National Marine Fisheries Service
Southwest Region Habitat Conservation Division
Santa Rosa Area Office

San Francisco Bay Light Monitoring Survey Protocol

Revised January 2010

The purpose of this protocol is to provide guidance to entities conducting activities in San Francisco (SF) Bay and northern California that may cause increases in turbidity above background levels and impact *Zostera marina* (eelgrass). Water column turbidity reduces the amount of light available for photosynthesis and consequently affects the depth distribution, density and productivity of eelgrass (Thayer *et al.* 1984; Zimmerman *et al.* 1991; Lee *et al.* 2007). Although eelgrass in SF Bay is adapted to growing in low light environments, if the period of irradiance-saturated photosynthesis (H_{sat}) decreases below 3-5 hours per day, the maintenance of whole plant carbon balance and growth period is negatively affected (Zimmerman *et al.* 1991). Due to high turbidity levels in SF Bay, eelgrass plants located at the deeper edges of established eelgrass beds are less likely to accumulate large carbon reserves making them unable to withstand 30 days of reduced light conditions (Zimmerman *et al.* 1991). This protocol was established to ensure consistent collection of light monitoring data, and to guide users on the appropriate application of such measurements.

NMFS Santa Rosa Office staff are available for guidance in the use of this protocol. The lead action agency should provide a detailed monitoring plan to NMFS for approval 60 days prior to the light monitoring survey.

Light survey during project activities:

Objective: Determine increased light attenuation associated with project activities in eelgrass beds.

1. During daylight project activities, photosynthetically active radiation (PAR) should be measured at selected sampling locations. These locations should include the deeper edges of established eelgrass beds near the project site. NMFS also recommends selecting a reference station at a similar depth, near eelgrass beds, but of adequate distance away from project activities and any other sources of turbidity. Reference stations should be selected with NMFS guidance and approval. A reference station will insure that project activities are not held responsible for lowered light conditions caused by natural variation. Sampling locations and frequency may vary due to site conditions and project activities and, therefore, should be approved by NMFS Santa Rosa Office staff 60 days before sampling occurs.
    a. Depth (meters) at mean lower low water and GPS coordinates should be recorded at each sampling location.

b. PAR measurements should be recorded near the top of eelgrass plants (approximately 0.5 meters above the substrate).
c. Measurements of PAR should be recorded at regular intervals throughout the duration of daylight project activities, and should always include a measurement at the noon hour. Number of days, frequency and start/end time of measurements will depend on time of year and equipment available. If automated equipment is available, NMFS recommends measurements of PAR be taken every 10 minutes from sunrise to sunset daily, for a minimum of seven days. Increasing the frequency of PAR measurements will improve the accuracy of measurements (Banas *et al.* 2005).
d. The timing of flood and ebb tides should be recorded.

2. The maximum daily PAR measurement (I_m) should be used to calculate the daily period of irradiance-saturated photosynthesis (H_{sat}):

$$H_{sat} = D\left[1 - \frac{2}{\pi}\sin^{-1}\left(\frac{I_k}{I_m}\right)\right]$$

D = day length from sunrise to sunset[1] (= time that PAR>10 µmol photon $m^{-2}s^{-1}$)
I_k = 35 µmoles photon m^{-2} s^{-1} (Zimmerman *et al*. 1991).
I_m = daily maximum PAR measurement (CHM2HILL 1998).

H_{sat} should be calculated after sampling completion each day, at each sampling location.

Minimization Measures and Reporting:

1. If the daily period of H_{sat} is above 5 hours at the reference site, but below 5 hours near the project site, then project activities should cease during daylight hours until turbidity levels reduce and daily H_{sat} increases above 5 hours (typically within a few tidal cycles).

2. If sampling did not occur at a reference station and the calculated daily period of H_{sat} is below 5 hours at eelgrass beds near the project area, then project activities should cease during daylight hours until turbidity levels reduce and daily H_{sat} increases above 5 hours (typically within a few tidal cycles).

3. If project activities are reducing H_{sat} below 5 hours, modifications to operating procedures should be considered (e.g., timing of dredging, type of gear, use of silt

[1] Day length should not be calculated using theoretical sunrise and sunset estimates. Site-specific variability will greatly influence the actual day length at each site (i.e. adjacent buildings or hills may shade an area for significant time at sunrise or sunset), as will daily climatic conditions (i.e. fog, cloud cover…etc.). A minimum level of PAR will be set as 10 µmol photon $m^{-2}s^{-1}$, the light compensation point (H_{comp}) for eelgrass (Dennison and Alberte 1982), as a threshold level to determine actual day length hours.

curtains…etc.) in order to minimize impacts to eelgrass as well as continuity of dredging operations.

4. The results of the light monitoring studies should be provided to NMFS within 30 days of completion.

Literature Cited:

CH2MHILL. 1998. Richmond Harbor Eelgrass Monitoring Draft Report #1. Prepared for: U.S. Army Corps of Engineers, San Francisco District, Environmental Planning Section. January 1998.

Banas, D., P. Grillas, I. Auby, F. Lescuyer, E. Coulet, J. C. Moreteau & B. Millet. 2005. Short time scale changes in underwater irradiance in a wind-exposed lagoon (Vaccares lagoon, France): efficiency of infrequent field measurements of water turbidity or weather data to predict irradiance in the water column. Hydrobiologia, 551: 3-16.

Dennison, W. C. & R. S. Alberte. 1982. Photosynthetic Responses of Zostera-Marina L (Eelgrass) to *In situ* Manipulations of Light-Intensity. Oecologia, 55: 137-144.

Lee, K.-S., S. R. Park & Y. K. Kim. 2007. Effects of irradiance, temperature, and nutrients on growth dynamics of seagrasses: A review. Journal of Experimental Marine Biology and Ecology, 350: 144-175.

Thayer, G. W., W. J. Kenworthy & M. S. Fonseca. 1984. Ecology of eelgrass meadows of the Atlantic Coast: a community profile. pp. Pages: 165.

Zimmerman, R. C., J. L. Reguzzoni, S. Wyllie-Echeverria, M. Josselyn & R. S. Alberte. 1991. Assessment of Environmental Suitability for Growth of Zostera-Marina L (Eelgrass) in San-Francisco Bay. Aquatic Botany, 39: 353-366.