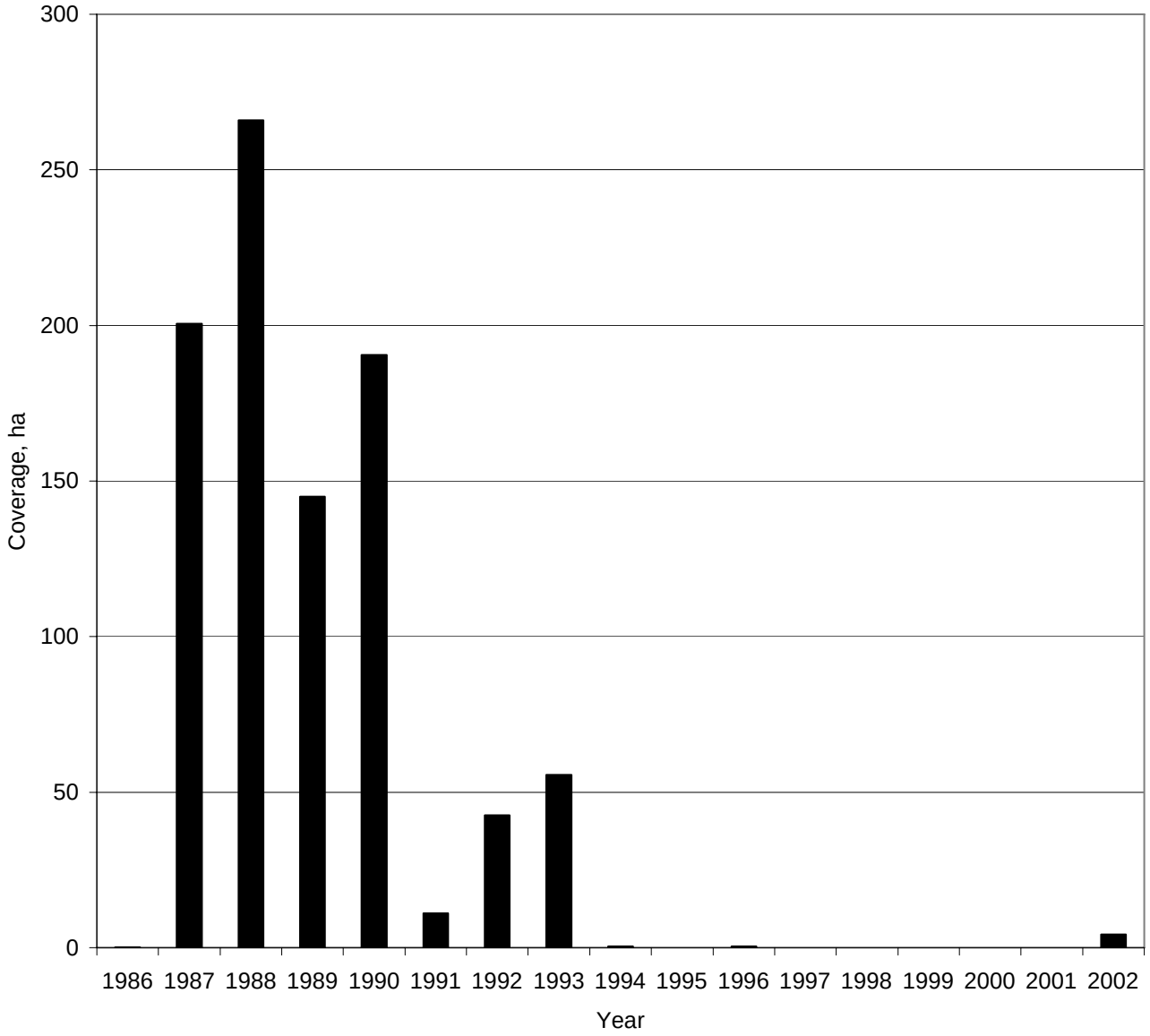


Figure 36. Areal coverage of *Caulerpa prolifera* in Hillsborough Bay from 1986-2002.