Coastal Metadata:
LiDAR datasets:

LiDAR 2000: Collected between 9/20/2000 and 11/02/2000. Vertical accuracy stated as between 15cm and 20cm. Working with the assumption of 15cm. Original data in geographic coordinate system, reprojected using LASTools to UTM zone 19N. Used height filtering using the inputs of "town or flat terrain" and default granularity. Point density in beach area is .53 points/m, gridded to 2m using triangulation natural neighbor interpolation.

LiDAR 2007: Collected in the June/July 2007 time period. Vertical accuracy 30cm. Original data in geographic coordinate system, reprojected using LASTools to UTM zone 19N. Used height filtering using the inputs of "town or flat terrain" and default granularity. Point density in beach area is 1.19 points/m, gridded to 1m triangulation natural neighbor interpolation.

LiDAR 2010: Collected between 05/24/2010 and 07/10/2010. Vertical accuracy 0.172m. Original data in geographic coordinate system, reprojected using LASTools to UTM zone 19N. Filtered "ground" points only for final gridding. Point density in beach area is 1.61 points/m, gridded to 1m triangulation natural neighbor interpolation.

LiDAR ARRA: Collected on May 14 2011. Vertical accuracy 15cm. Original data collected in UTM zone 19N. Used original ground classified gridding provided by vendor to 2m size.

LiDAR 2011: Collected between 09/25/2011 and 09/30/2011. Vertical accuracy 0.2m. Original data in geographic coordinate system, reprojected using LASTools to UTM zone 19N. Filtered "ground points only for final gridding. Point density 1.4 points/m, gridded to 1m triangulation natural neighbor interpolation.

Sandy LiDAR:
Collected in two sets, 12/8/2013 and 4/12/2014. The April 2014 only covers the southern portion of the coast, and only the entirety of Seabrook beach. Original delivered dataset was a mashup of the 2013 and 2014 data along a random line in the middle of Hampton Beach. In order to create one 2013 dataset for the whole coast, I took the original swaths (which were segregated by date) tiled and then classified them using LAS tools. Using the classified LAS, I then gridded using triangulation natural neighbor interpolation, 1m spacing. I did this for the southern portions where the 2014 data was in the original DEM, replacing it with 2013 data. Stated vertical accuracy for the whole dataset is .189m.

For all datasets: used a combination of 4 band aerial imagery and gridded intensity values from LiDAR data and a hillshade with 45 degree azimuth and 5x vertical exaggeration to define extent of sand areas. These were digitized at a 1:2500 scale. These were then used as the zones for analysis. Beaches were also guided by Environmental Sensitivity Index classification digitized by NHDES in 2004. Beaches were inclusive of sand and gravel, and those that were open to the ocean and not perched on rock outcrops (such as those

near Ordione state park, class 2A in ESI). Additionally, some beaches that meet these criteria near Ordione and Newcastle were excluded because they do not include the 2000 time step.

Mean high water for NOAA site 8423898 Fort Point, NH is 3.564m above the tidal datum. NAVD88 in the tidal datum is 2.35m, so MHW in NAVD88 is 1.214m. Extracted the value of 1.214m using the "contour" function in ArcMap, as well as plus or minus the value of the vertical accuracy of the dataset. As a comparison, I tested the NOAA vdatum projection tool for a small portion of the 2011 dataset and reprojected to MHW datum. Comparing the two lines, they are nearly identical with an approximate 12cm offset between the two. This fell at all times within the vertical accuracy of the LiDAR datasets. Because of the length of processing in vdatum, I decided to go with the simple conversion of subtraction.

Difference of DEMs (DoD): The minimum of cell sizes was used, and only the overlapping area between the two were used. All DEMs were interpolated using the same origin as the ARRA lidar dataset to achieve alignment between datasets. DoD grids were classified using the combined stated vertical accuracy of the two datasets. For example, if one dataset had a vertical accuracy of 15cm and another had an accuracy of 20cm, the cells that showed change as +/-35cm were excluded from analysis of volume change. All beaches taken together showed a net erosion of -87272.5$m^3$. Seabrook and Hampton beaches showed the largest net gain 52200.11$m^3$ and 28615.43$m^3$ respectively. The Bass Beach area showed small net gain, and North Beach, Plaice Cove and Rye Beach showed the highest net erosion, -67265.36$m^3$, -45100.12$m^3$, and -30182.53$m^3$ respectively. The remaining beaches showed smaller volumes of erosion.

Aerial images
All georeferenced images were referenced with at least 6 points, using 1$^{st}$ order affline transformation. I digitized the wet/dry line at 1:5000, increasing contrast in some cases. NOAA T-sheets and USGS topos were digitized along the shoreline at a 1:5000 scale.

DSAS:
No bias correction was applied to the MHW vs High Water Line

Shorelines were cast from an offshore baseline with 50 m spacing. Results of this are that the Weighted Linear Regression (WLR) showed a mean of 0.12m/year with a standard deviation of 0.43m. The max erosion was -0.75 m/yr (Wallis Sands) and the max accretion was 2.18m/yr (Hampton Beach against the jetty). The regular linear regression was a mean of 0.11m/year, a standard deviation of 0.58m, a maximum erosion of -2.05m/year (Hampton Beach almost off the beach to the North) and a maximum accretion of 2.97m/year (Seabrook Beach near jetty).

Short term rates (1970-most recent) WLR had a mean of -0.0004 m/year and a standard deviation of 0.52m/year. The max erosion was -1.51m/year (Plaice Cove) and the max accretion was 1.14m/year (Hampton Beach). LRR for the short term time period had a mean of 0.20m/year, and a standard deviation of 0.41m. The maximum erosion was -

0.81m/year (Hampton Beach) and the maximum accretion was 1.06m/year (Seabrook Beach).

Shorelines derived only from photos (1970-current) have a mean WLR of 0.31 m/year, standard deviation of 0.45 m, maximum erosion of -0.51 m/year (Unnamed Beach) and maximum accretion of 1.44 m/year (Seabrook Beach).
LRR of 0.12 m/year, standard deviation of 0.37 m, maximum erosion of -1.03 m/year (Hampton beach near jetty) and maximum accretion of 0.99m/year (Seabrook Beach).

The take-home message of this is that there doesn't really seem to be much going on.

Update regarding lidar dems. Went through the 2000, 2007 and minor parts of 2010 and reclassified some points using the ESRI lidar profile tool. LAStools was very aggressive in classifying stuff as non-ground. In particular there were problems along seawalls, groins and jetties that would be nice to have in the DEM. Made minor changes to 2010 and no changes to ARRA or 2011.

Error analysis: A number of methods were employed to get at error analysis. First, a set of 80 points, 40 in low slope and 40 in high slope, were created in the area of Seabrook and Hampton beaches. These points were located on stable structures that should have no net change vertically from year to year such as parking lots, roads, seawalls and jetties. The values from the DoD for each time period were extracted to the points, and Root Mean Square Error (RMSE) was calculated. The results are presented below:

| 2011-ARRA | arra-2010 | 2010-2007 | 2007-2000 | |
|---|---|---|---|---|
| 0.25 | 0.21 | 0.31 | 0.42 | All |
| 0.35 | 0.25 | 0.42 | 0.57 | High Slope |
| 0.06 | 0.16 | 0.15 | 0.15 | Low Slope |

Alternatively, the average for all values are reported below:

| 2011-ARRA | arra-2010-2 | 2010-2007-2 | 2007-2000-2 | |
|---|---|---|---|---|
| -0.04 | 0.07 | -0.07 | -0.08 | All |
| -0.08 | 0.02 | -0.03 | -0.14 | High Slope |
| 0.01 | 0.13 | -0.12 | -0.02 | Low Slope |

An additional metric was used, rather than just point metrics, I drew polygons around all the built structures such as seawalls and jetties in the area of beaches. Zonal statistics were run on the DoDs for each time step using the individual structures as zones. The mean value for each polygon was used and the mean value for all those is summarized below:

| 2011-ARRA | ARRA-2010 | 2010-2007 | 2007-2000 | |
|---|---|---|---|---|
| -0.06 | 0.03 | 0.35 | -0.04 | AVG |
| 0.12 | 0.28 | 0.98 | 0.25 | RMSE |