KECK GEOLOGY CONSORTIUM

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

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Dr. Robert J. Varga, Editor
Director, Keck Geology Consortium
Pomona College

Dr. Tekla Harms
Symposium Convenor
Amherst College

Carol Morgan
Keck Geology Consortium Administrative Assistant

Diane Kadyk
Symposium Proceedings Layout & Design
Department of Earth & Environment
Franklin & Marshall College

Keck Geology Consortium
Geology Department, Pomona College
185 E. 6th St., Claremont, CA 91711
(909) 607-0651, keckgeology@pomona.edu, keckgeology.org

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Robert J. Varga
Editor and Keck Director
Pomona College

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Diane Kadyk
Proceedings Layout & Design
Franklin & Marshall College

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2011-2012 PROJECTS

TECTONIC EVOLUTION OF THE CHUGACH-PRINCE WILLIAM TERRANE, SOUTH-CENTRAL ALASKA
Faculty: *JOHN GARVER*, Union College, *Cameron Davidson*, Carleton College
Students: *EMILY JOHNSON*, Whitman College, *BENJAMIN CARLSON*, Union College, *LUCY MINER*, Macalester College, *STEVEN ESPINOSA*, University of Texas-El Paso, *HANNAH HILBERT-WOLF*, Carleton College, *SARAH OLIVAS*, University of Texas-El Paso.

ORIGINS OF SINUOUS AND BRAIDED CHANNELS ON ASCRAEUS MONS, MARS
Faculty: *ANDREW DE WET*, Franklin & Marshall College, *JAKE BLEACHER*, NASA-GSFC, *BRENT GARRY*, Smithsonian
Students: *JULIA SIGNORELLA*, Franklin & Marshall College, *ANDREW COLLINS*, The College of Wooster, *ZACHARY SCHIERL*, Whitman College.

TROPICAL HOLOCENE CLIMATIC INSIGHTS FROM RECORDS OF VARIABILITY IN ANDEAN PALEOGLACIERS
Faculty: *DONALD RODBELL*, Union College, *NATHAN STANSELL*, Byrd Polar Research Center
Students: *CHRISTOPHER SEDLAK*, Ohio State University, *SASHA ROTHENBERG*, Union College, *EMMA CORONADO*, St. Lawrence University, *JESSICA TREANTON*, Colorado College.

EOCENE TECTONIC EVOLUTION OF THE TETON-ABSAROKA RANGES, WYOMING
Faculty: *JOHN CRADDOCK*. Macalester College, *DAVE MALONE*. Illinois State University
Students: *ANDREW KELLY*, Amherst College, *KATHRYN SCHROEDER*, Illinois State University, *MAREN MATHISEN*, Augustana College, *ALISON MACNAMEE*, Colgate University, *STUART KENDERES*, Western Kentucky University, *BEN KRASUSHAAR*

INTERDISCIPLINARY STUDIES IN THE CRITICAL ZONE, BOULDER CREEK CATCHMENT, FRONT RANGE, COLORADO
Faculty: *DAVID DETHIER*, Williams College
Students: JAMES WINKLER, University of Connecticut, SARAH *BEGANSKAS*, Amherst College, *ALEXANDRA HORNE*, Mt. Holyoke College

DEPTH-RELATED PATTERNS OF BIOEROSION: ST. JOHN, U.S. VIRGIN ISLANDS
Faculty: *DENNY HUBBARD* and *KARLA PARSONS-HUBBARD*, Oberlin College
Students: *ELIZABETH WHITCHER*, Oberlin College, *JOHNATHAN ROGERS*, University of Wisconsin-Oshkosh, *WILLIAM BENSON*, Washington & Lee University, *CONOR NEAL*, Franklin & Marshall College, *CORNELIA CLARK*, Pomona College, *CLAIRE McELROY*, Otterbein College.

THE HRAFNFJORDUR CENTRAL VOLCANO, NORTHWESTERN ICELAND
Faculty: *BRENNAN JORDAN*, University of South Dakota, *MEAGEN POLLOCK*, The College of Wooster
Students: *KATHRYN KUMAMOTO*, Williams College, *EMILY CARBONE*, Smith College, *ERICA WINELAND-THOMSON*, Colorado College, *THAD STODDARD*, University of South Dakota, *NINA WHITNEY*, Carleton College, *KATHARINE, SCHLEICH*, The College of Wooster.

SEDIMENT DYNAMICS OF THE LOWER CONNECTICUT RIVER
Faculty: *SUZANNE O'CONNELL* and *PETER PATTON*, Wesleyan University
Students: *MICHAEL CUTTLER*, Boston College, *ELIZABETH GEORGE*, Washington & Lee University, *JONATHON SCHNEYER*, University of Massachusetts-Amherst, *TIRZAH ABBOTT*, Beloit College, *DANIELLE MARTIN*, Wesleyan University, *HANNAH BLATCHFORD*, Beloit College.

ANATOMY OF A MID-CRUSTAL SUTURE: PETROLOGY OF THE CENTRAL METASEDIMENTARY BELT BOUNDARY THRUST ZONE, GRENVILLE PROVINCE, ONTARIO
Faculty: *WILLIAM PECK,* Colgate University, *STEVE DUNN,* Mount Holyoke College, *MICHELLE MARKLEY*, Mount Holyoke College
Students: *KENJO AGUSTSSON*, California Polytechnic State University, *BO MONTANYE*, Colgate University, *NAOMI BARSHI*, Smith College, *CALLIE SENDEK*, Pomona College, *CALVIN MAKO*, University of Maine, Orono, *ABIGAIL MONREAL*, University of Texas-El Paso, *EDWARD MARSHALL*, Earlham College, *NEVA FOWLER-GERACE*, Oberlin College, *JACQUELYNE NESBIT*, Princeton University.

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Keck Geology Consortium: Projects 2011-2012
Short Contributions— Connecticut River Project

ANTHROPOGENIC IMPACTS AND ENVIRONMENTAL CHANGES RECORDED IN THE IN THE DEPOSITIONAL HISTORY OF THE LOWER CONNECTICUT RIVER
Project Faculty: SUZANNE O'CONNELL Wesleyan University

FRESH-WATER DIATOMS AS BIOINDICATORS OF POLLUTION IN SELDEN COVE, CONNECTICUT RIVER
TIRZAH ABBOT, Beloit College
Research Advisor: Carl Mendelson

GEOCHEMICAL CHARACTERIZATION OF TIDAL COVES OF THE CONNECTICUT RIVER ESTUARY
HANNAH BLATCHFORD, Beloit College
Research Advisor: Carl Mendelson

VARIABILITY OF SUSPENDED-SEDIMENT DISTRIBUTION IN THE CONNECTICUT RIVER ESTUARY
MICHAEL CUTLER, Boston College
Research Advisor: Gail Kineke

RECONSTRUCTING ENVIRONMENTAL CHANGES IN THE LOWER CONNECTICUT RIVER USING DIATOMS
ELIZABETH JEAN GEORGE, Washington and Lee University
Research Advisor: David J. Harbor

INVASIVE FRESHWATER CLAM, CORBICULA FLUMINEA, HABITATS IN THE LOWER CONNECTICUT RIVER
DANIELLE MARTIN, Wesleyan University
Research Advisor: Suzanne O'Connell

COMPARING SEDIMENT DEPOSITION USING MERCURY INVENTORIES FOR BACK-WATER AND SALT MARSH ENVIRONMENTS
JONATHAN SCHNEYER, University of Massachusetts Amherst
Research Advisor: Jon Woodruff

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Keckgeology.org

COMPARING SEDIMENT DEPOSITION USING MERCURY INVENTORIES FOR BACK-WATER AND SALT MARSH ENVIRONMENTS

JONATHAN SCHNEYER, University of Massachusetts Amherst
Research Advisor: Jon Woodruff

ABSTRACT

Preliminary work has been done studying the inventories of mercury in backwater and marsh environments along the Connecticut River. Varekamp et al., 2003 and Jacobacci, 2011 investigated the concentrations of mercury in Great Island Marsh and Selden Cove, respectively. Only one core from each location was selected by these authors as an introductory look into mercury inventory and sediment deposition histories. This project aims to expand on each of these studies by incorporating data from additional cores in order to see the spatial variability of mercury across three different depositional environments; two back-water environments of different depths and a salt water marsh. Selden Cove and Hamburg Cove represent back-water environments with maximum water depths of roughly 1 and 3 m, respectively. Jacobacci, 2011 explored the mercury inventory in the shallower Selden Cove. I am looking to compare her results to the mercury concentrations from two more core locations in Selden Cove. Similarly, Varekamp et al., 2003 used data from one core taken at Great Island Marsh. Here I present results from six more cores to generate a better understanding of the heterogeneity of deposition across the marsh. In addition to continuing the work of Jacobacci and Varekamp, data from Hamburg Cove, a deeper back-water environment, is added to compare the relationship between accommodation space for sediment in backwater environments and resulting mercury inventories. The onset of mercury in a core represents the beginning of urbanization along the river around roughly 1850-1900 AD, when waste from industrial factories, such as hatting, started being introduced to the river (Varekamp et al., 2003). The deposition of sediment in these environments is enhanced by tidal pumping (i.e. flood dominated asymmetry in sediment flux, Woodruff et al., 2012). Results presented here support tides playing an important role in deposition along the Connecticut River, with the magnitude of overall sediment accumulation controlled predominantly by the water depth of the depositional environment.

SITE LOCATIONS

Three locations were selected because they represent different levels of sediment accommodation space. From South to North they are: Great Island Marsh, Hamburg Cove and Selden Cove. Figure 1A presents a map of the Connecticut River Estuary with the site locations marked. Great Island Marsh is located at the mouth of the Connecticut River, with its southern edge bordering Long Island Sound. The marsh is roughly 1.3 km^2 in area and is highly vegetated with grasses and reeds. During periods of high tide, water inundates areas of low and moderate elevations of the marsh; however some areas remain above the tidal water. There are also a series of tidal creeks, both natural and man-made, with some of which these channels becoming dry during low tides. Hamburg Cover is located almost 13 km from the Long Island Sound. Unlike Great Island Marsh, it is an off-river backwater site connected directly to the river via a 3 meter deep navigation channel, and therefore experiences the tides differently. With the exception of this man-made navigation channel, the mouth of the Hamburg inlet is shallow and approximately 200 m wide and extends 500 m from the river to Hamburg Cove. Despite its width, the mouth of Hamburg Cove is fairly shallow, usually staying at 0.3 m outside the navigational channel. The navigation channel is deeper and dredged. The channel was dredged initially in the late 19th century but no records of further dredging can be found (Maloney, 2001). Hamburg Cove itself has an average depth of 2.2 m with a maximum depth of 5.5 meters at its center. It has an area of 0.43 km^2. The average tidal range for Hamburg Cove is 0.82 m but can be as high as 0.98 m during spring tides.

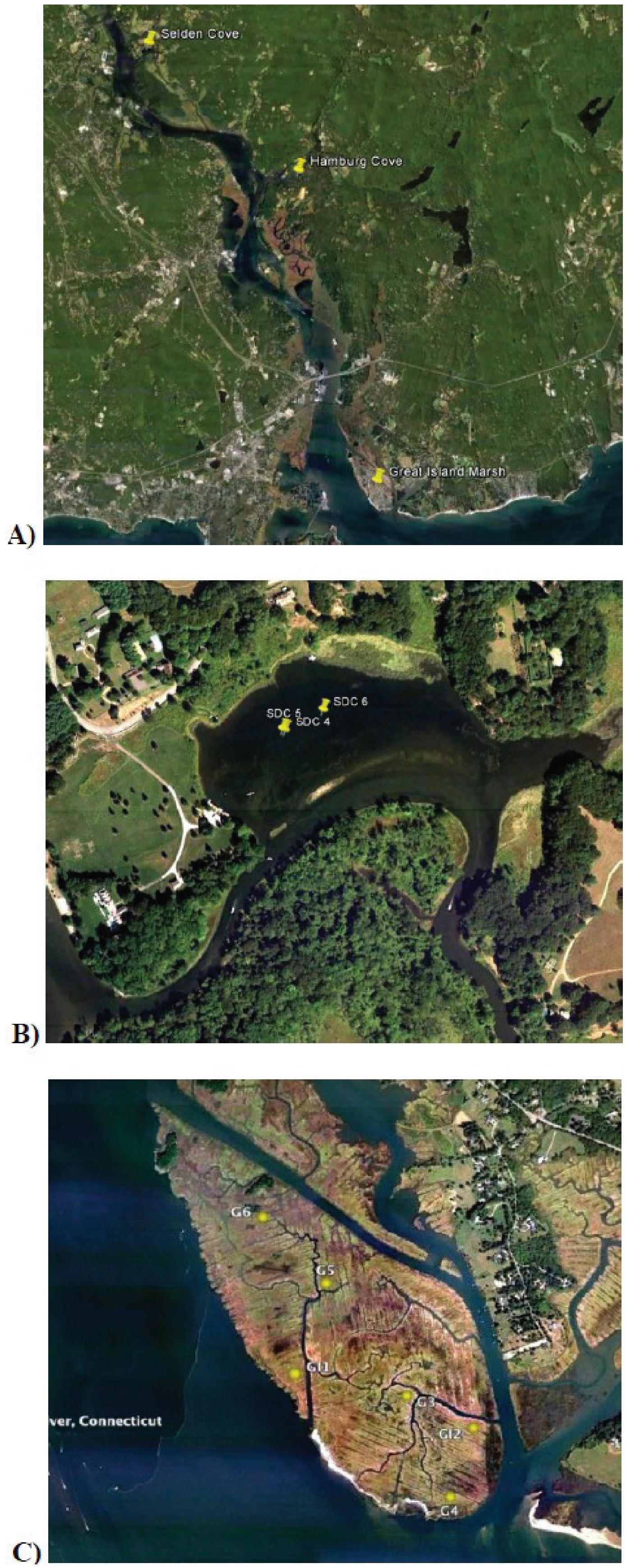

Figure 1: Map of the Connecticut River with Selden Cove (A), Hamburg Cove (B) and Great Island Marsh (C), with core sites (yellow circles).

Selden Cove is located further up river, 16 km from the Long Island Sound. It is much shallower that Hamburg Cove with a maximum depths that do not exceed 1.5 m and an area of 0.08 km^2. Selden Cove connects to the river via two different channels. The first is located to the southwest and is approximately 400 m long. The depth of this channel range from 1.2 – 1.5 m. The second channel (Selden Creek) is roughly 3 km long and located to the southeast. This channel is deeper than the first channel, reaching depths of 3.96 m. This second, shorter channel was created during a large storm in 1854 (Maloney, 2001), where evidence for this channel is present in navigation charts after this date, but not before. Sediment from up river is carried into back-water and marsh environments via tides, which have a range of roughly 1 m near the Connecticut River mouth and typically extend 100 km upstream from the mouth, although the length of this tidal reach varies is significantly shorter during high freshwater discharge. During times of low discharge and high tidal strength (i.e. spring tides), salt water from the Long Island Sound can reach as far as 15 km up the river (Horne and Patton, 1989), with this salinity reach shortening to less than 5 km during high river discharge events. Selden Cove is typically located above the head of salt; however it is well within the tidal reach for the river and thus experiences tidal effects despite being a fresh water cove.

Sample Collection

Cores were taken from Selden Cove, Hamburg Cove, and Great Island Marsh over the course of summer and fall of 2011. In June and July 2011 two cores were collected from Selden Cove, abbreviated SD5 and SD6 (Figure 1B), and one from Hamburg Cove. At Selden Cove and Hamburg Cove, a Push Core System was used, which includes a slide hammer to push a core tube into the sediment. In order to see a profile of the entire marsh, six locations at Great Island Marsh were chosen, labeled GI 1-6 (Figure 1C). A Russian Peat Core was used at Great Island Marsh due to the presence of vegetation. This setup includes driving the barrel into the marsh and twisting a blade, which cuts a semi-cylinder shaped section of the sediment. The sediment was sampled in 5 cm intervals. Testing for porosity and loss of ignition (organic matter concentrations) were performed at the University

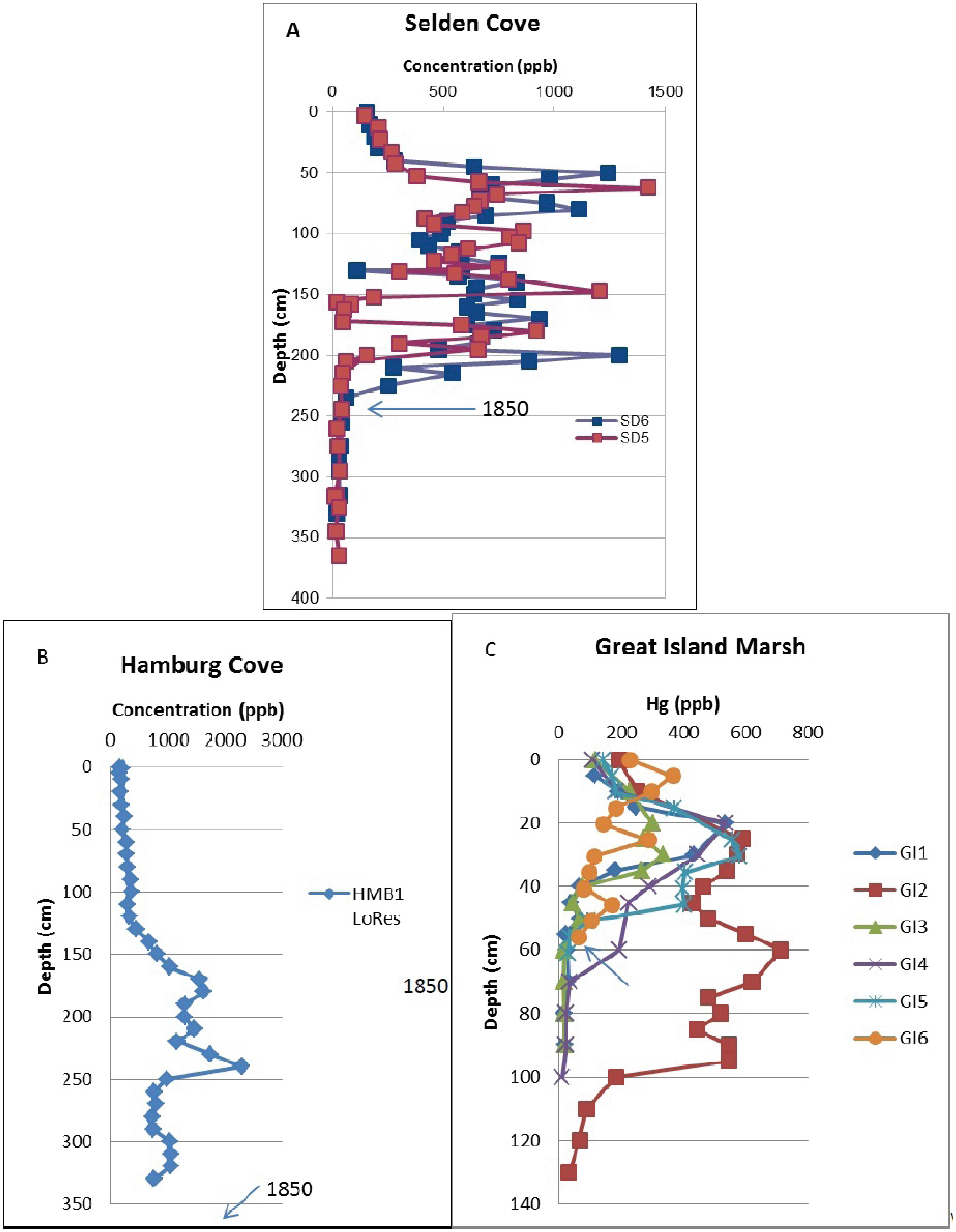

Figure 2: Hg depth profiles for Selden Cove (A), Hamburg Cove (B) and Great Island Marsh (C).

of Massachusetts and the measuring of mercury levels were done at Amherst College.

Mercury Concentrations:

We use mercury as an age constraint because of its relationship to the industrial revolution and date the increase in mercury at ~1850 AD. Waste products, such as mercury, derived from manufacturing plants along the Connecticut River were dumped into the river and adsorbed to suspended sediments that were later trapped in back-water and marsh settings (Varekamp et al., 2003). The onset of mercury therefore likely represents the beginning of the Industrial Revolution at approximately 1850 AD. Using the sediment depth of this chronological constrain we can therefore estimate the average sedimentation rate at each of our three sites since the onset of industrialization.

Sediment from Great Island Marsh was sampled in 10 cm intervals. Figure 2 shows a combined graph for all of the Great Island Marsh Cores. At approximately 20 to 25 cm below the surface of the sediment we see a shallow peak in Hg that ranges from 550 to 330 ppb. This peak is present throughout all four cores. In GI2 we see a second deeper peak at 50 cm below the surface, which reaches over 700 ppb. One possible explanation the deeper penetration of industrial related Hg in GI2 is its location on the marsh. GI2 is located on a major channel of the marsh and it is possible that constant over wash from the tides has led to higher rates of deposition at this location, with mercury concentrations rise above background levels at a depth of 60 cm below the sediment-water interface.

Selden Cove was sampled at a much higher resolution. Mercury concentrations were measured every 5 cm for the entire core. The patterns in the Hg peaks were similar to those of Great Island Marsh. The primary peak for both SD5 and SD6 occur at a depth of 50 cm below the surface. Concentrations of mercury at these locations are much higher than Great Island Marsh, with peak levels of 1424 ppb and 1244 ppb, respectively. Another set of peaks, similar to the core taken at GI2, occurs deeper within the sediment at 150 cm for SD5 and 200 cm for SD6. Concentrations in SD5 and SD6 are less in this deeper peak when compared to the shallower maxima in Hg, a finding different to observations at GI2. The concentrations of these peaks are similar to the first, reaching just over 1204 ppb and 1293 ppb, respectively. Both the SD5 and SD6 cores drop to background levels of mercury below sediment depths of 200 and 250 cm, respectively.

The data from Hamburg Cove suggests a higher rate of deposition than both Selden Cove and Great Island Marsh. In Great Island Marsh and Selden Cove the highest peaks of mercury at 30-50 cm however in Hamburg Cove the shallower peak is at 170 cm and the highest peak is at 240 cm. This suggests that the rate of deposition is substantially higher in Hamburg Cove, relative to the other two study sites.

Rates of Deposition:

One of the most important factors to look at when considering mercury versus depth profiles is where the mercury concentration curve begins to rise above background levels. This point in core correlates to roughly 1850, when industrial factories began to dump waste into the river. In Selden Cove, we see mercury concentrations begin to rise at a depth of between 245 to 250 cm. Assuming that this depth correlates to the mid-19th century, we can say that 250 cm of sediment has been deposited since 1850 yielding a rate of deposition of 1.56 cm/year. Using the same procedure, sedimentation rates for Great Island Marsh are 0.375 cm/year for GI 1 and 3 - 6. The onset of mercury in GI 2 occurs slightly deeper, which is likely the result of the cores location on the flood plain of a main channel, at approximately 130 cm, giving it a rate of deposition of 0.813 cm/year. Hamburg Cove data is less complete and does not extend to a depth where Hg drops to background concentrations. The onset of mercury deposition is at least 300 cm deep suggesting a rate of deposition of greater than 1.875 cm/year. The rate of deposition in Hamburg Cove is therefore higher than at Selden Cove. The determining factor here is that Hamburg Cove is deeper in water depth than Selden Cove. The depth of Hamburg allows sediment to settle and accumulate at the bottom without being disturbed or remobilized by tides, waves and/or fresh water flow. When tidal water enters Selden Cove, it likely scours the shallower bottom and remobilized sediment is carried out into the river. This accounts for the difference in deposition rates relative to Hamburg Cove, which is deeper and therefore experiences less disruption at the bottom by waves and tides. The depositional rate of Hamburg Cove will therefore likely continue to be higher than that of Selden until Hamburg Cove shallows to depths similar to Selden Cove.

Great Island marsh experiences a lower rate of deposition than either of the back-water coves, and is likely due to its elevation being limited to high water. Here, sea-level rise is the dominant mechanism for providing additional accommodation space in the marsh, with the depositional rate of Great Island Marsh correlates to annual sea level rise which is 2mm/year (Donnelly and Bertness, 2001).

Sediment Analysis

Future work for this project will include deriving the volumes of clastic and organic material for the three study sites as well as Hg inventories. This will be done by using the deposition rates derived from the mercury depth profiles presented here, in combination with measurements obtained for percent organic material, and average densities for sediment and organic matter (e.g. Jacobacci, 2011).

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