# Management of Small Docks and Piers

# Environmental Impacts and Issues

# Forward—

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# Introduction—

Private docks have been implicated in a number of environmental impacts. Some of these have received scientific investigation and some remain anecdotal. In an attempt to clarify what is known about environmental impacts from docks, NOAA’s National Centers for Coastal Ocean Science convened a workshop in January of 2003. This session brought together scientists and a group of coastal managers from across the country to discuss the environmental impacts of small docks. The results of that workshop may be found in Kelty and Bliven (2003).

The workshop identified four general impacts:

Impacts to vegetation

Impacts from contaminants related to docks

Impacts from associated boating use

Impacts to sediments and substrate

Impacts to wildlife habitat were discussed as part of the topics above, as this is a significant cross-cutting issue.

# Impacts to Vegetation from Small Docks—

Marsh plants and submerged aquatic vegetation (SAV) are ecologically critical as a source of food and nursery habitat for fish, shellfish, amphibians, reptiles, birds and mammals that live in coastal waters or the adjacent marsh and uplands (Weigert *et al.,* 1981; Teal, 1962, 1969; Weinstein, 1996). Vegetated areas also stabilize shoreline and bottom sediments against erosion (Kearney *et al.,* 1983; Teal, 1986) and take up contaminants and excess nutrients from the water and sediments (Vernberg, 1996).

Impacts to plant health and productivity from docks generally occur in one of the following ways:

Short-term construction impacts,

Chronic impacts from shading,

Chronic impacts from storage of floats and boats and associated foot traffic, and

Impacts from boat use (covered later in this module as a separate topic).

## *Short-Term Construction Impacts—*

Activities during construction can destroy plants either above the tide line (*e.g.,* marsh grasses such as *Spartina* or *Distichlis*) or below (*e.g.*, sea grasses such as *Zostera* or *Halodule*) by pulling them from the substrate or destroying their root systems. The peat beds underlying salt marshes can be compacted through the improper use of heavy equipment leading to ponding of saline waters and a resultant loss or changing of marsh vegetation. Although these impacts are seemingly evident, limited research appears to have been done on the long-term effect of these activities.

Setting pilings in sea grass beds may have immediate impacts as well as causing long-term changes. The act of installing pilings destroys any vegetation within the footprint of the pilings. The use of “jetting” with high-pressure hoses typically disturbs adjacent vegetation and sediments—depopulating grasses existing there prior to construction. Once areas are depopulated, the presence of pilings may lessen chances for regrowth. Beal, Schmit, and Williams (1999) suggest that changes in seagrass communities in the vicinity of pilings may be caused by the modification of currents, sediment deposition, attraction of bioturbators, and leaching from chemically treated wood.

Shafer and Robinson (2001) tracked the regrowth of the seagrass *Halodule wrightii* beneath docks in St. Andrew Bay, FL. They noted bare areas from 35–78 inches in diameter around pilings, ”even though the age of these docks varied widely” suggesting that regrowth is affected by the presence of pilings. Use of high pressure jetting produced a six- to seven-foot diameter hole around each piling, which was then backfilled to hold the piling in place. The resultant “halo” might remain for 10 years without seagrass regrowth. The authors found that where piles were installed using low-pressure jetting techniques there was, “little or no sand deposition around the pilings and the remaining seagrasses around the pilings looked healthy and had good growth around the piling.”

Dock construction also impacts marsh grass. Sanger and Holland (2002) noted a barren path through the marsh along each side of a newly constructed dock in North Carolina where vegetation had been almost totally destroyed. However, construction did not appreciably alter the original marsh elevations. Resurveying the site 15 months later, the researchers found that *Spartina. alterniflora* had recolonized the area and substantial recovery had occurred.

## *Chronic Impacts from Shading—*

Both marsh grasses and sea grasses have adapted to living in extended periods of sunlight. Therefore, shading can have significant impacts on the health and productivity of these plants. Figure 1 illustrates some of the potential impacts from dock shading. Two thresholds are shown; the minimum amount of light necessary for the plant to reach full growth, and the minimum amount of light for the plant to sustain itself. Below the first threshold, plants are stunted in growth or grow tall and spindly in an attempt to reach sunlight. Below the second threshold, plants die.

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**Figure 1.** Light Profile under a dock (From Nightengale and Simenstad 2001. Ron Thom, pers. comm.). The graph illustrates how the shading of an east-west oriented dock affects light levels and vegetation growth below a dock in Washington state. The two horizontal lines indicate the light levels necessary for full, unaffected growth of plants (Minimum light needed for full growth) and the amount of light for plants to live (Minimum light for plant maintenance). Note that much of the area beneath the illustrated dock is below the threshold for plant life. Note also that the shading is somewhat offset to the north due to the declination of the sun.

Amount of Light Required by Vegetation—

Susceptibility to shading varies by species, even those occupying similar habitats. For example, in marsh grasses, densities of *Spartina patens* (Salt Meadow Grass or Salt Hay Grass) and *Distichlis spicata* (Spike Grass or Salt Grass) are more sensitive than *Spartina alterniflora* (Smooth Cordgrass or Saltwater Coordgrass) (Kearney *et al.* 1983).

Light levels necessary for plants to sustain themselves generally range between 12–25 percent of ambient light, depending on the species. Specifically for seagrasses, a National Marine Fisheries Service (NMFS) Technical Memorandum reports that “the light requirements of temperate and tropical seagrasses are very similar” requiring “at least 15 to 25% of the incident light just for maintenance” (Kenworthy and Haunert, 1991). Light requirements are presumably higher to allow full growth but there has been limited research that provides specific percentages.

NMFS’ summary report is supported by studies on individual seagrass species. For example, Shaefer and Robinson (2001) report that light levels of 13–14 percent of mean daily surface irradiance (SI) are necessary for survival of the seagrass *Halodule wrightii*. Shaefer (1999) found that seagrass densities were 40–47 percent less in areas shaded at levels of 16–19 percent SI. Burdick and Short (1999) observed similar trends in the eelgrass, *Zostera marina,* which required light levels of at least 15 percent of surface irradiance for survival and approximately 50–60 percent for healthy beds.

## Direct Impacts of Shading—

As we have already demonstrated, marsh and submerged aquatic vegetation need adequate light levels to survive and flourish. Therefore shading from docks can have significant implications for this vegetation. Recent studies have shown that shoot density, biomass, and overall plant growth may be reduced by dock shading (Sanger and Holland, 2002; McGuire, 1990; Burdick and Short, 1999). In some instances, researchers found an increase in the height of marsh grasses found under docks, possibly due to etiolation. (Etiolation is a condition in which plants growing in reduced light levels elongate much more rapidly than normal as a means of reaching light. It is characterized by long weak stems and small leaves.)

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**Figure 2.** Eelgrass density was significantly lower under and near docks than at sites removed from the dock by various distances (Burdick and Short, 1999).

Impacts due to shading also appear in fresh waters. Garrison *et al.* (2005) investigated shading impacts on submerged vegetation and relationships to fish and invertebrate habitats. They found significant shading under docks “with a corresponding reduction in aquatic plant abundance” in Wisconsin lakes. By placing unbaited minnow traps below piers and within nearby, control vegetated zones, the researchers also found decreased numbers of macroinvertebrates and vertebrates as well as changes in species composition.

Wilson (2002), working in fresh-tidal waters in Connecticut, found that not only did shading have impacts on existing submerged aquatic vegetation but it also adversely affected its ability to regenerate after being mechanically disturbed. (Wilson manually clipped the submerged vegetation in his research but suggests that similar effects would be found from disturbance by boat propellers.)

Geographic Area Affected by Shading—

It is clear that shading from docks can have an adverse impact on the underlying vegetation but one of the questions coastal managers grapple with most is how much total marsh grass or seagrass with be affected by docks, and will the addition of more docks have a significant impact on the total amount of vegetation present. Sanger and Holland (2002) compared the area of marsh affected by docks to the total area within specific creek systems and also estimated the amount of marsh affected by docks through out coastal South Carolina. Based on the number of docks present in 1999, they estimated that docks reduced *S. alterniflora* densities by 0.03–0.72 percent within their study sites. When they projected to a total possible build-out of similarly sized docks in the creek systems, Sanger and Holland calculated that docks would cause a 0.18–5.45 percent decrease in marsh grass. Finally, Sanger and Holland applied this approach to the projected build-out of docks for all eight coastal counties by the year 2010. They estimated that a reduction in marsh density of between 0.03–1.98 percent could be attributed to dock impacts.

Smith and Mezich (1999, in Shafer 2001) note that up to 50 acres of seagrass beds had been negatively impacted in the early 1990s by single-family docks in the Palm Beach County, Florida. Studies in Georgia (Alexander and Robinson, 2004) suggested a maximum estimate of 4–6 percent of the marsh around Wilmington Island could be shaded if full build-out should occur under the provisions of current state laws.

It should be noted that the significance of these shading impacts to the coastal ecosystem as a whole varies by region and the amount of salt marsh or seagrasses present. In areas where coastal vegetation is already severely reduced or otherwise impacted (*e.g.,* New England and Florida) affected areas as a percentage of the entire marsh system could be higher than those reported for South Carolina and Georgia.

## Indirect Impacts of Shading—

Changes in vegetation density and hardiness may lead to increasing sediment erosion and resuspension, and increased undercutting of the marsh shoreline near the dock because robust healthy marsh and seagrass vegetation is no longer present to hold the sediments in place (Burdick and Short 1999).

Burdick and Short (1999) also found that shading of eelgrass beds can lead to fragmentation, thereby disrupting wildlife habitat. The work of Garrison *et al.* (2005) mentioned previously showed that the loss of vegetation due to shading by docks reduced fish and large invertebrate abundance and altered species composition in Wisconsin lakes.

A subsequent effect of the shading by docks in Connecticut was reported to be accelerated soil erosion beneath structures passing over *S. alterniflora* at the edge of the marsh (Kearny *et al.* 1983).

## Factors that Affect Shading—

Kearney *et al*. (1983) studied impacts to marsh grasses from walkways/docks from “all the structures” within Connecticut’s major salt marsh regions, collecting data on vegetation density and height beneath and adjacent to the structures, and the physical dimensions of the docks (width, height, plank width, and spacing between planking—they did not include orientation). They found that dock height was the only statistically significant variable; docks less than 12–16 inches above the marsh shaded out all vegetation in every study site. Any impacts from dock width, plank width, and plank spacing were not statistically significant. However, it should be noted that a National Marine Fisheries Service study that assessed dock impacts on marsh grass vegetation in Connecticut, Rhode Island, and Massachusetts cast some doubt on the methodology and statistical analyses of Kearney *et al* (1983) (Colligan and Collins, 1995).

In a field study conducted in Waquoit Bay, Falmouth/Mashpee and Nantucket Harbor (all in Massachusetts), Burdick and Short (1999) found that dock height was not the only factor influencing shading impacts on eelgrass beds but that the orientation of the dock and dock width also played significant roles. According to their data, North-South orientated docks had less impact than East-West orientated ones.

While orientation may be an important factor in northern latitudes, it may not play a significant role in lower latitudes. Sanger and Holland (2002) assessed impacts on *S. alterniflora* from 32 docks in the Charleston, SC area*.* The structures represented a range of lengths, orientations, and ages. They found no significant difference in reduction in *S. alterniflora* density due to shading between North-South oriented docks and those with an East-West orientation.

The National Marine Fisheries Service suggests that spacing between decking planks on the order of an inch or two has little effect on shading impacts, particularly in northern latitudes (Michael Ludwig, NMFS, Personal Communication, 2003). There appears, however, to have been little systematic research on this topic.

In summary, it appears that dock height and width are significant factors that contribute to shading impacts on vegetation. However, but it is still unclear whether orientation and spacing between decking boards have measurable impacts. There appear to be differences in these impacts between northern and southern latitudes.

## Models to Predict Shading—

McGuire (1990) measured the effects of shading by open pile structures on *S. alterniflora* density in a fringe marsh in the York River Estuary (VA). She subsequently developed a computer program to calculate the total number of hours of shading produced by each structure based on height, width and orientation of the structure and compared the computer projections with the results of her field studies. The computer program developed as part of this project appears to hold promise as a predictive tool. Unfortunately, no electronic copies of the program remain (the text of the program is available) and it is written in Pascal. To be effective the program would have to be rewritten in a contemporary, and more user-friendly, format.

Burdick and Short (1998) modeled the impact of shading on eelgrass. They presented their results in an informational CD entitled “Dock Design with the Environment in Mind: Minimizing dock impacts to eelgrass beds.” The CD contains illustrative estimates of impacts to *Zostera* from docks of specific height, width, and orientation. They did not attempt to develop a process to assess the impacts from differently sized and oriented docks but feel that a computer model could be produced to predict impacts from any combination of design factors (personal communication, 2005).

## Cumulative Impacts from Shading—

The issue of cumulative impacts to vegetation from shading or dock construction has not been heavily researched. Consequently is it not clear whether such impacts are additive or have some greater effect.

# *Chronic Impacts from Storage of Floats and Boats—*

Floats, boats, or any other solid structure stored, either permanently or seasonally on the marsh face will significantly shade, and therefore destroy, any vegetation present.

# *Ramifications of Impacts to Vegetation—*

Shading of vegetation, to the point where its health is impaired, can have several adverse impacts.

Lessening of input to the Aquatic Food Web—

Marsh and seagrass vegetation and the detritus they produce constitute a major portion of food available to the base of the aquatic food web. For example, these habitats are critical to the life cycle of shellfish and juvenile finfish that inhabit embayments and estuaries. Significant loss of vegetation may adversely affect populations of these species (Teal, 1986).

# Modification of topography and lessening productivity of the marsh—

Compaction of marsh peat from construction or continually walking to and from a dock changes the marsh topography and may lead to long-term changes in marsh vegetation and drainage (Hruby, 1990). The distribution and species of marsh vegetation are strongly linked to elevation in relation to tidal flooding. Ponding of salt water on the marsh face will eventually lead to changes in vegetation to less productive species (Lefor, 1992).

*Fragmentation of habitat—*

Marshes are important for many species, including fish, birds, mammals and reptiles. Similarly many aquatic organisms, including game fish, shellfish, and the food they eat, depend on submerged aquatic vegetation. Docks, piers and associated walkways to docks fragment these valuable wetland habitats. The presence of docks or subsequent damage to the surrounding vegetation can deter wildlife from frequenting the area. Small docks also fragment eelgrass beds (Burdick and Short, 1999)—primarily through shading of the grasses. There are, unfortunately, limited research results available to quantify the impacts due to habitat fragmentation.

There is a body of empirical evidence showing that fragmentation of habitat causes changes in species diversity and composition (Wilson, 2002). These changes may be in small beds or an entire estuary. Rare or specialized species tend to be the first to disappear from impacted environments (Wilson, 2002.

**Impacts from Contaminants Related to Docks—**

The most common contaminant-related concern associated with small docks is leaching of wood preservatives. Wood continuously exposed to water can decay rapidly. Pilings are also subject to wood-boring and fouling organisms that speed their break-down. To protect the wood and ensure docks will have a reasonable lifespan, the wood is typically treated with preservative chemicals that, in turn, can leach into surrounding waters. Historically, the most commonly used materials were oil-based: creosote or pentachlorophenols. Presently, wood products pressure-treated with chromated copper arsenate (CCA) are the most common material used for dock construction.

# *Creosote and Pentachlorophenol—*

Oil based preservatives containing creosote (CRT) or pentachlorophenol (PCP), applied to the surface of wood materials, leach readily and have wide-spread environmental and human health impacts Most states have banned their use for small docks and piers.

# *Chromated copper arsenate (CCA)—*

CCA-treated wood comes in a variety of “strengths” (the amount of preservative retained in the wood after treatment. The Southern Pine Council (2004) makes the following recommendations for specific uses:

|  |  |
| --- | --- |
| Concentrations of CCA Wood TreatmentsRecommended for Various Uses | |
| Retentions *(lbs./cu.ft.)* | Uses/Exposures |
| 0.10 – 0.25  0.21 – 0.41  0.31– 0.61  2.50 | Above ground  Soil & Freshwater use  Permanent Wood Foundation  Saltwater use |

**Table 1.** Concentrations of CCA wood treatments recommended for various uses.





*, specifications, applications.* Available through the Southern Forest Products Association, P.O. Box 641700 Kenner, LA 70064-1700 (504) 443-4464 or Southeastern Lumber Manufacturers Association, P.O. Box 1788, Forest Park, GA. (404) 361-1445.

Thayer, G.W., D.A. Wolff and R. B. Williams. 1975. The Impact of Man on Seagrass. *American Scientist* 63:288–296.

Teal, John. 1962. Energy Flow in the Salt Marsh Ecosystem. *Ecology* 43: 614–624.

Teal, John, and Mildred Teal. 1969. *Life and Death of a Saltmarsh.* Little, Brown and Company.

Teal, John. 1986. *The Ecology of Regularly Flooded Salt Marshes of New England: A Community Profile.* U.S. Fish and Wildlife Service. Biological Report 85(7.4).

Vernberg, F.J. 1996. Ecology of Southeastern Saltmarshes. In *Sustainable Development in the Southeastern Coastal Zone.* Eds. Vernberg, F.J., W.B. Venberg and T. Siewicki. University of South Carolina Press.

Weigert, R.G., L.R. Pomeroy, and W.J. Wiebe. 1981. Ecology of Salt Marshes: An Introduction. In *The Ecology of a Saltmarsh.* Eds. L.R. Pomeroy and R.G. Wiegert. Springer-Verlag.

Weinstein, J.E. 1996. Anthropogenic Impacts on Salt Marshes—A Review. In *Sustainable Development in the Southeastern Coastal Zone.* Eds. Vernberg, F.J., W.B. Venberg and T. Siewicki. University of South Carolina Press.

Weis, P., J.S. Weis, and L.M. Coohill. 1991. Toxicity to Estuarine Organisms of Leachates from Chromated Copper Arsenate Treated Wood. *Archives of. Environmental Contamination and Toxicology*. 20: 118–124.

Weis, P., J.S. Weis, A. Greenberg, and T.J. Nosker. 1992 Toxicity of Construction Materials in the Marine Environment: A Comparison of Chromated-Copper-arsenate-Treated Wood and Recycled Plastic. *Archives of Environmental Contamination and Toxicology*. 22: 99–106.

Weis, P. J.S. Weis and J. Couch 1993. Histopathology and bioaccumulation in oysters (*Crassostrea virginica*) living on wood preserved with chromated copper arsenate. *Diseases of Aquatic Organisms.* 17: 41-46.

Weis, J.S., P. Weis, and T. Proctor. 1998. The extent of benthic impacts of CCA-treated wood structures in Atlantic Coast Estuaries. *Archives of Environmental Contamination and Toxicology*. 34: 313–322.

Weis, J.S. and P. Weis. 1996. The effects of using wood treated with chromated copper arsenate in shallow water environments: a review. *Estuaries* 19:306–310.

Weis, J.S. and P. Weis. 1998. *Effects of CCA Wood Docks and Resulting Boats on Bioaccumulation of Contaminants in Shellfish Resources: Final Report to DEP*. A report to the NJ DEP.

Wendt, P.H., R.F. Van Dolah, M.Y. Bobo, T.D. Mathews, and M.V. Levisen. 1996. Wood Preservative Leachates from Docks in an Estuarine Environment. *Archives of Environmental Contamination and Toxicology*, 31:71–79.

Wilson, Joshua. 2002. *The Effects of Docks and Mechanical Disturbance on Submerged Aquatic Vegetation in Tidal-Fresh Hamburg Cove (Lyme, CT)*. Yale School of Forestry and Environmental Studies.

Zabawa, C., C. Ostrom, R. J. Byrne, J. D. Boon III, R. Waller, and D. Blades. 1980. *Final report on the role of boat wakes in shore erosion in Anne Arundel County, Maryland*. Tidewater Administration, Maryland Dept. of Natural Resources. 12/1/80. 238 pp

Zieman, J.C. 1976. The ecological effects of physical damage from motorboats on turtle grass beds in southern Florida. *Aquatic Botany* 2:127–139

Ziencina, Mitchell. 2002. Massachusetts Department of Environmental Protection, Lakeville, MA.