Yaquina Bay, Oregon, Intertidal Sediment Temperature Database, 1998 – 2006:
Abstract, Introduction, Materials and Methods, References

David T. Specht

U.S. Environmental Protection Agency
ORD/NHEERL/WED/Pacific Coast Ecology Branch
2111 SE Marine Science Drive
Newport, OR 97365-5260
Tel: 541-867-4037
e-mail: specht.david@epa.gov

ABSTRACT

Sediment temperature was measured using submersible Onset TidbiT® recording thermistor thermometers at eelgrass (*Zostera marina, Z. japonica*) mid-rhizome root depth (~5 cm) at habitat stations on transects from ~MLLW (mean lower low water) at the channel edge to near MHHW (mean higher high water) at or near the shoreline at various locations in Yaquina Bay, OR, from July 1998 through July 2006. Within the semi-diurnal mean tide range of ~2+ m, about 85% of the upper *Z. marina* habitat (subtidal to +~1.0 m relative to MLLW) is revealed on the average low tide; inversely, the non-indigenous *Z. japonica* habitat, at ~+2m, is only periodically completely inundated by extreme or "storm" tides. The potential for direct exposure of the sediment surface to insolation is mediated by the coincidence of low tide during daylight, and further by cloud cover, or by evaporative cooling when low tide occurs at night, and especially during significant wind events. Insolation and/or evaporative cooling during retreat of tidal flood (low tide) can result in rapidly changing sediment temperatures; tidal retreat and consequent evaporative cooling at night can also induce this change, often considerably below that of the ambient water, especially during wintertime. The flooding water temperature is temporarily mediated by the heat content of the sediment as the tidal front advances upslope. Riverine landform runoff water temperature in this estuary is often substantially different than the temperature of the flooding salt wedge – warmer in summertime, especially during episodes of coastal upwelling, when the salt wedge is substantially colder than river flow, and during wintertime, when runoff water is often colder than salt-wedge flooding seawater. All these scenarios have considerable potential to stress plants and animals within these habitats, and so potentially may define their distribution tolerance boundaries.

Yaquina Bay, Oregon, Intertidal Sediment Temperature Database, 1998 – 2006:
Abstract, Introduction, Materials and Methods, References

Keywords: sediment temperature, *Zostera marina*, *Zostera japonica*, eelgrass, Pacific Northwest, estuary, intertidal habitat, temperature variance,

Introduction:

A number of factors influence the presence, extent of habitat, rate of growth and general robustness of species and the communities that they comprise. Among those factors for *Zostera* spp. (eelgrasses) in estuaries are temperature, both of the bedded sediment and of the overlying water column (or air mass during low tide exposure), which vary in response to a number of sources and stresses, such as insolation, tidal movement, wind direction and speed, air temperature, sources of nutrition, varying salinity (due both to tidal mixing and to rate and quantity of fresh-water runoff) and turbidity, along with predation, abrasion and disease considerations.

In the Yaquina estuary, the distribution of the native eelgrass *Zostera marina* occurs mainly in the lower, oceanic segment of the bay (Young et al., 2010, 2012), characterized by broad intertidal mud/sand flats, from ~2m below MLLW to ~+1m above MLLW, whereas the non-indigenous *Z. japonica*, introduced ~1974 (Bayer, 1979), occurs at or near the MHHW line, but has spread of late downslope, broadening its distribution, but leaving a significant expanse of "bare" intertidal mudflat uncolonized but for episammic diatoms and predominantly ulvoid green macroalgae, the latter occurring seasonally and climaxing in the mid- to late summertime (Young et al., 2008).

In order to determine if temperature, particularly sediment temperature, was a significant environmental factor in limiting the boundaries of acceptable habitat for either *Zostera* species, transects roughly perpendicular to the axis of the estuary riverine channel were set with sensor locations at MLLW upslope to MHHW within either species habitats, and in between at suitable locations in the "bare" unoccupied habitat (Fig. 1). At one MHHW station, a set of vertically deployed sensors were set to determine vertical temperature diffusion, at 2.5, 5 and 10 cm depth. All other deployments were set at 5 cm depth, the nominal mid-depth of typical *Z. marina* root-rhizome mass in this estuary.

Newly available to the market in the late 1990s, the Onset TidbiT® submersible recording thermometers were employed to record sediment temperature at the mid-root/rhizome depth (nominally 5 cm depth) at 15 minute intervals for deployments lasting from 2 to ~11+ months (the maximum memory capacity of ~32,000 bytes amounted, at 15 minute measurement intervals, to ~337 days). To be able to access locations at the lower intertidal ends of the transects, sensors were deployed on "minus" tides, which exposed the sites long enough to allow placement and/or recovery of the unit and GPS/transit survey location determination. Accordingly, the lower sites were not accessible for months-long periods during the winter/spring period. During that time period, weather-dictated hydraulic events often eroded or deposited sediment at a given site, effectively changing the buried depth of the sensor, and, in some cases, exposing the sensor directly to the overlying water column and/or open air during low tides, typically the result of an erosion/deposition-causing high-runoff flood event.

Methods:

Sensor technology:

The epoxy encapsulated thermistor, circuit-board, lithium battery unit (Onset TidbiT®), waterproof and submersible, with infra-red optical readout, programmable measurement interval, and 32K data memory was deployed at each location. Each sensor was tethered (see Figure 2) via a plastic zip-tie to an annealed 17 ga. stainless-steel wire loop extending horizontally 5 cm down from the top of a two-foot epoxy-coated plant stake (topped by a flexible yellow plastic brush flag for visibility). The units, with a range of -20° to +50° or +70° C (depending on model available at time of purchase), were accurate to ~0.5°C, and were calibrated prior to and subsequent to each deployment by immersion for ~1 hour (~4 or more measurement intervals) in an ice-water bath to determine correctible offset of the recorded data set, and to note start and end points for determination of possible drift during deployment. The five-year lithium battery life actually allowed approximately three deployments per unit of between 3 and 11 months (on average). About 25% of the locations were accessible by tidal exposure only during extreme low tide series. The nonvolatile EEPROM[1] memory was always set to stop recording when full, instead of overwriting the front end of the data record; some of the time, tidal exposure scenarios did not allow timely recovery of the unit. When this occurred for a given deployment, a short ice-point bath calibration was run soon after the data upload was accomplished.

Transect location:

Transects perpendicular to the axis of the Yaquina estuary riverine channel were established in the lower bay in Sally's Bend (River Mile, [RM] ~3, NE shore), an expansive mud/sand flat of

[1] **E**lectrically **E**rasable **P**rogrammable **R**ead-**O**nly **M**emory

extensive *Zostera marina*, “bare” and *Z. japonica* habitats, most of which was overlain during the summer months by green ulvoid macroalgae, on Idaho Flat (RM ~3, SW shore), on the opposite side of the channel, at Raccoon Flat (RM ~5, west shore), in muddy intertidal habitat, at Riverbend (RM ~5.5, east shore), and at Craigie Flat (RM ~9, east shore), the muddiest site and steepest vertical gradient (see Fig. 1).

Station intervals:

Generally, the stations proceeded from MLLW in the *Z. marina* habitat upslope through the bare habitat to the *Z. japonica* habitat at MHHW at the shoreline; the lower bay transects had 5 or 6 stations transiting the habitats, while the upper two transects had four and three stations, as the gradients were steeper and intervals much shorter. Overall mean station horizontal interval is ~190 feet. Mean vertical interval is 1.75 feet.

Sampling frequency:

Sampling interval was set at 15 minutes, one of a number of pre-programmed timing choices, as trial sets indicated that the sensor’s response would provide sufficient data points to reliably indicate temperature change due to insolation, tidal covering by the water column, or evaporative cooling during tidal exposure, over the course of a typical day.

Data reduction:

Temperature data was recorded using TidbiT® sensors in Onset Computer® Inc. proprietary format, *.dtf files, in which raw data was viewed, graphed and manipulated using Box Car® (and subsequent versions through Box Car Pro 4.0®) proprietary software. Confirmed data was then exported in Microsoft® Excel format to Windows Excel® format (*.xls) for permanent storage and ultimate use; the original *.dtf files are retained permanently. Files were examined in *.dtf format using Box Car ® software to detect and provide timing information for trimming pre- and post-deployment calibration data, ultimately to allow calculation of and correction for temperature offset. By viewing the data graphically, it was possible to note correlation of temperature patterns that coincided with tidal cycles (exposure or submergence from water column), storm and other severe weather events.

QA methods:

Data files were examined graphically for outlier data, then corrected for temperature offset using pre- and post-deployment data obtained by immersion in an icewater bath, nominally at 0°C, adding the average difference between pre-and post-deployment data to each data point of a set for which the offset was below 0°C, and subtracting the average difference from those sets which were above 0°C. In cases where there was obvious drift in the sensor during the deployment, the average was obtained, and data classified according to maintaining the drift in the offset within ±0.5°C, ±1.0°, or ≥1.0°C during the deployment.

Figure 1. Vertical transect locations in Yaquina Bay, OR; top to bottom, Sallys Bend, Idaho Flat, Raccoon Flat, River Bend, and Craigie Flat.

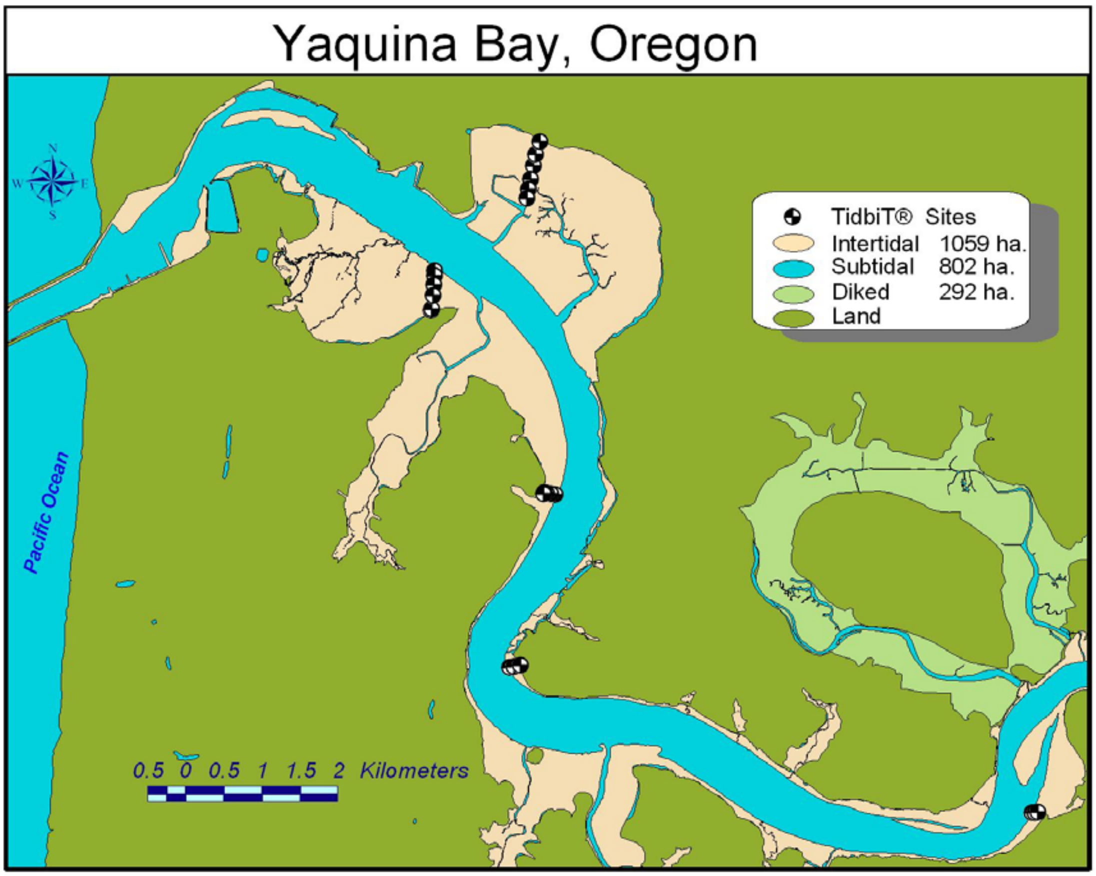

Fig. 2. Deployment of temperature loggers in habitat.

<<< Onset TidbiT® temperature logger wired to 2' plant stake with yellow plastic brush flag, ready for insertion in *Zostera marina* habitat

Temperature logger, deployed at transect site, top of stake flush with sediment surface >>>

References cited:

1) NOAA. 1988. National Estuarine Inventory: Supplement 1. Physical and Hydrologic Characteristics. The Oregon Estuaries. SAB, OAD, OOMA, NOS, NOAA, Rockville, MD. HMSC/GC/856/.P591/1988.
2) Percy, K.L., C. Sutterlin, D. A. Bella and P. C. Klingeman. 1974. Oregon Estuaries. Sea Grant College Program. Oregon State University, Corvallis, OR.
3) National Oceanic and Atmospheric Administration (NOAA). 1998. NOAA's Estuarine Eutrophication Survey, Volume 5: Pacific Coast Region. Silver Spring, MD: Office of Ocean Resources Conservation and Assessment. 75 pp.
4) Young, D., P. Clinton, D. Specht, TChris Mochon Collura, and Ted DeWitt. (2010). Mapping intertidal eelgrass (Zostera marina L.) in three coastal estuaries of the Pacific Northwest USA using false colour near-infrared aerial photography. International Journal of Remote Sensing 31, 1699-1715.
5) Young, D., P. Clinton, D. Specht, Dewitt, T.H., Lee II, H. 2008. Monitoring the expanding distribution of non-indigenous dwarf eelgrass *Zostera japonica* in a Pacific Northwest USA estuary using high resolution digital aerial orthophotography. Spatial Science 53, 87-97.
6) Young, D., P. Clinton, D. Specht, Mochon Collura, T., Lee II, H. 2012. Determining bathymetric distributions of the eelgrass *Zostera marina* L. in three turbid estuaries on the eastern North Pacific coast. Botanica Marina 55, 229-240.
7) Bayer, R.D. 1979. Intertidal zonation of *Zostera marina* in the Yaquina Estuary, Oregon. Syesis 12:147-154.

This tiny completely sealed underwater temperature data logger utilizes optic communications for launch and readout. This model records 32K of temperature measurements from -20°C to +50°C (-4°F to 122°F). Waterproof to 333m (1000ft),

Features:

- Waterproof to 1000 feet
- Completely sealed in epoxy; very durable
- User-selectable sampling interval: 0.5 seconds to 9 hours, recording times up to several years
- Blinking LED light shows if temperature goes out of user-determined limits
- Precision components eliminate the need for user calibration
- Programmable start time/date
- Triggered start with coupler or magnet
- Memory modes stop when full or wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Multiple sampling with minimum, maximum or averaging
- Blinking LED light confirms operation
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Mounting tab
- Compliance certificate available
- NIST-traceable temperature accuracy certification available
- 5 year non-replaceable battery (typical use :16 three-month deployments in water (+35°F to +80°F) with 4 minute or longer intervals (no multiple sampling), 1 offload per deployment.)