Summary Report for Perdido Bay

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Summary Report for Perdido Bay

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General assessment

Seagrasses in Perdido Bay are primarily shoalgrass (*Halodule wrightii*), and covered about 430 acres in 2015. Seagrass cover increased by 92 acres (or 27%) since the mapping effort in 2010. Between 1987 and 2002, however, about 80% of the seagrass acreage disappeared, leaving only 122 acres in the bay; since 2002, seagrass acreage has increased steadily. In 1992, only 38% of beds were continuous, while in 2015, 92% of the acreage was continuous beds. Nearly all seagrass beds in Perdido Bay are in the southern portion, in Kees Bayou, Russell Bayou, and the eastern bay near Rabbit Island. A mapping assessment of 2010 imagery showed that in the southern bay, about 13% of seagrass beds were lightly scarred by propellers. The Deepwater Horizon oil spill in 2010 affected the bay, particularly near the inlet on the eastern side.

Geographic extent

Perdido Bay is the westernmost estuary in the Florida Panhandle and is located inside a barrier bar adjacent to the Gulf of Mexico (see Kirschenfeld et al. 2006; Livingston 2015). The bay's watershed covers about 1,160 square miles, and about 30% is in Florida and 70% is in Alabama. The Florida portion of the bay is in Escambia County. The connection to the Gulf of Mexico, Perdido Pass, is in Alabama and is maintained by dredging. The Perdido River and its tributaries supply freshwater to the estuary, and average flow at Barrineau Park, 27 miles from the mouth of the river, is 770 cubic feet per second (U.S. Geological Survey). Most of the base flow of the river is from groundwater seepage. Much of the shoreline of the river and bay is bordered with wetlands. Perdido Pass was deepened in the early 1900s; before that time, the bay was mostly a freshwater system (Livingston 2015). Perdido Bay is shallow (average depth 2 m), and its water area is about 50 square miles. In Florida, the watershed is mostly undeveloped with 38% in forests and 23% in wetlands. About 20% of the area is developed, and 15% is in agricultural use (NWFWMD SWIM 2017). Sources of water pollution include non-point-source (NPS) runoff from urban, residential, and agricultural areas, septic systems, and industrial waste. From the 1950s to the early 2000s, Perdido Bay was affected by pulp mill effluent that drained into Elevenmile Creek, a tributary of the bay located near the mouth of the Perdido River. Beginning in 2013, wastewater from the mill was transferred to a treatment wetland. In Florida, the bay area begins at the Alabama–Florida state line to the west, extends east to Sunset Pass, and then north and west to include Kees Bayou and Russell Bayou along the northern section of the bay. The Gulf Coast Intracoastal Waterway passes through southern Perdido Bay and connects the bay with Big Lagoon to the east and Mobile Bay to the west.

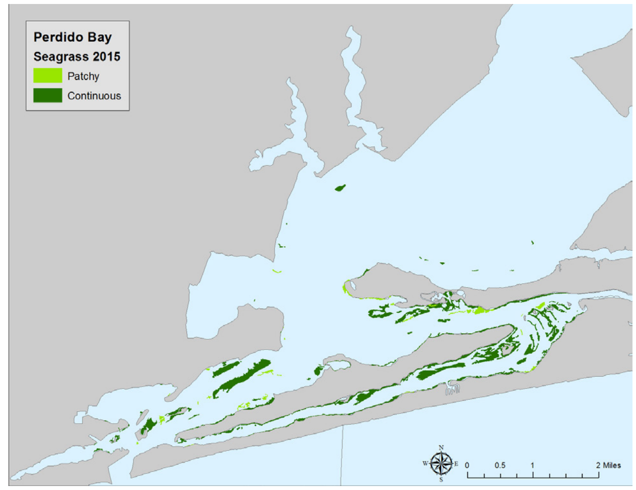

Figure 1. Seagrass map of Perdido Bay, 2015.

General status of seagrasses in Perdido Bay			
Status and stressors	**Status**	**Trend**	**Assessment, causes**
Seagrass acreage	Green	Increasing	27% increase, 2010–2015
Water clarity	Orange	Decreases northward	Locally turbid
Natural events	Yellow	Sporadic	El Niño, tropical cyclones
Propeller scarring	Yellow	Localized	Near Rabbit Island, eastern bay

Table 1. Seagrass acreage in Perdido Bay, 1987, 1992, 2002, 2010, and 2015.

					Change, 2010–2015	
1987	1992	2002	2010	2015	Acres	%
575	256	122	338	430	92	27%

Mapping and monitoring recommendations

- Acquire imagery at least every six years, and map to evaluate status and trends in seagrass acreage.
- Implement a monitoring program to evaluate seagrass beds annually.

Management and restoration recommendations

- Evaluate restoration efforts funded by Deepwater Horizon penalty monies and continue efforts to implement new restoration plans.
- Use the recently released Surface Water Improvement and Management (SWIM) plan of the Northwest Florida Water Management District (NWFWMD) to identify and implement efforts for improving quality and clarity of freshwater runoff.
- Monitor seagrass beds in high-use areas to detect propeller scarring.
- Use the boating and angling guide for waters in the region to improve boater education and awareness of seagrass beds and to reduce propeller scarring.

Table 2. Patchy and continuous seagrass acreage in Perdido Bay in 1992, 2002, 2010, and 2015.

Year	Patchy	Continuous	Total
1992	158	98	256
2002	total acreage only		122
2010	44	294	338
2015	34	396	430

Summary assessment

The status of seagrasses and the potential for recovery of seagrass beds in the Florida Panhandle are being assessed by the Roadblocks to Seagrass Recovery project of the FWRI (http://myfwc.com/research/habitat/seagrasses/projects/roadblocks/). This project is funded by the National Fish and Wildlife Federation (NFWF) Gulf Environmental Benefit Fund (GEBF), and activities include mapping of seagrasses from the Alabama state line to the mouth of the Suwannee River, field assessments of seagrass cover and species composition, and quantitative estimation of factors affecting recovery and restoration of seagrasses. These factors include current and historical seagrass extent, optical water quality and light attenuation, sediment quality and toxicity, bathymetry, propeller scarring, and physical stressors such as wind energy. Data

Seagrass Status and Potential Stressors in Perdido Bay			
Status indicator	**Status**	**Trend**	**Assessment, causes**
Seagrass cover	Green	Increasing	27% increase, 2010–2015
Seagrass meadow texture	Green	Improving	Continuous shoalgrass and widgeongrass
Seagrass species composition	Green	Stable	Affected by storm runoff
Overall seagrass trends	Green	Recently improved	50% loss since 1940
Seagrass stressor	**Intensity**	**Impact**	**Explanation**
Water clarity	Orange	Decreases northward	Runoff from large watershed
Nutrients	Yellow	Need data	Septic tanks, storm runoff
Phytoplankton	Orange	Elevated in summer	Stimulated by nutrients in runoff
Natural events	Yellow	Sporadic	El Niño,tropical cyclones
Propeller scarring	Yellow	Localized	Near Rabbit Island, eastern bay

and results are part of a seagrass recovery potential (SRP) model that will be served on the Web.

Interpretation of imagery collected in December 2015 as part of the Roadblocks project showed that seagrasses covered 430 acres in Perdido Bay at that time (Table 1) and that acreage had increased by 92 acres since 2010. Comparison of mapping data from 1987 and 2002 showed large-scale losses (80%) of seagrasses over 15 years. In 2002, only 122 acres of seagrass remained in the bay. The recent increase in seagrass has included both steady additions to total acreage, primarily as continuous beds, and conversion of a large proportion (78%) of patchy beds to continuous beds (Table 2). A study of the short-term effects of the 2004 hurricane season found that seagrasses tolerated these storms well (Byron and Heck 2006). Seagrass maps from 1940 showed that seagrasses then covered 1,186 acres and that most of the acreage was in the lower portions of Perdido Bay (Kirschenfeld et al. 2006).

Rapid population growth and development have contributed nutrients to runoff and decreased water quality in the bay (Livingston 2015). Shoalgrass is the most common seagrass in the bay, but widgeongrass (*Ruppia maritima*) and turtlegrass (*Thalassia testudinum*) also occur occasionally. The freshwater species tapegrass (*Vallisneria americana*) is found in the upper tidal reaches of the bay.

Seagrass mapping assessment

Kirschenfeld et al. (2006) provide a detailed and historical mapping assessment of seagrasses in Perdido Bay and estimated that the bay contained 1,186 acres of seagrass in 1940. Most of the seagrass beds surveyed in 1987 had disappeared by 2002. Mapping data from 2010 imagery showed that seagrass area sharply increased from values measured in 2002, from 122 to 338 acres. Imagery was acquired in December 2015, and photo-interpretation showed that there were 430 acres of seagrass, located mostly in the southern Bay. This is a 27% increase in acreage from 2010.

Assessment of propeller scarring

As part of the Roadblocks to Seagrass Recovery project, FWRI staff used 2010 imagery to assess propeller scarring in seagrass beds. In ArcMap, imagery was overlain by a grid of 1-ha cells, and scarring was assessed by counting the number of scars in each cell (Figure 2). In Perdido Bay, propeller scarring occurred in about 13% of vegetated grid cells, and most cells had only 1–5 scars (Table 3).

Table 3. Assessment of propeller scarring of seagrass beds in Perdido Bay using imagery acquired in 2010. Imagery was overlain by a grid with each cell having an area of 1 ha. Each grid cell received a scarring score. Doughnut beds are circular and bare at the center.

Score	Description	# cells	% of vegetated cells
0	Vegetated, no scars	777	85.9%
1	1–5 scars	86	9.5%
2	5–10 scars	30	3.3%
3	11–20 scars	4	0.4%
7	Doughnut beds	8	0.9%
	Total vegetated	**905**	
	Total scarred	**120**	**13.3%**

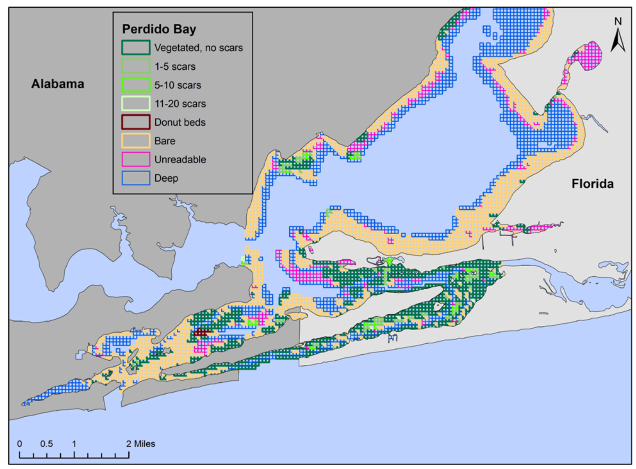

Figure 2. Scoring of 1-ha grid cells for propeller scarring in southern Perdido Bay.

Monitoring assessment

As part of the Florida Fish and Wildlife Conservation Commission's (FWC) Roadblocks to Seagrass Recovery project, Dauphin Island Sea Laboratory (DISL) was contracted to conduct field assessments of seagrass cover in the summer of 2016 and to collect water samples bimonthly in 2016 to measure optical water quality of bay waters. DISL staff visited 20 locations in the southern bay where seagrass was present and assessed seagrass cover in five 0.25-m^2 quadrats at each site. Three species of seagrass were observed (Figure 3): shoalgrass, widgeongrass, and turtlegrass. Shoalgrass occurred in half of quadrats surveyed and had high density when present (Table 4). Widgeongrass was observed in only 8 quadrats and at very low density. Surprisingly, turtlegrass was found in 5 quadrats at high density at one site in the southeastern corner of the bay (Figure 3). Three genera of macroalgae were also found, all members of Rhodophyta.

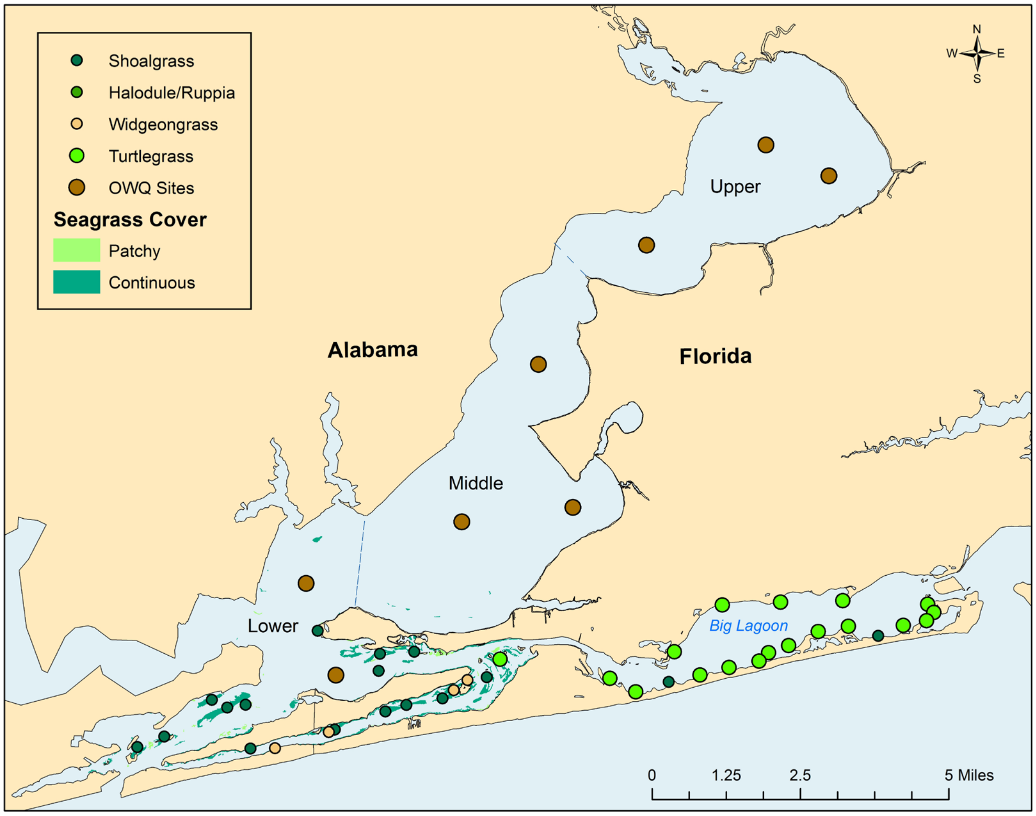

Figure 3. Seagrass mapping data, location of optical water quality (OWQ) sampling sites, and seagrass species present at field assessment sites in Perdido Bay, 2016. Dashed lines indicate approximate boundaries between bay subregions.

Table 4. Mean seagrass and macroalgal cover in Perdido Bay, summer 2016. For each species, only quadrats where the species was present were included in the estimation of mean and standard deviation.

	Seagrass cover (%)		
Species	**Mean**	**Std. dev.**	**N**
Seagrasses			
Halodule wrightii	67.8	21.1	100
Ruppia maritima	3.6	1.9	8
Thalassia testudinum	45.0	15.0	5
Macroalgae			
Ceramium spp.	1.0	0	2
Chondria spp.	7.8	7.3	27
Hypnea spp.	2.6	2.2	5

Staff from DISL also collected seagrass biomass data from the beds' deep edge at 14 locations in lower Perdido Bay in spring, summer, and fall of 2014. Some areas to which seagrasses have been transplanted are monitored by the Northwest District of the Florida Department of Environmental Protection (NWFDEP). The NWFDEP has also monitored water quality in the bay and its tributaries. However, seagrasses throughout Perdido Bay are not regularly monitored by field assessment.

Water quality and clarity

In 2016, water samples were collected along a transect from the upper bay to near the mouth of the bay (see Figure 3) in March, May, August, and November to measure chlorophyll-a concentration, turbidity, color, and total suspended solids (TSS). At the same time, light profiles from surface to bottom were collected to estimate light attenuation with depth (k_{par}). All parameters were highest in the upper bay, which receives freshwater from the Perdido River and its tributaries. Chlorophyll-a and color were highest in August (Figure 4). In low-lying watersheds in the southeastern United States, freshwater runoff is often low in summer due to high evaporation and plant transpiration rates while decomposition rates of plant materials are high because of warm temperatures. Nutrients become concentrated in surface waters, and color reflects the high dissolved organic carbon concentrations resulting from decomposition. In contrast, turbidity did not show much seasonal variation but was extremely high

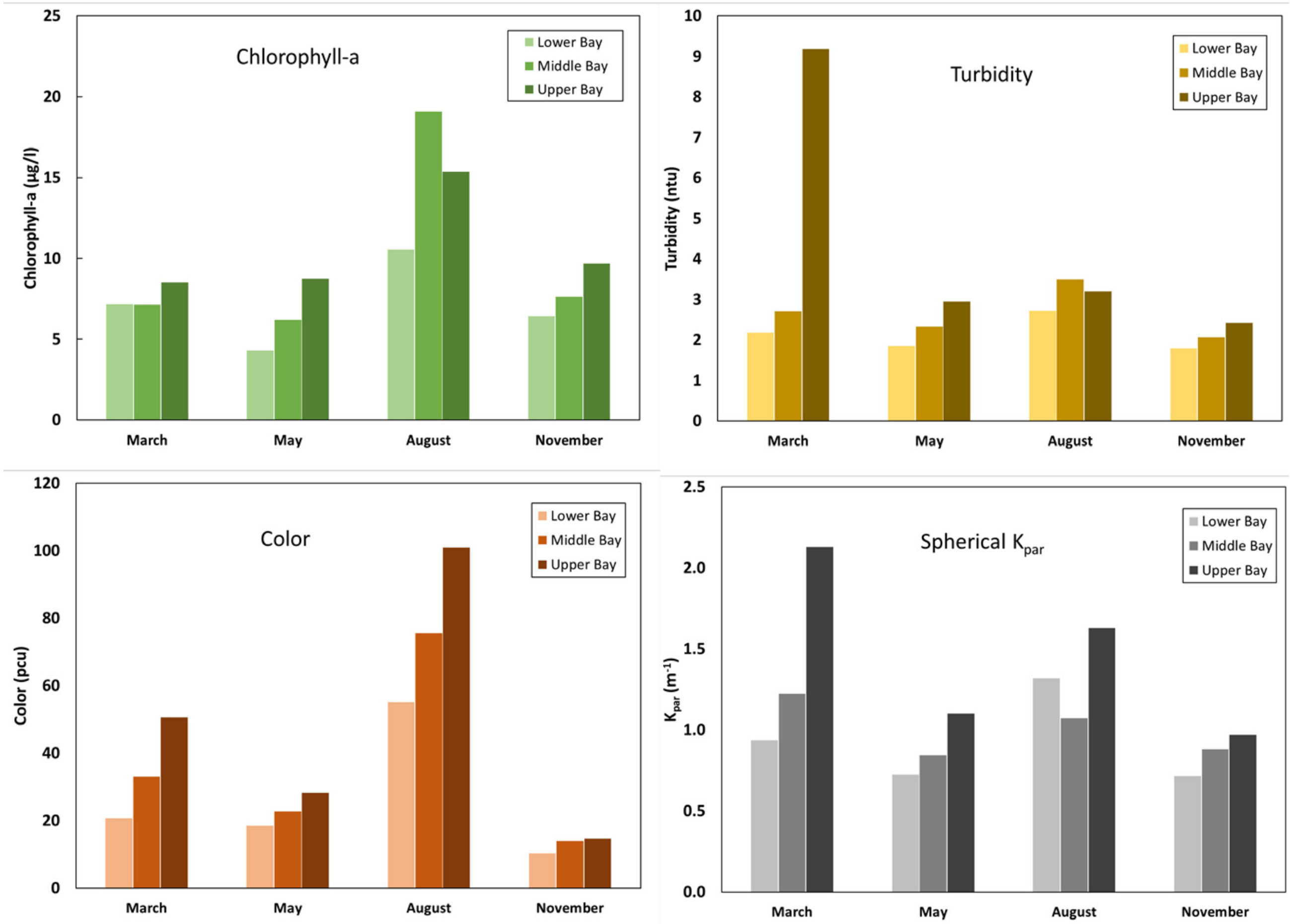

Figure 4. Mean values of the optical water quality parameters chlorophyll-a concentration (µg/l), turbidity (ntu), color (pcu), and spherical k_{par} in lower, middle, and upper reaches of Perdido Bay, 2016.

in the upper bay in March, probably due to high seasonal spring runoff. K_{par} was greatest in the upper bay in March, likely due to the high turbidity values. K_{par} values >1 generally indicate poor light environment on the bottom; mean k_{par} values in middle and upper Perdido Bay, where seagrass is absent, were usually >1.

Watershed management

The Northwest Florida Water Management District, http://nwfwater.com/, through the Surface Water Improvement and Management (SWIM) program, identifies and addresses issues of water resource concern in the SWIM planning basins. The 2017 Perdido River and Bay Watershed Surface Water Improvement and Management Plan, also referred to as the SWIM plan (https://www.nwfwater.com/Water-Resources/Surface-Water-Improvement-and-Management/Perdido-River-and-Bay), lists the following priority objectives:

- Protect and, as needed, restore water quality in impacted or designated priority areas: listed impaired waters; urban bayous and streams; Big Lagoon; Perdido River; and outstanding Florida waters (OFWs).
- Reduce water quality impacts of legacy pollutants.
- Restore water quality in impaired river, stream, and estuarine waters.
- Reduce loading of nutrients and other pollutants from onsite sewage treatment and disposal systems.
- Reduce pollutant loading from aging infrastructure.
- Improve treatment of urban stormwater.
- Reduce basin wide NPS pollution from agricultural areas and erosion sites.
- Reduce sedimentation from unpaved roads, borrow pits, landscape erosion, and construction sites.
- Protect, and as necessary, restore major wetland areas and functions.
- Protect and restore riparian and littoral habitats.
- Where needed, restore wetland and stream hydrology.

- Restore and enhance estuarine benthic habitats.
- Restore seagrass beds, including through water quality improvement.
- Ensure that restoration projects are compatible with coastal change.
- Evaluate and correct hydrological alterations as necessary.
- Restore tributary stream channels and floodplain connections, including bayou drainages, other tidal creeks, and tributaries in agricultural areas.
- Protect and reestablish functional floodplain area.
- Restore the function of vegetated riparian buffers on public and private lands.
- Continue to make data and information publicly available to enable communities to reduce flood risk.
- Create long-term partnerships among stakeholders, including government, academic institutions, non-governmental organizations, businesses, and residents to maximize effectiveness of project implementation.
- Expand education and outreach about watershed resources and personal practices to protect water and habitat quality.
- Build the capacity of landowners, agricultural producers, and others to protect watershed resources, functions, and benefits.
- Support agricultural, silvicultural, and urban best management practices.

Mapping methods, data, and imagery

In 2002, 2008, 2009, and 2015, the Mobile Bay (Alabama) National Estuary Program contracted Vittor and Associates Inc. to survey submerged aquatic vegetation (SAV) in the region using photo-interpreted and ground-truthed aerial imagery. Imagery collected by Vittor and Associates Inc. was orthorectified, and then seagrass beds were digitally delineated. The minimum mapping unit was 0.1 acre. Field surveys were completed close in time to imagery acquisition to document presence and species of seagrasses and habitat characteristics. Please see Vittor and Associates, Inc. (2009, 2016) for details.

High-resolution (1 m) four-band aerial imagery was collected for the entire northern Gulf coast in October 2010, and photo-interpretation of Perdido Bay was completed by PhotoScience Inc. (St. Petersburg, Florida). High-resolution (1 m), four-band aerial imagery was collected for the Florida Panhandle estuaries by the National Agricultural Imagery Program (NAIP) in December 2015 and photo-interpreted for benthic habitats by Dewberry (Tampa). The Florida Land Use, Cover, and Forms Classification System (FLUCCS; Florida Department of Transportation 1999) was used to classify bottom features as continuous seagrass, patchy seagrass, oyster bed, bare intertidal, shallow bare bottom, or deep bare bottom. Bottom features were delineated by polygonal shapefiles, with a minimum mapping unit of 0.1 ha. Mapping data and imagery reside at FWC (contact Paul Carlson).

Propeller scarring assessment

As part of the Roadblocks to Seagrass Recovery project, scientists at FWRI assessed the extent and severity of propeller scarring on seagrass beds in Perdido Bay using imagery acquired in 2013 by the NAIP. Using ArcMap, water areas less than 4 m deep were overlain by a grid constructed of square cells 100 m on a side, thus covering 1 ha each. For each cell that was over seagrass, the number of scars were counted and the cell was scored in the following manner:

Description	Score
Vegetated, no scars	0
<5 scars	1
5–10 scars	2
11–25 scars	3
26–50 scars	4
>50 scars	5
Doughnut-shaped beds	7
Unreadable, vegetated	10

When scoring was completed for each subregion, then the number of cells having each score was summed and compared with the total number of vegetated cells to calculate the percentage for each scarring score and overall scarring percentage. In addition, maps were created showing the distribution of scarring intensity, and these maps constitute a layer of the Seagrass Recovery Potential model of the Roadblocks project.

Monitoring methods and data

While there is no routine field monitoring program in Perdido Bay, field assessment of seagrass cover was completed in the summer of 2016 by staff of DISL as part of the FWC Roadblocks to Seagrass Recovery project. At each of 20 sites where seagrass was present, cover of seagrass and macroalgae was assessed in five 0.25-m^2 quadrats using a modification of the Braun-Blanquet method.

In addition, scientists measured the standard water-quality parameters of surface and bottom water temperature, salinity, pH, and oxygen concentration, as well as Secchi depth and water depth.

Optical water quality measurements

Measurements of optical water quality parameters—chlorophyll-a, color, turbidity, total suspended solids, and light attenuation—help determine the amount of sunlight reaching seagrass beds. The amount of light on the bottom is often critical to the survival of seagrass communities, and the attenuation of light in the water column results from reflection, diffraction, and absorption by water itself, by the quantity and size of particles in the water, and the amount of color added to the water column by the presence of colored dissolved organic matter (CDOM). The quantity and character of particles in the water are estimated by the measurement of chlorophyll-a as a proxy for phytoplankton, by measurement of TSS as an estimate of the number of particles in the water, and by the measurement of turbidity, which estimates light scattering by particles as well as the quantity of particles present. The color of the water column can be measured by light absorption of a filtered water sample at 440 nm (color) or, for CDOM, by light absorption over 300–600 nm.

Chlorophyll-a concentrations were determined by filtering triplicate 60-ml aliquots of surface water through 25-mm-diameter GFF glass fiber filters in the field. Each filter was stored in a microcentrifuge vial and immediately frozen in liquid nitrogen. In the laboratory, filters were transferred to an ultralow freezer and held at −60°C until analysis. To measure the amount of chlorophyll-a, filters were extracted in 10 ml of methanol in the dark for 40 hours at 4°C. On the day of analysis, methanol extracts were centrifuged at 3,500 rpm for 20 minutes to remove filter fibers from the extract. Fluorescence of each extract was measured using a Turner Designs model 10-AU-005 fluorometer following the methods of Welshmeyer (1994). Calibration of the fluorometer uses fresh spinach extracts and the trichromatic equations of the Environmental Protection Agency (EPA) method 446.0.

Water samples for the measurement of color, turbidity, and TSS were collected by triple rinsing each sample bottle with sample water and then filling each bottle nearly full. Samples were kept on ice or refrigerated until analysis. To measure color, water was filtered through a 0.22-μm membrane filter. Light absorbance at 440 nm of the filtered sample was determined using a 10-cm cell path in a Hitachi U-2900 spectrophotometer after Kirk (1976) and Gallegos et al. (1990). Absorbance of certified color standards was used to estimate color in platinum cobalt units (pcu). Turbidity was measured nephelometrically on a Hach 2100Q turbidimeter using calibrated standards following method 214 A of the *Standard Methods for the Examination of Water and Wastewater* (1985), and units were nephelometric turbidity units (ntu). TSS was measured gravimetrically following method 2540 D of *Standard Methods* (1985) by filtering water samples through combusted, tared GFC glass-fiber filters. Filters were then dried at 50°C for at least five days and then re-weighed using a 5-place Mettler balance.

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