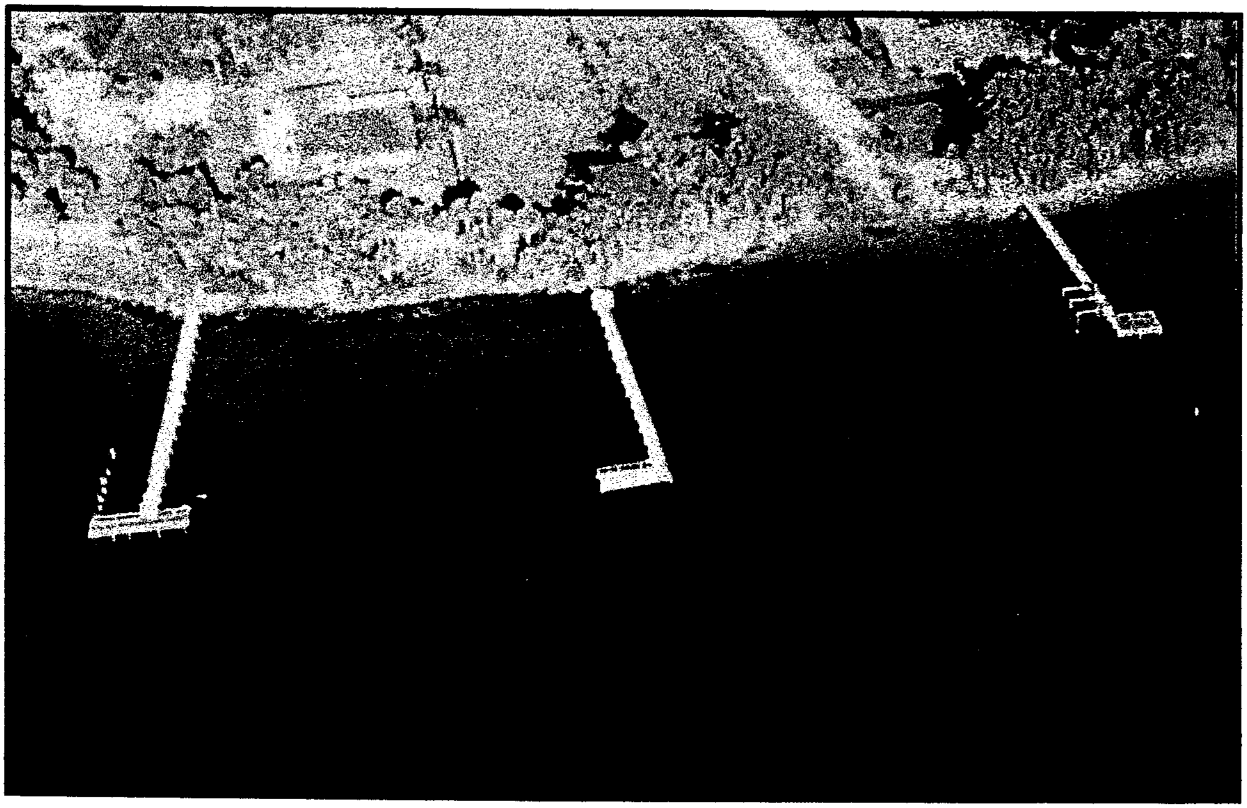
Comprehensive Assessment of the Effects of Single Family Docks on Seagrass in Palm Beach County, Florida



Draft Report for the Florida Fish & Wildlife Conservation Commission

Prepared by:

Kent Smith and Ron Mezich

Office of Environmental Services

Bureau of Protected Species Management

620 S. Meridian Street

Tallahassee, FL 32399-1600

ABSTRACT:

Seagrass is the primary foraging resource in estuarine and marine waters for the West Indian manatee (Trichechus manatus latirostris). Due to extensive coastal development, seagrass communities have been dramatically reduced throughout the manatee's range in Florida and especially in nearshore areas preferentially used by manatees. The Bureau of Protected Species Management within the Florida Fish and Wildlife Conservation Commission has maintained an active management and research program directed toward the protection of seagrass communities as manatee habitat. Recent efforts have focused on the cumulative effect of docks and related boating activities on seagrass. Assessment of aerial photographs of Palm Beach County from 1996 alone indicate that over 3,500 single family docks exist with the potential to damage seagrass. Experimental studies assessing dock construction characteristics, before and after comparisons of permitted docks and a study assessing the cumulative effect of construction in a populous county in southeast Florida are being used to address a state-wide cumulative dock construction effect. Our survey of dock impacts to seagrass communities in Palm Beach County indicate that 2% of the county's seagrass beds have been eliminated by dock construction to date. Information gained from these efforts will be used to effect biologically relevant changes to dock construction criteria in administrative rules reducing and possibly reversing the loss of seagrass associated with old and new dock construction.

Table of Contents

List of Figures

List of Tables

Introduction:

Seagrasses are highly specialized macrophytes which are well adapted to performing allaspects of their life history in an euryhaline entirely aquatic environment (Phillips and Menez, 1988). Seagrass meadows are highly productive and support diverse communities of animals and plants (Zieman, 1982; Zieman and Zieman, 1989). Seagrasses are of primary importance to large endangered grazers such as the West Indian manatee (*Trichechus manatus*) and green sea turtles (*Chelonia mydas*) (Smith, 1993; Bjorndal, 1979). Understanding and controlling losses of seagrass due to human activities is of paramount importance to managers of all aquatic resources.

Vessel mooring, marina development and operation and docking facilities lead to small focal and large scale seagrass destruction (Livingston, 1987; Walker, et al., 1989; Hastings, et al., 1995; Meeker, 1995; Burdick and Short, 1999). Much of this destruction is caused by dredging of shallow seagrass meadows to provide deep water access for motorboats, but a large amount is also caused by direct shading of seagrass beds through placement of privately owned over-water structures (primarily docks) above them (Burdick and Short, 1999).

Docks and other over-water structures limit seagrass growth under and around them primarily through reduction of ambient light levels (shading) (Bulthuis, 1984; Rudolph, 1985; Carlson and Acker, 1985; Molnar, et al., 1989; Haunert and Kenworthy, 1990; Burdick and Short, 1999). Ambient light reduction leads to reduced productivity and abundance, and loss, leading to discontinuities in seagrass beds (Burdick and Short, 1999). Patchy seagrass beds are less resistant to natural and artifical disturbances. Shading associated with low docks in the relatively clear waters of Biscayne Bay diminished light levels to 7-13% of incident light at 0.75 m depths, eliminating manatee (*Syringodium filiforme*) and Cuban shoal *grass (Halodule wrightii*) there under (Molnar, et al., 1989). Level of light reaching eelgrass (*Zostera marina*) beds below docks in Waquoit Bay, Massachusetts, was positively correlated with dock height and width (Burdick and Short, 1999). Canopy structure, the product of canopy height and shoot density, was determined to be most affected by light levels in this study, so docks closer to the water and of greater width controlled seagrass growth through greater shading of ambient light. Burdick and Short (1999) also found that docks in a north-south orientation, which were elevated at least 3 m above the benthos, allowed the most seagrass growth under their shading influence. An east-west orientation was found to be the most detrimental to seagrass growth, as the docks orientation matched that of the sun's travel arch, increasing the daily shading period relative to north-south oriented docks. Loflin (1990) found seagrass absent beneath approximately 80% of the docks surveyed in Pine Island Sound and San Carlos Bay, Florida. In this study, seagrass was found in only 8.6% of shoot count samples taken under surveyed docks. Loflin correlated total seagrass loss with total area shaded, but did not find an association with seagrass loss and dock height, width or orientation.

It is possible to reduce the shading effect of docks to some degree, which may provide for continued seagrass growth under docks. Burdick and Short (1999) developed a model that predicted the optimal height above substrate and width for docks that would allow optimal canopy structure based on meeting the light requirements for eelgrass growth under such docks. In their model, a north-south oriented dock (with a width of 1 m) must be elevated 3 m off the substrate in order for 30% of the incident light to reach eelgrass below the dock during peak irradiance periods in this model. This model also considers different height and width requirements for docks with orientations offset from the north-south plane. This study contrasts the dock survey performed by Loflin (1990), who through less rigorous measurements of seagrass effects documented that the measured dock shadow area was correlated with dock area, but not to width, height above mean high water (MHW) or orientation. Narrow width and height ranges due to small tidal range and sample may be responsible for this finding. Minimizing dock size or placement in areas devoid of seagrass was recommended by Loflin as a means of controlling seagrass loss on a regional basis. Molnar and coworkers (1989) measured light levels passing through one inch opening aluminum grating material and found 70% incident light transmission, indicating that dock construction materials can reduce dock shading impacts to some degree. Preliminary results of current dock experiments examining the use of grating and elevating docks off the substrate in Florida waters show increased light levels and seagrass persistence below manipulated docks (Jeff Beal, personal communication; Deborah Shafer, WRP Technical Note VN-RS-3.1, June 1999).

Docks shade and eliminate seagrass, but they are a guaranteed right in the eyes of waterfront property owners. The riparian rights of waterfront property owners have long been recognized by federal and Florida state governments as allowing the construction of docks over sovereign submerged land held in public trust (Meeker, 1995). Access to adjacent waters has been interpreted to allow for single and multi-family dock and pier development which, when such structures are under certain threshold areal dimensions and meet standard construction conditions, is not extensively monitored by the Florida Department of Environmental Protection (FDEP). The FDEP does not review the dock plans or intervene to minimize the effects of such structures on aquatic resources. Over-water structures do not require Environmental Resource Permits (ERPs) from FDEP if docks are 500 square feet or under within Aquatic Preserves (aquatic areas of Florida designated by Florida Statute as of important ecological value to the citizens of the state) or 1000 square feet or under outside such preserves. Recent efforts to assess cumulative loss of seagrass due to exempt structures in highly developed areas of Florida led to our finding that adequate records of such impacts have not been routinely kept nor assessed by local, state or federal aquatic resource management agencies.

In this study, we performed a survey of exempt over-water structures, primarily single family docks, in Palm Beach County, Florida. Because all but the northern most waters of the County are outside designated Aquatic Preserves, the maximum size for county docks should be 1000 ft^2. Our primary goal was to assess the direct and indirect impact to seagrasses of a subsample of the more than 3,500 such structures in the county. This leads to the development of a more exact estimate of total seagrass loss in Palm Beach County, which is essential for management if it is to control seagrass loss due to dock development in this region. A second goal was to examine constructed dock characteristics and their effects to seagrass systems in order to develop recommendations regarding construction criteria for docks allowing optimal seagrass growth. In order to meet these goals, the physical characteristics of docks and direct physical effects of the docks on seagrass systems were measured. We collected and analyzed information including structure dimensions, structural characteristics, orientation, height above mean high water (MHW), areal extent of additions to docks and moored boats, water depth, seagrass community composition and percent cover of seagrass beds outside and under the shading influence of such docks. In particular, we measured seagrass loss areas due to direct dock shading, halo effect, floating docks, moored boats, and boat lifts. Dock construction and location characteristics were also recorded. Mean dock characteristics and impacts to seagrasses were calculated from collected data and are reported relative to known numbers of docks and seagrass distribution. Our results identify the magnitude of seagrass loss on a County-wide basis due to exempt docks in a highly developed coastal region and highlight the importance of considering these structures in comprehensive management of seagrass in Florida as both endangered species foraging habitat and a critically important marine resource.

Methods:

Single and multi-family docks in Palm Beach County, Florida that are generally exempt from requiring a FDEP permit for construction were identified and numbered from 1996 aerial photographs. Docks were divided to one of three regions; North Palm Beach County (NPBC), Lake Worth Lagoon (LWL) and South Palm Beach County (SPBC). A total of two hundred docks were randomly selected for sampling from all identified single family docks in the county by using a random number table generated by SAS software (SAS 6.12 for Windows, SAS Institute, Inc., Cary, N.C.). The number of sample docks assigned to each region was based upon the relative percentage of docks within county waters in that region. Sampling was performed during the second week of June, 1999, by three teams.

The length and width of dock platforms and associated boats and dock platform additions were measured by personnel using a measuring wheel (Keson Roadrunner Model RR 3M) calibrated to meters or feet. Measurement of the dock dimensions began where the apparent high tide line impinged upon the shore. Dock height above Mean High Water (MHW) was measured by using a rigid 1.25 inch diameter 3 meter long PVC pole marked in centimeter increments. Dock height was measured from the top of the fouling line on an outer piling to the bottom lip of the dock decking material. Boat and davit (boat lift or craddle) width measurements were either measured along an associated solid surface or estimated from known standard boat widths. All dock area and height data were converted into linear or areal measures based on feet for convenience of interpretation by resource managers and because most ERP applications are based on measurements in feet and acres of impact.

While dock area data were being collected, two snorkelers inspected the benthos to each side of the dock from shore to just off the end of the dock. Seagrass presence or absence was documented. If seagrass was present around docks, seagrass cover was measured adjacent to the dock where the influence of the dock was not visually detected and in the area where the dock influenced seagrass cover (directly adjacent to the dock and/or under the decking cover). Where seagrass was observed, percent cover determinations were made by haphazardly tossing 0.25 meter PVC quadrats within the defined seagrass areas three times by each snorkeler both outside and under the influence of the dock for a total of six times per snorkeler per dock side. Percent cover determinations were made based on a modified Braun-Blanquet (1932) technique, where snorkelers, whose assessment skills had been calibrated and tested for accuracy prior to the survey, visually compressed seagrass to naturally occuring density levels within the quadrat and reported these estimates of percent cover to a data recorder. Snorkelers also measured and reported the average distance from the edge of the dock to the edge of the seagrass bed with fiberglass meter tapes or calibrated measuring sticks to determine the indirect peripheral effect ("halo effect") on each side of the dock. Seagrass bed and dock characteristics were mapped on data sheets and 35 mm single lens reflex cameras were used to photograph each dock. Photos of each dock were used to augment interpretation of mapped dock data during data assessment.

Dock and seagrass data were entered into an Access (Access for Windows 95, Microsoft Corp., Redmond, WA) database, which was later transferred into an Excel (Excel '97, Microsoft Corp., Redmond, WA) database for data manipulation. Descriptive statistics for all parameters were produced using the Descriptive Statistics analysis function in Excel. Experiment wise error rates were maintained at the alpha level of 0.05 for all statistical analyses. Relationships between tested parameters were determined *a posteriori*. Data for seagrass cover under and outside the influence of docks were log transformed ($\log_{10} x+2$), tested for parametric assumptions (Shapiro-Wilk test for normality, homoscedasticity), which they failed, and ultimately analyzed using Wilcoxon's Signed Rank nonparametric test with SAS statistical software (SAS 6.12 for Windows, SAS Institute, Inc., Cary, N.C.). Log transformed ($\log_{10} x+2$) data for seagrass cover under the influence of docks and dock area parameters were also initially tested for parametric assumptions, which they failed, and analyzed using Spearman's Correlation coefficient analyses with SAS statistical software. A similar test was also performed for a comparison of total area covered to the total halo area around docks. A linear regression was performed for halo area around docks in seagrass areas against dock height data after parametric assumptions of normality and linearity were tested (data met parametric assumptions) also using SAS. Paired two sample mean t-tests of dock to seagrass halo area, dock to dock + additions (davits, etc.), side to side halo area for E-W and N-S dock orientation, and total dock area to total shaded area for docks in seagrass areas data were performed using the T-test: two sample paired means function in Excel. Assumption testing for sample data normality for these tests was performed using Hartley's test of homogeneity of variances with robustness for normality (F_{max} table, Kirk, 1982).

Results:

Regional Characteristics:

Palm Beach County intercoastal waters consist of narrow Intercoastal Waterway (ICW) channels punctuated by large open basins like Lake Worth Lagoon. Four inlets flush these waterways with clean seawater of Gulf Stream origin, making for extremely clear water in the vicinity of inlets. Channelized freshwater canals and one major river system, the Loxahatchee River, also deliver diverted freshwater into intercoastal waters contributing to an area of darkly colored water where oceanic flushing is not present. Extensive artificial residential canal networks fork off of the ICW and lagoon systems due to the high level of shoreline development in the region. The entire western shoreline of this system is highly urbanized with both industrial and residential development. Eastern shoreline development is primarily residential in nature.

Dock Characteristics:

A total of 200 out of 3,592 (5.6%) exempt single and multi-family docks were randomly surveyed. The majority of these docks were built against seawalled shoreline (62%) with only 16% being built out from natural shoreline (mangrove fringes primarily). About 14 % of docks were built out from a shoreline with a combination of planted mangroves behind rip rap owing to shoreline restoration initiatives in this region. Most docks (74%) were found more than 2 miles from inlets. An essentially equal number of docks were oriented in both major directions; 57% shore normal east-west and 43% shore normal north-south. The majority of sampled docks were found in residential canals (55%) with the next largest number found lining the ICW (36%) and the remainder in the Loxahatchee River (9%). Most sampled docks were L-shaped (39%) or straight (30%) with the remained being T-shaped (17%), U-shaped (2%) or marginal (mostly parallel to a seawall) (12%). The vast majority of sampled docks were decked with pressure treated wood planking (94%), but some had concrete (4%), metal (1%) or fiberglass (1%) decking. Pressure treated wood pilings were also predominantly used (56%) to support the sampled docks with concrete pilings providing the next largest dock support category (33%). Variations of wood with plastic sheathing, plastic alone, metal, concrete and wood combinations, and fiberglass contributed to the remaining 11% of support piling types. Only 3% of all sampled docks had a sunlight obscuring cover over them.

A total of 83 (41.5%) of sampled docks had some addition contributing to shaded area added to them (**Figure 1**). Davits (boat lifts or cradling platforms) represented the majority of such additions and were found on 30% of all sampled docks. Floating docks, finger piers, and other add-ons contributed to another 17% of sampled docks. When dock area alone (without additions) was analyzed for compliance with the 1000 ft^2 maximum, 17 docks (8.5%) of those sampled were found to be out of compliance (mean area over 1000 ft^2 was 638.6 $ft^2 \pm 814.2$ SD; range 30-2377 ft^2). Additions to docks brought the number of docks out of compliance to 32 (16%) of the sample total (mean area over 1000 ft^2 was 589.3 $ft^2 \pm 723.8$ SD; range 15-2496 ft^2). If applied on a county-wide basis, 305 docks alone and 575 docks with fixed additions exceed maximum area requirements for exempt docks.

Seagrass/Dock Characteristics:

Approximately 75% of docks surveyed in the ICW had seagrass around them, but only 16% of docks in canals had seagrass present around them. Seagrass was present almost equally around docks greater than (40% with seagrass)or less than 2 miles (46% with seagrass) from inlets. Shoreline type also provided essentially equal numbers of associated docks with and without seagrass around them except for shorelines with rip rap and mangroves, for which 85% of associated docks had no seagrass. The mean nearshore bed depth was determined to be 2.1 ft $\pm$ 1.5 SD and the mean offshore bed depth was 6.7 ft $\pm$3.2 SD. Seagrass bed depth ranged from <1-14.5 feet around docks. Width of seagrass beds around docks ranged from 2-118 ft with a mean of 31.9 ft $\pm$ 27.1 SD, although seagrass beds extended beyond 46 (55%) of the 83 docks with seagrass (measurements were not taken beyond the offshore terminus of the dock).

Seagrass communities were observed around 83 (41.5%) of the 200 sampled docks. Outside the shading influence of these docks, the predominant seagrass species comprising these communties included Johnson's seagrass (Halophila johnsonii), paddle grass (Halophila decipiens), and Cuban shoal grass (Halodule wrightii). Manatee grass (Syringodium filiforme) and turtle grass (Thalassia testudinum) were found at 4% and 1% of docks in seagrass areas respectively (**Figure 2**). For all docks where seagrass was observed around such structures, Johnson's seagrass occurred most frequently (80%) with Cuban shoal grass (63%) and paddle grass (47%) next in order of observed frequency. Paddle grass and Johnson's seagrass were observed as mixed communities most frequently (38%) around docks. Estimated mean percent cover outside the influence of docks was 23.8% $\pm$ 18.4 SD and ranged from 1-85% cover.

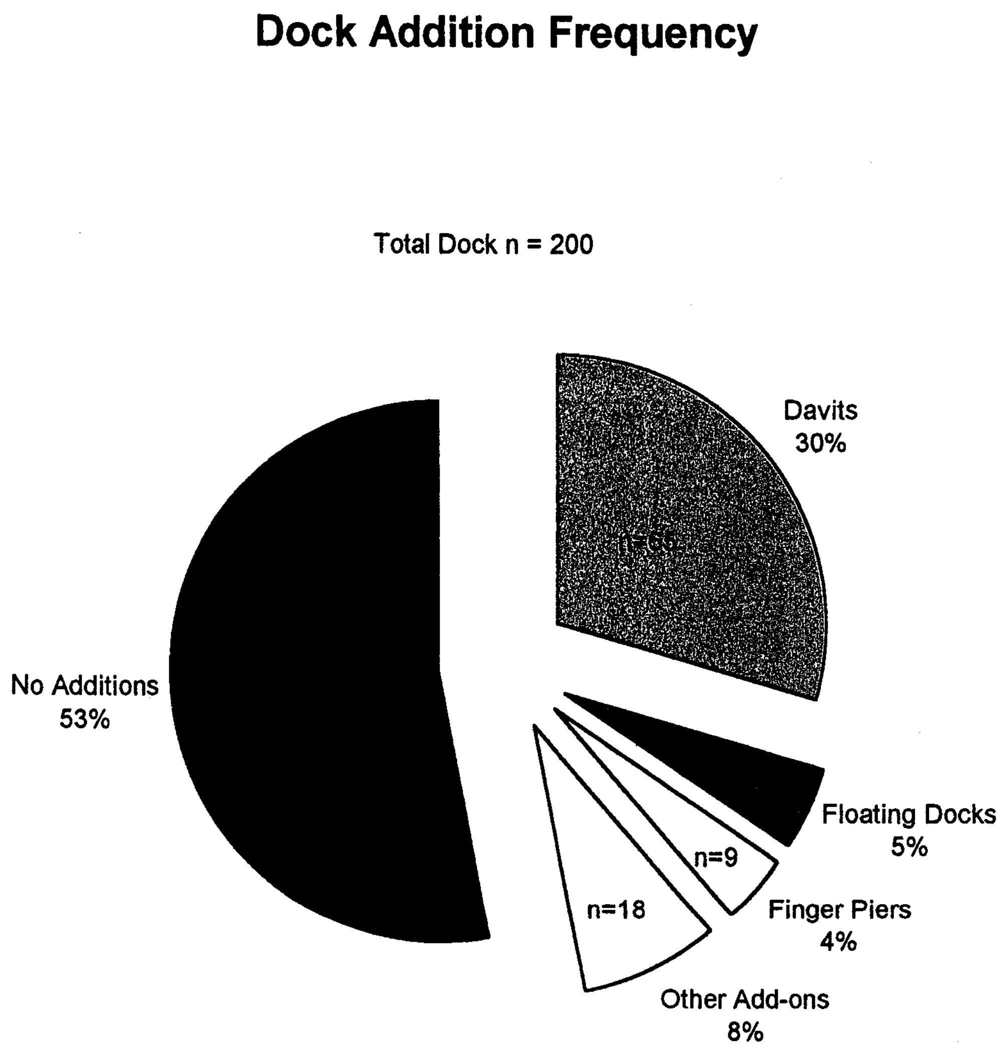


Figure 1: Relative number of additions observed on surveyed docks.

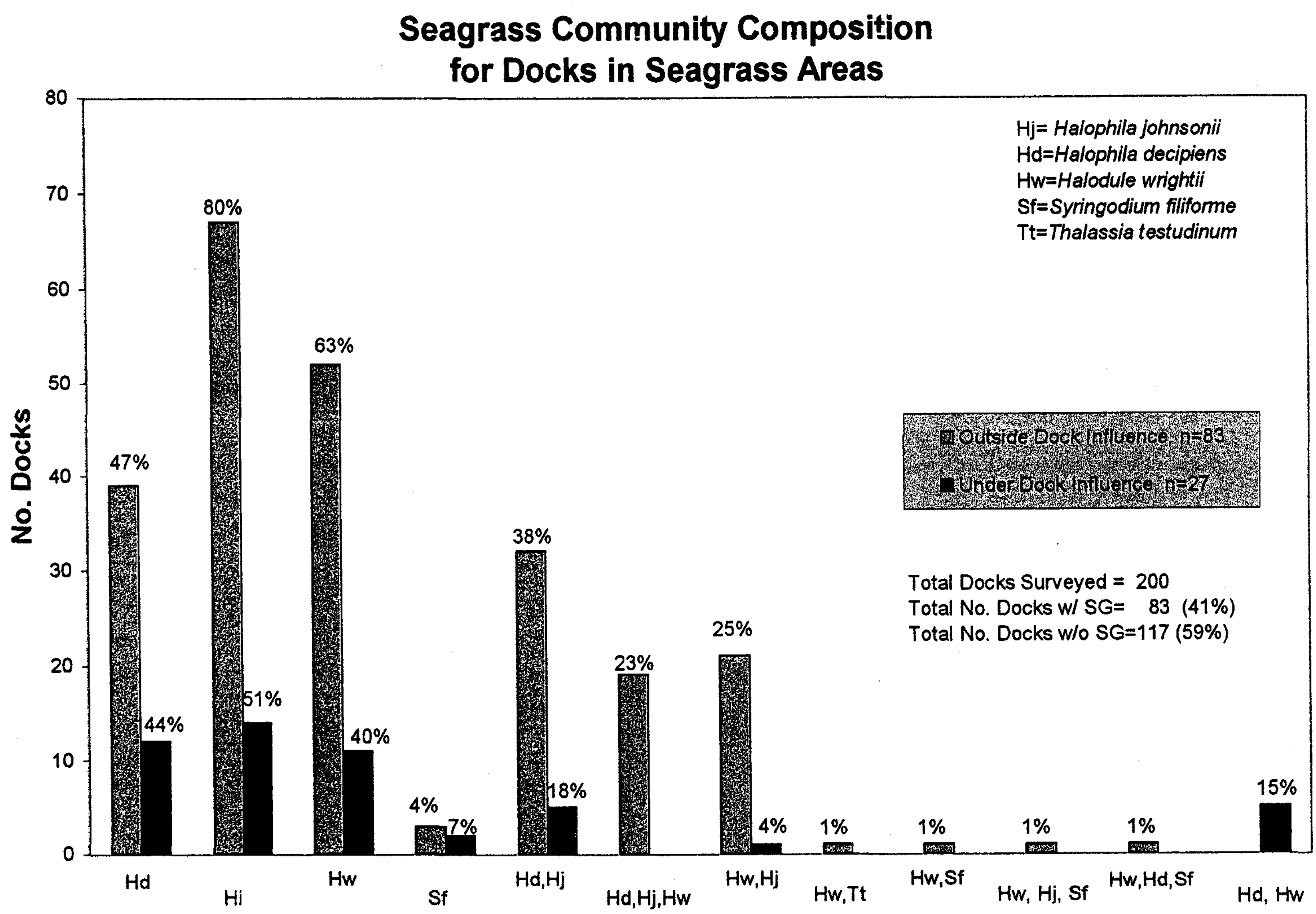


Figure 2: Observed seagrass community constituents around surveyed docks.
(Note: Graph column % values are based on observation frequencies for identified species and species assemblages and therefore do not sum to 100%.)

Seagrass was observed persisting under the influence (within the shaded area) of the dock at a total of 27 docks. Johnson's seagrass remianed the most frequently observed seagrass under docks (51%) followed closely by paddle grass (44%) and Cuban shoal grass (40%). The most frequently observed mixed seagrass community under docks was Johnson's seagrass and paddle grass (18%). Estimated mean % seagrass cover under the influence of docks was 2.1% $\pm$ 4.8 SD and ranged from 0-25% cover.

Effects of Docks on Seagrass:

Seagrass % cover under the influence of docks (either under or within the halo shadow) was significantly lower than that outside the influence of the dock in adjacent seagrass beds ($p<0.0001$) **(Figure 3)**. Although, some seagrass cover was occasionally observed under existing docks, the amount of coverage was in all cases substantially less than that outside the dock's influence. The majority of docks with seagrass around them had no seagrass under the docks and a clearly defined line demarcating the bed edge or beginning of the measured halo adjacent to the dock was usually present.

Seagrass % cover under the influence of docks is not signifcantly correlated with height above MHW for sampled docks ($p>0.70$) **(Figure 4)**. This correlation is based on height data that were taken at 28 of 83 docks found existing within seagrass beds. The calculated data trend line has a barely positive slope ($b = 0.0057$) indicating a possible increase in seagrass cover with increasing dock height above MHW, but no statistically significant relationship was determined. The majority of docks were measured at 2-3 feet above MHW. Most sampled docks were within this narrow height range (mean = 3.0 ft $\pm$ 1.0 SD; range 1-6 above MHW, $n = 166$), which skewed the data set and did not allow for a meaningful height relationship interpretation.

Total halo area around docks in seagrass does not significantly vary with dock height either ($p>0.30$) **(Figure 5)**. The regression analysis for this relationship was based on height measurements for 28 of 83 docks in seagrass areas. Although the relationship between dock height and halo area is not significant, the slope of the regression line indicates a strong negative association, indicating that the halo area may decrease as dock height increases. Again, a narrow range exists for dock heights measured based upon the population sampled causing limitations in performed statistical analyses of height relationships to seagrass persistence.

The total area around the dock with absent or greatly reduced seagrass % cover (halo area) is significantly positively correlated with the total area covered by docks with all additions ($p<0.0001$) **(Figure 6)**. Halo area was determined for 81 of 83 docks located in seagrass beds. The data trend line slope value ($b = 1.67$) indicates a positive trend in the relationship between these factors. Collected data were clustered at the lower scale for both total covered area and halo area, which is expected based upon design criteria for single family docks. Mean values and (ranges) for both measured parameters were 1408.5ft^2 $\pm$ 2460.3 SD (146-22319 ft^2) and 341.9 ft^2 $\pm$ 319.6 SD (10-1826 ft^2).

Dock Area Relationships and Seagrass Effects: Paired t-test Results:

The mean areas of individual dock additions for all surveyed docks (including those for davits, floating docks, and moored boats) significantly increased the total area covered by over