Coastal Change Analysis

This program involved developing a number of components that the City can use to better understand and manage its coastal resources. In particular, we are providing an estimate of coastal bluff erosion based on a series of aerial surveys, a description of the salt marsh plant communities and their extent within the city, and a survey of beach habitats. This work was done at the Kachemak Bay Research Reserve. Questions about the work should be addressed to:
Steve Biard or Scott Pegau
Kachemak Bay Research Reserve
95 Sterling Hwy, Suite 2
Homer, Alaska 99603
907-226-4655

Shoreline map
The shoreline mapping effort was conducted using standard techniques (Kaminsky et al. 1999, Moore 2000, Moore and Griggs 2002, Ruggeiero et al. 2003). The map of coastal erosion rates (Figure 1) was developed by mapping the bluff edge on aerial maps collected in 1951, 1961, 1968, 1975, 1996, and 2003. We recently received imagery from 1984 and will incorporate that data into this project and deliver the updated project to the city at a later date. Each set of images was rectified with an emphasis on points above the shoreline bluff and below the large bluffs north of the city. The images were initially rectified to common features with those found in the 1996 images to provide a rough rectification. A more precise rectification was accomplished by sequentially rectifying it set of images, i.e. 1975 was rectified to 1996 and 1968 rectified to 1975. This sequential approach allowed more features common to each image set to be identified and used in the rectification. For those portions of the coast with a bluff we drew a line at the top edge of the shoreline bluff. This feature was used because there is less error caused by the angle that the picture was taken and any skewing of the picture caused by the rectification process. In many cases the top edge of the bluff was evident by the change in vegetation. In some cases the growth of alders obscured the bluff edge and may create apparent accretion on the bluff. Slumps that moved large section of the bluff closer to the sea also created areas with apparent accretion. In areas without a bluff, a vegetation, wrack (debris), or change in sediment type line was followed. Such areas include Bishop's Beach, Mariner Park, and the Spit. Our level of confidence in the placement of our coastline in these areas is lower. We believe that the error in the placement of the bluff line is approximately 2 m. For the erosion estimates from 1951 to 2003 this gives an error in erosion of <0.1 m/yr.

In general, slightly higher erosion rates were observed west of the spit (~0.8 m/yr) than on the eastern side (~0.6 m/yr). The western portion of headlands had the highest observed erosion rates (>6m/yr), but the high erosion rates are extremely episodic. A notable exception to this pattern is Munson point where the high erosion rates were observed east of the headland. We believe the section with low erosion along Munson point is a result of our following the bluff edge. A gravel bar that has been eroding at a fairly high rate protected this section. Very few sections of the bluff were found to have little or no erosion. Most of these sections are protected by mudflats or gravel bars at the base of the Spit. A region of uncharacteristically high erosion exists below West Hill Road. In this area there appears to be an old slump that has been more susceptible to erosion.

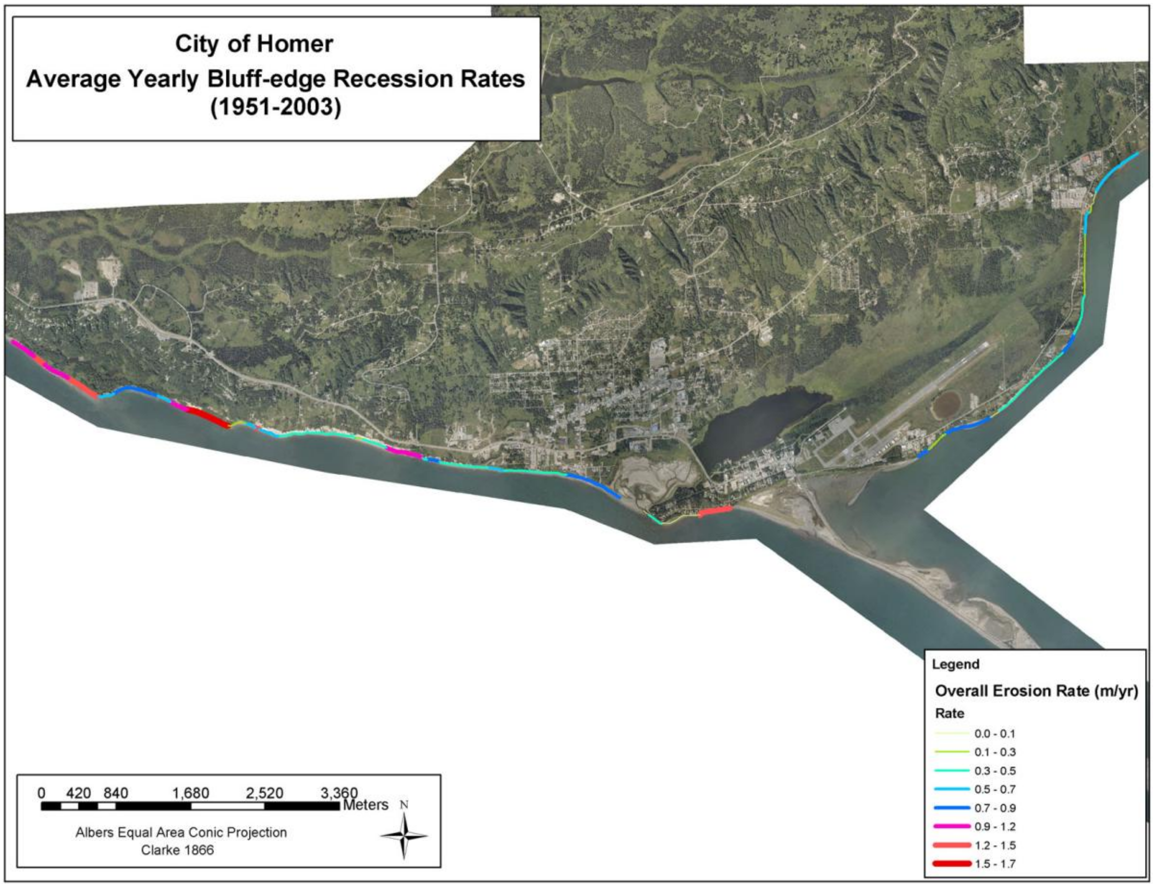


Figure 1. Overall bluff erosion rates from 1951-2003. Few areas have not experienced significant erosion.

Products delivered include a GIS project containing the mosaic of rectified images and a derived coastline for each aerial survey. The map of coastal erosion rates (Fig. 1) and a spreadsheet of estimated erosion between sets of imagery and the overall erosion rate (Tables 1-3) have been provided. A PowerPoint presentation has been developed based on the results of this project. The presentation has been shown in KBRR's exhibit area at the Alaska Islands and Ocean Visitors Center in Homer, Alaska. The presentation includes the overall erosion rate and then focuses on eight areas of interests (Fig. 2). At each area of interest we focus in on a small area of the coastline and cycle through the aerial images. To provide a reference point the 1951 coastline is provided on each image (Fig. 3). At the end of each sequence a summary slide with all of the coastlines is provided (Fig. 4).

Table 1. Average erosion rates between images

Time Period	Ave. Yearly Erosion Rate (m/yr)
51-61	1.04
61-68	0.78
68-75	1.49
75-96	0.46
96-03	0.57

Table 2. Overall erosion per section

ID	Total displacement	Total rate	Lat (NAD27)	Lon (NAD27)
1	78.360	1.5	59.6503080	-151.6425139
2	57.100	1.1	59.6421547	-151.5754115
3	41.719	0.8	59.6391634	-151.5419007
4	86.118	1.7	59.6352523	-151.5147861
5	67.275	1.3	59.6174636	-151.4531566
6	22.380	0.4	59.6448860	-151.4570525
7	34.687	0.7	59.6640277	-151.4384704
8	59.429	1.1	59.6547301	-151.6538967
9	60.957	1.2	59.6523189	-151.6483554
10	36.029	0.7	59.6500794	-151.6327493
11	44.775	0.9	59.6494840	-151.6285536
12	49.695	1.0	59.6483004	-151.6220217
13	86.165	1.7	59.6462498	-151.6154893
14	33.087	0.6	59.6456247	-151.6075339
15	33.504	0.6	59.6451177	-151.6028825
16	27.839	0.5	59.6450873	-151.5951691
17	16.244	0.3	59.6444312	-151.5865083
18	19.160	0.4	59.6437452	-151.5826237
19	26.428	0.5	59.6413903	-151.5699917
20	22.391	0.4	59.6409243	-151.5642877
21	32.439	0.6	59.6405731	-151.5599893
22	19.557	0.4	59.6400341	-151.5494979
23	39.943	0.8	59.6385368	-151.5394076
24	32.416	0.6	59.6407695	-151.4724899
25	55.578	1.1	59.6429354	-151.4656612
26	20.511	0.4	59.6476347	-151.4506457
27	47.029	0.9	59.6506890	-151.4439671
28	23.974	0.5	59.6545314	-151.4401893
29	17.929	0.3	59.6581897	-151.4395194

30	15.609	0.3	59.6609628	-151.4392637
31	32.054	0.6	59.6669983	-151.4355836
32	29.697	0.6	59.6684698	-151.4326721
33	4.942	0.1	59.6355740	-151.5287780
34	25.303	0.5	59.6345869	-151.5271526

Table 3. Erosion rates calculated for segments along the coastline.

ID	Years	Length (m)	Number of Years	Rate (m/yr)
1	51-61	0.682	10	0.1
1	61-68	14.788	7	2.1
1	68-75	43.461	7	6.2
1	75-96	19.279	21	0.9
1	96-03	0.150	7	0.0
2	51-61	14.724	10	1.5
2	61-68	13.652	7	2.0
2	68-75	13.145	7	1.9
2	75-96	15.326	21	0.7
2	96-03	0.253	7	0.0
3	51-61	11.428	10	1.1
3	61-68	3.856	7	0.6
3	68-75	5.095	7	0.7
3	75-96	18.929	21	0.9
3	96-03	2.411	7	0.3
4	51-61	4.663	10	0.5
4	61-68	19.623	7	2.8
4	68-75	16.185	7	2.3
4	75-96	37.040	21	1.8
4	96-03	8.607	7	1.2
5	51-61	6.911	10	0.7
5	61-68	0.805	7	0.1
5	68-96	36.504	28	1.3
5	96-03	23.055	7	3.3
6	51-68	9.114	10	0.9
6	68-75	8.419	7	0.6
6	75-96	2.338	21	0.1
6	96-03	2.509	7	0.4
7	51-61	9.654	10	1.0
7	61-68	4.827	7	0.7
7	68-75	0.485	7	0.1
7	75-96	15.252	21	0.7
7	96-03	4.469	7	0.6
8	51-61	4.051	10	0.4
8	61-68	3.177	7	0.5
8	68-75	44.976	7	6.4
8	75-96	3.830	21	0.2
8	96-03	3.395	7	0.5

9	51-61	6.210	10	0.6
9	61-68	7.028	7	1.0
9	68-75	31.875	7	4.6
9	75-96	8.553	21	0.4
9	96-03	7.291	7	1.0
10	51-61	5.890	10	0.6
10	61-68	5.595	7	0.8
10	68-75	13.203	7	1.9
10	75-96	8.904	21	0.4
10	96-03	2.437	7	0.3
11	51-61	19.673	10	2.0
11	61-68	5.083	7	0.7
11	68-75	12.922	7	1.8
11	75-96	6.847	21	0.3
11	96-03	0.250	7	0.0
12	51-61	22.970	10	2.3
12	61-68	2.469	7	0.4
12	68-75	8.585	7	1.2
12	75-03	15.671	28	0.6
13	51-61	27.380	10	2.7
13	61-68	3.697	7	0.5
13	68-75	27.540	7	3.9
13	75-96	27.064	21	1.3
13	96-03	0.484	7	0.1
14	51-61	15.288	10	1.5
14	61-68	9.031	7	1.3
14	68-96	2.103	28	0.1
14	96-03	6.665	7	1.0
15	51-61	20.891	10	2.1
15	61-68	1.627	7	0.2
15	68-75	4.229	7	0.6
15	75-96	0.558	21	0.0
15	96-03	6.199	7	0.9
16	51-61	0.778	10	0.1
16	61-68	6.246	7	0.9
16	68-75	2.443	7	0.3
16	75-96	0.609	21	0.0
16	96-03	17.763	7	2.5
17	51-61	1.276	10	0.1
17	61-68	0.612	7	0.1
17	68-75	7.783	7	1.1
17	75-96	5.434	21	0.3
17	96-03	1.139	7	0.2
18	51-61	4.622	10	0.5
18	61-68	1.769	7	0.3
18	68-75	6.453	7	0.9
18	75-96	4.568	21	0.2

18 96-03	1.748	7	0.2
19 51-61	5.154	10	0.5
19 61-68	7.555	7	1.1
19 68-75	1.600	7	0.2
19 75-96	7.807	21	0.4
19 96-03	4.312	7	0.6
20 51-61	5.360	10	0.5
20 61-68	1.336	7	0.2
20 68-75	2.577	7	0.4
20 75-96	9.603	21	0.5
20 96-03	3.515	7	0.5
21 51-61	11.408	10	1.1
21 61-68	3.560	7	0.5
21 68-75	3.214	7	0.5
21 75-96	13.120	21	0.6
21 96-03	1.137	7	0.2
22 51-61	4.459	10	0.4
22 61-68	1.116	7	0.2
22 68-75	4.730	7	0.7
22 75-96	8.601	21	0.4
22 96-03	0.651	7	0.1
23 51-61	26.590	10	2.7
23 61-68	1.195	7	0.2
23 68-75	0.626	7	0.1
23 75-96	10.825	21	0.5
23 96-03	0.707	7	0.1
24 51-61	12.070	10	1.2
24 61-68	8.997	7	1.3
24 68-75	3.339	7	0.5
24 75-03	8.010	28	0.3
25 51-61	31.303	10	3.1
25 61-75	6.595	14	0.5
25 75-96	16.140	21	0.8
25 96-03	1.540	7	0.2
26 51-61	7.290	10	0.7
26 61-68	0.221	7	0.0
26 68-75	0.180	7	0.0
26 75-96	6.969	21	0.3
26 96-03	5.851	7	0.8
27 51-61	14.763	10	1.5
27 61-68	6.853	7	1.0
27 68-75	8.392	7	1.2
27 75-96	9.072	21	0.4
27 96-03	7.949	7	1.1
28 51-61	2.581	10	0.3
28 61-68	2.642	7	0.4
28 68-75	14.339	7	2.0

28	75-96	2.582	21	0.1
28	96-03	1.830	7	0.3
29	51-61	1.012	10	0.1
29	61-68	10.920	7	1.6
29	68-75	2.480	7	0.4
29	75-96	2.074	21	0.1
29	96-03	1.443	7	0.2
30	51-61	6.091	10	0.6
30	61-75	1.079	14	0.1
30	75-96	6.356	21	0.3
30	96-03	2.083	7	0.3
31	51-61	14.758	10	1.5
31	61-68	3.880	7	0.6
31	68-75	3.314	7	0.5
31	75-96	5.842	21	0.3
31	96-03	4.260	7	0.6
32	51-61	7.138	10	0.7
32	61-68	7.779	7	1.1
32	68-75	5.601	7	0.8
32	75-96	7.254	21	0.3
32	96-03	1.925	7	0.3
33	51-61	1.856	10	0.2
33	61-68	1.402	7	0.2
33	68-96	0.366	28	0.0
33	96-03	1.318	7	0.2
34	51-61	14.211	10	1.4
34	61-75	8.881	14	0.6
34	75-96	0.730	21	0.0
34	96-03	1.481	7	0.2

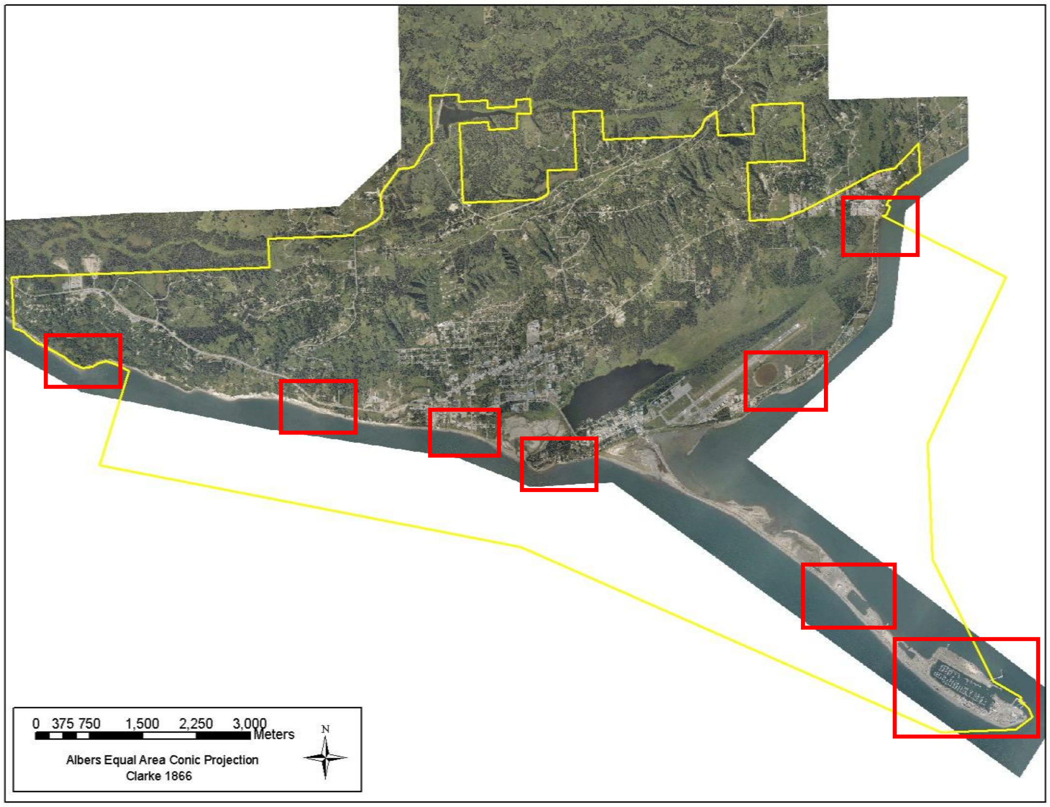
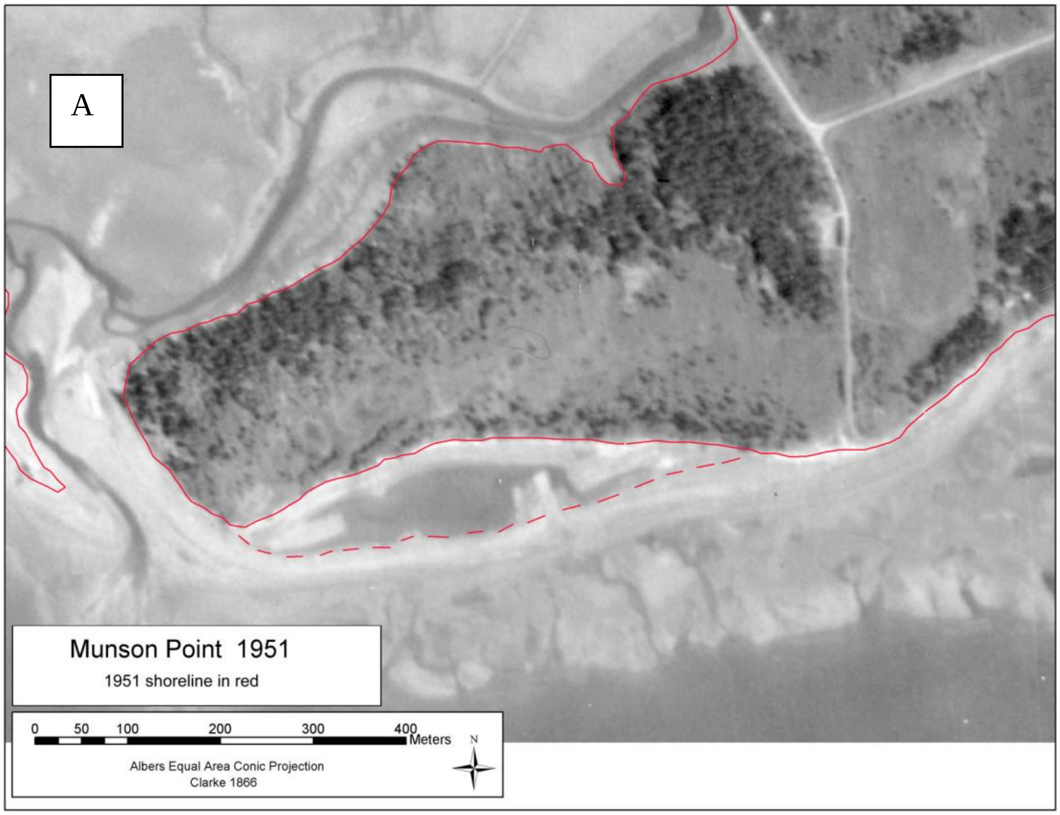
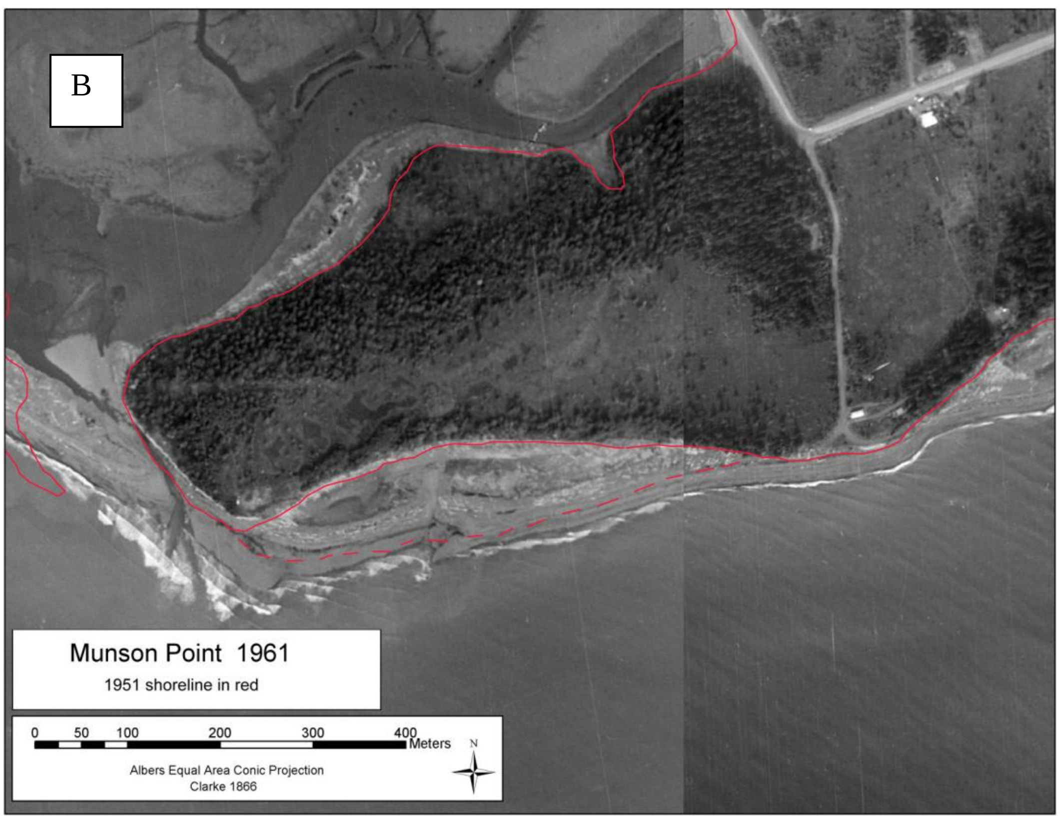
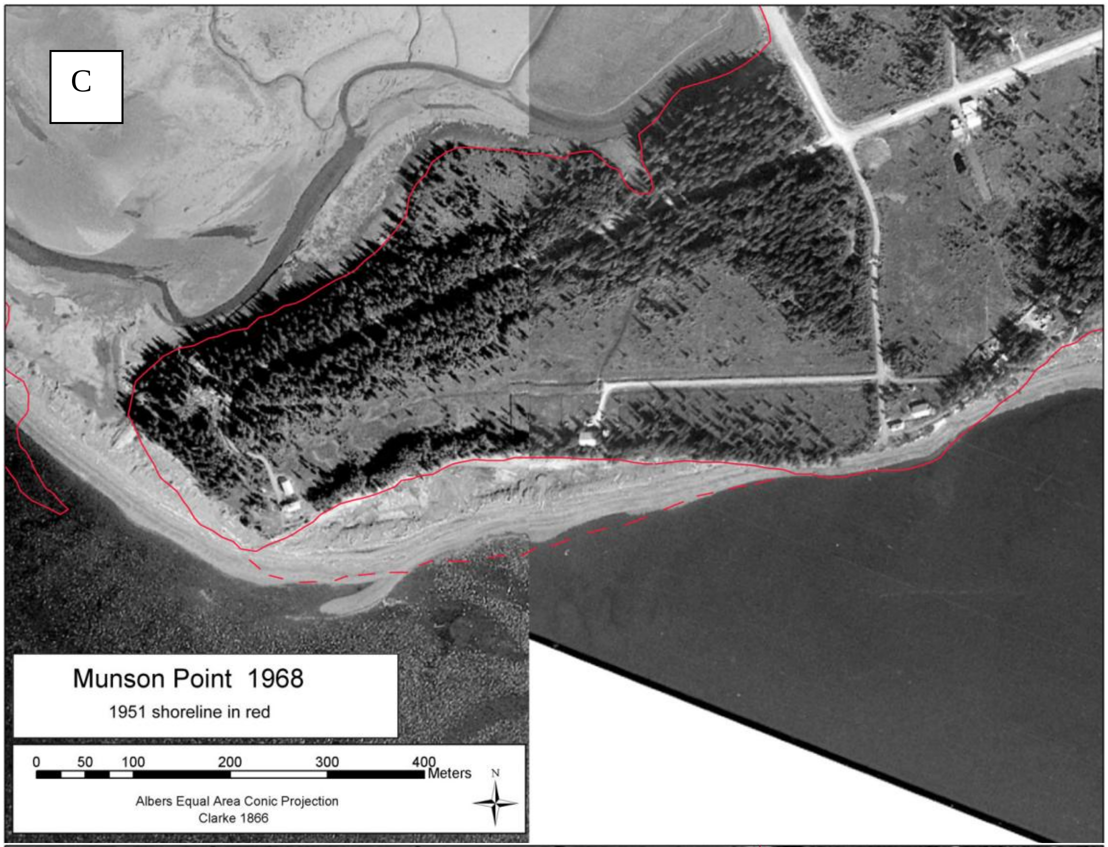
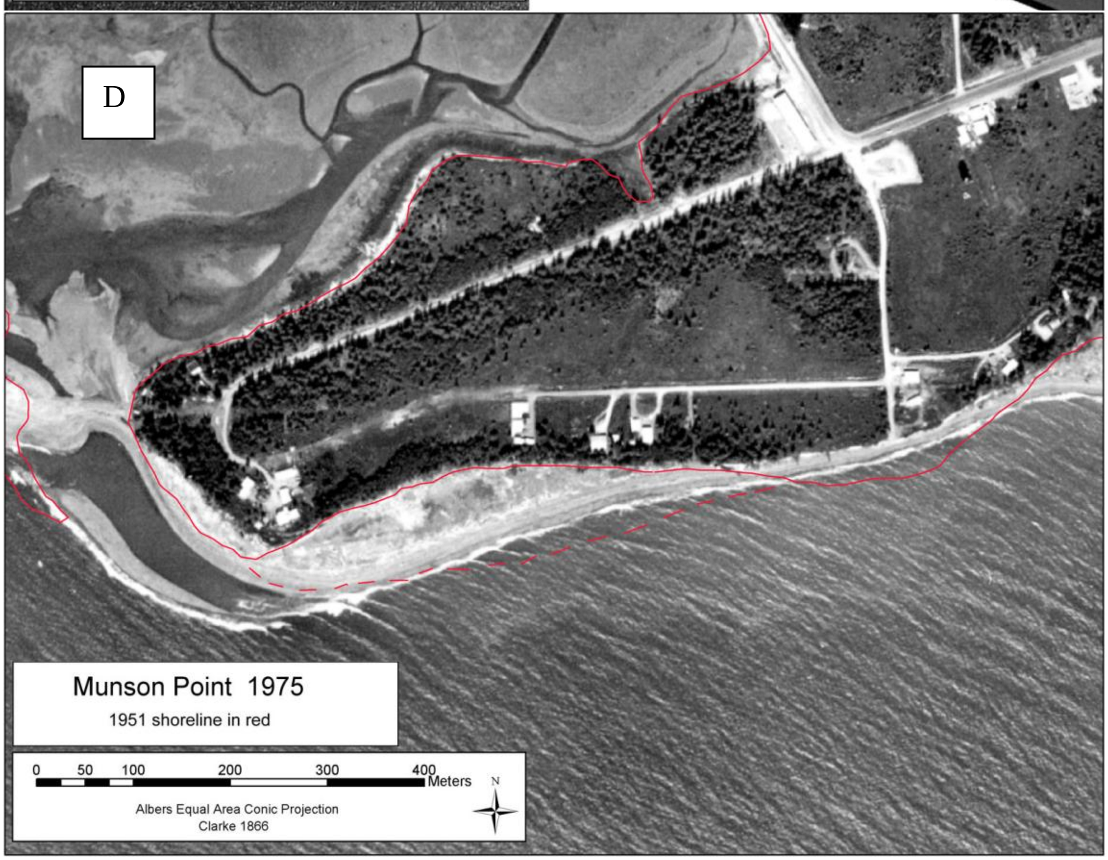


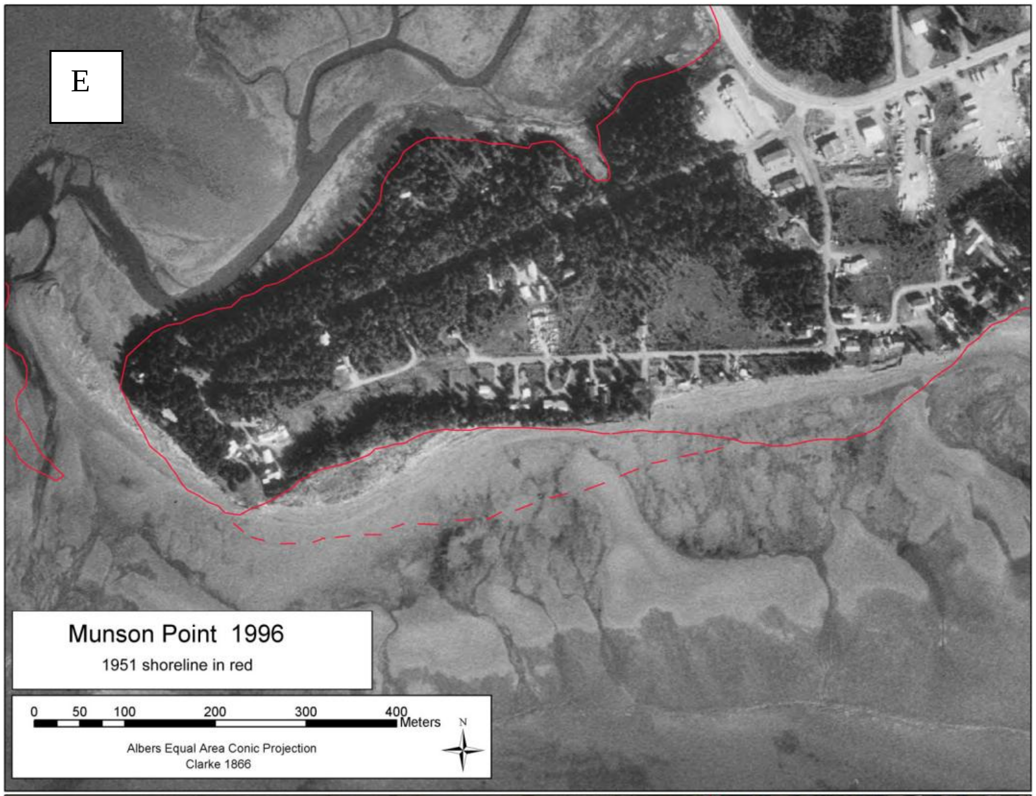
Figure 2. Focus area's highlighted in the PowerPoint presentation. The two areas on the Homer Spit are highlighted to observe use changes rather than erosional changes.


A
Munson Point 1951
1951 shoreline in red
0 50 100 200 300 400 Meters
N
Albers Equal Area Conic Projection
Clarke 1866


B
Munson Point 1961
1951 shoreline in red
0 50 100 200 300 400 Meters
N
Albers Equal Area Conic Projection
Clarke 1866


C
Munson Point 1968
1951 shoreline in red
0 50 100 200 300 400 Meters
N
Albers Equal Area Conic Projection
Clarke 1866


D
Munson Point 1975
1951 shoreline in red
0 50 100 200 300 400 Meters
N
Albers Equal Area Conic Projection
Clarke 1866



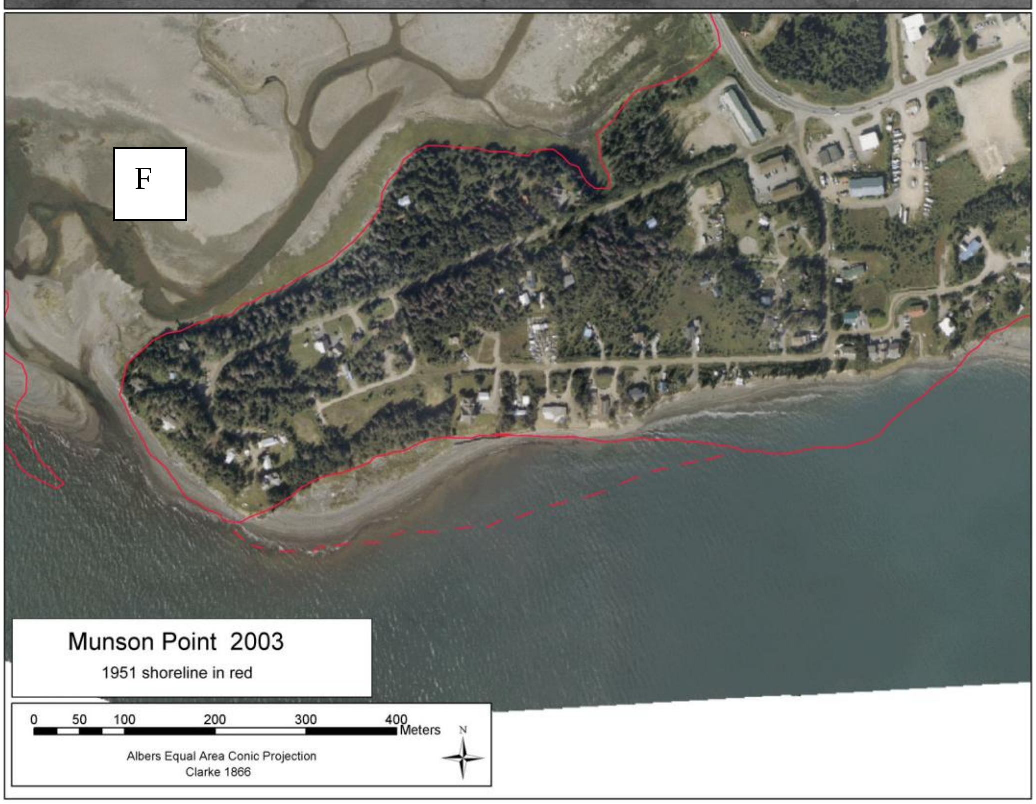


Figure 3 a-f. Munson Point focus area from a PowerPoint presentation of the work. The dotted line is an estimation of the beach line and the solid line is an estimation of the bluff line from the 1951 imagery.

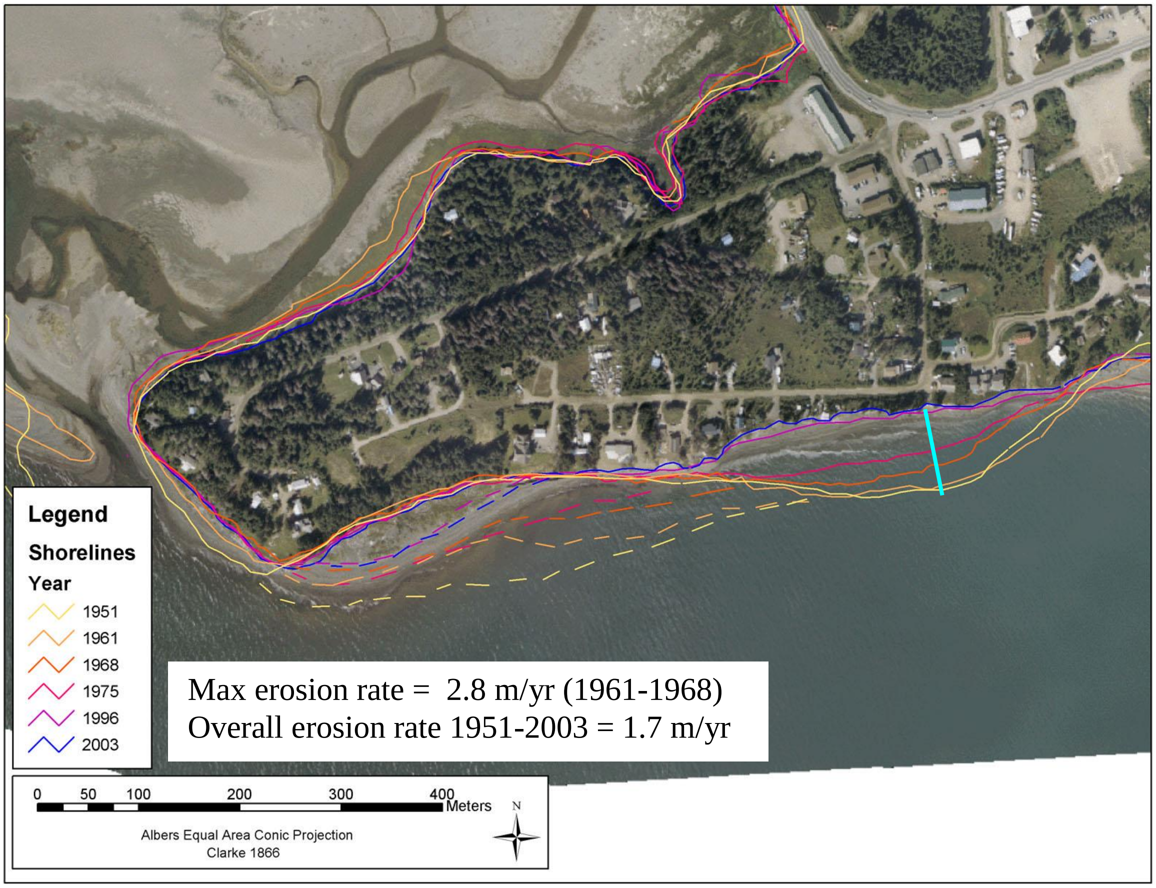


Figure 4. Summary slide for the Munson Point focus area.

Intertidal Habitat Map

We implemented a habitat mapping method developed in Alaska by Carl Schoch that partitions complex shorelines into physically homogeneous segments. Groups of physically similar segments can then be aggregated into groups of replicates that allow more rigorous monitoring of the marine environment. This method has been successfully applied to shorelines in Kenai Fjords, Lake Clark (Schoch and Chen, 1995; Schoch, 1996), and Katmai (Schoch 1994). The Homer section of the map is part of a larger effort to map the intertidal zone of Kachemak Bay. The method included identifying along-shore segments with uniform physical characteristics, mapping these segments onto an aerial photograph, photographing the segment, and logging physical and biological characteristics of each segment. The segment lines were incorporated into a GIS project that also included a high and low water line. The photographs were linked to the segments in the GIS project. The data was inputted into a Microsoft Access database, and the database was linked to the GIS project. The resulting project allows users to rapidly identify like habitats within Kachemak Bay and provides a tool to assess future habitat changes.

Homogeneous alongshore segments (10-100 meters in length) were delineated and the physical component of the habitat characterized by using indices of geophysical variables (Table 4) within each of four intertidal zones. Indices of the presence of common biological communities (Table 5) within each intertidal zone were also logged. The four intertidal zones were low, low-mid, high-mid, and high with Mean Lower Low water as the bottom of the low zone. Mapping occurred during times with a tide of plus two feet or lower. Each alongshore segment was marked on aerial photographs of the beach, and later the segments were incorporated into a GIS project. Photographs of each segment were taken. For much of the survey, additional photographs were taken of the substrate within each zone. The geophysical and biological data were entered into an Access database. The database and segment photographs were incorporated into a GIS project.

A high-resolution aerial survey conducted in 1996 was used to provide photographs of the coastline of Kachemak Bay. The photographs were orthorectified to overlay the USGS topographic map of Kachemak Bay. A mosaic of several photos was used to provide full coverage of the Bay. Based on features within overlapping areas of the photos we determined that the mean difference in position between images was 6.26 m. The final mapping resolution of the product was 1:5000. These are the same images that were used for the coastal change portion of this project.

On top of the image mosaic we drew low and high water lines. The low water line was initially derived from the USGS topographic maps, which were traced at a 1:10000 scale. This low water line was modified using stereoscopic aerial photographs and the orthorectified images, both of which were collected at low tide. Modifications were only made when the images showed that the low water line was further into the bay than the topographic maps. Polygons were drawn around any object that was larger than 10 pixels in any dimension. For smaller objects points were drawn. The low water line was further modified using the Shore zone aerial video footage. This was especially important in areas where there was heavy shading in the other aerial photographs, such as in Sadie Cove. The high-water line was drawn based on the aerial photographs. The primary reference was the vegetation or beach wrack lines. These lines are highly subjective and should not be considered the true high tide line. As with the low-water line the high-water line was modified using the Shore zone aerial video footage by using the wrack line and storm berms to help guide positioning. The Shore zone footage was also used to locate shoreline alterations and a separate shape file that delineates these modifications was added to the project.

As described earlier, segment lines were drawn on field copies of the aerial photographs and pictures were taken of each segment. The segment lines were then drawn in the GIS project between the high and low water lines. A photo point was added in each segment. The segment photo and data can be obtained by clicking on the photo point.

Generally to the west of the Homer Spit the intertidal habitat is very dynamic. Sand waves propagate towards the end of the spit. The movement of the sand will cause areas to shift from a cobble habitat to a sand habitat in a short period of time. This dynamic nature makes it difficult for biological communities to develop. East of the Homer Spit the intertidal area is less dynamic allowing more stable biological communities to develop.

Delivered to the City was the GIS project with shorelines and segment lines drawn (Fig. 5). Characteristics were provided in an Access database linked to GIS project (Fig. 6). Segment photographs were also provided.

Table 4. Physical characteristics. The scales generally run from least to most. General characteristics apply to the area rather than individual tidal zones. The tidal zones are high (H), high-mid (HM), low-mid (LM), and low (L), with the lower end of the low zone at mean low water.

Characteristic	Scale	Zones
Beach orientation	1-8	General
Net shore drift	1-8	General
Drift exposure	1-5	General
Regional energy regime	1-5	General
Rock type	1-5	General
Debris volume	1-5	General
Energy	1-5	H, HM, LM, L
Slope	1-8	H, HM, LM, L
Dynamism	1,3,5	H, HM, LM, L
Size	1-8	H, HM, LM, L
Roundness	1-5	H, HM, LM, L
Relief	1-5	H
Roughness		HM, LM, L
Use	1-5	H, HM, LM, L

Table 5. Biological characteristics. All biological characteristics are graded as N (none), P (<50%), and C (>50%).

Zone	Biotic characteristic
High	Barnacles, Verrucaria, Fucus, Algae
High-Mid	Barnacles, Mussels, Fucus, Algae
Low-Mid	Barnacles, Mussels, Fucus, Algae
Low	Barnacles, Mussels, Kelp, Algae

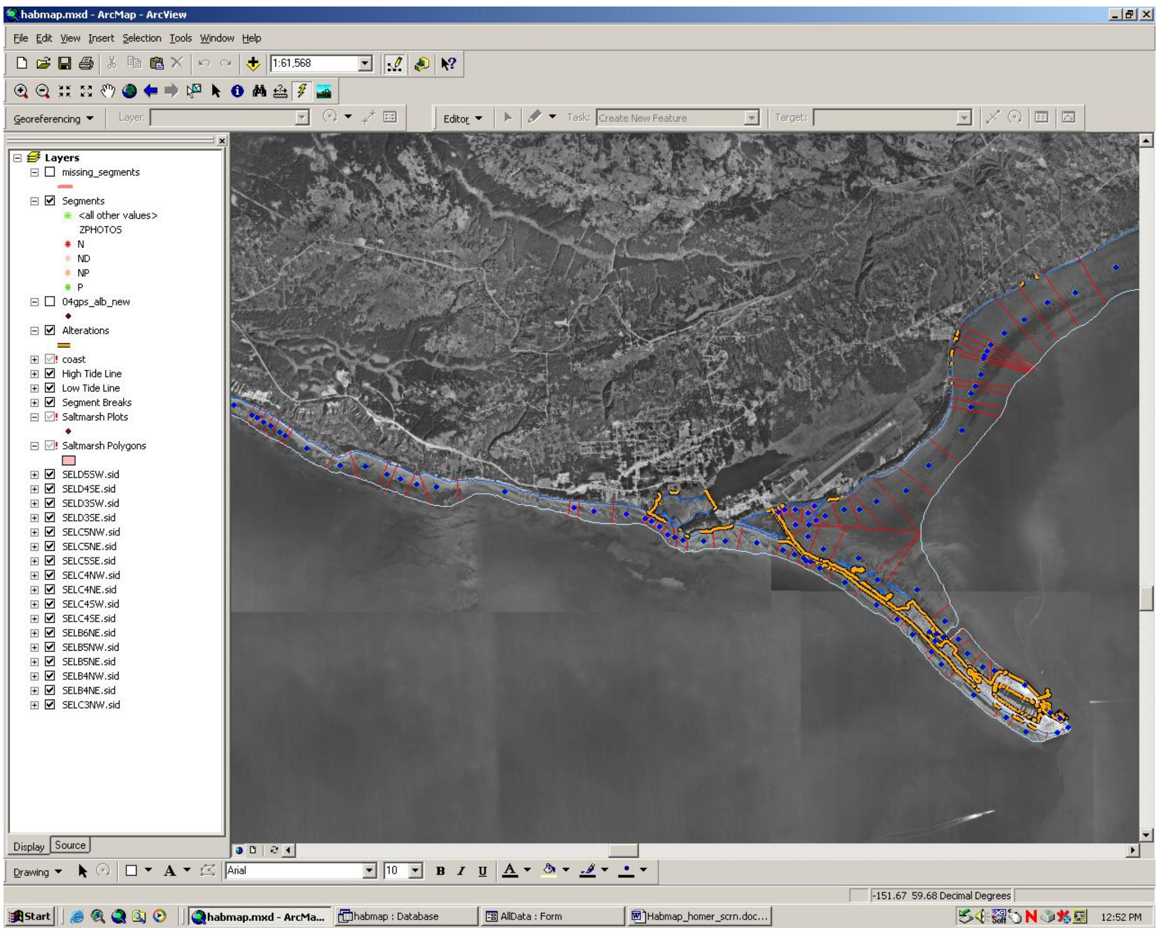


Figure 5. A screen shot of the habitat mapping GIS project. Red lines delineate the segments. The blue dot can be clicked on to provide the data for the segment and links to the photograph. The gold color lines are areas identified to have human modifications.

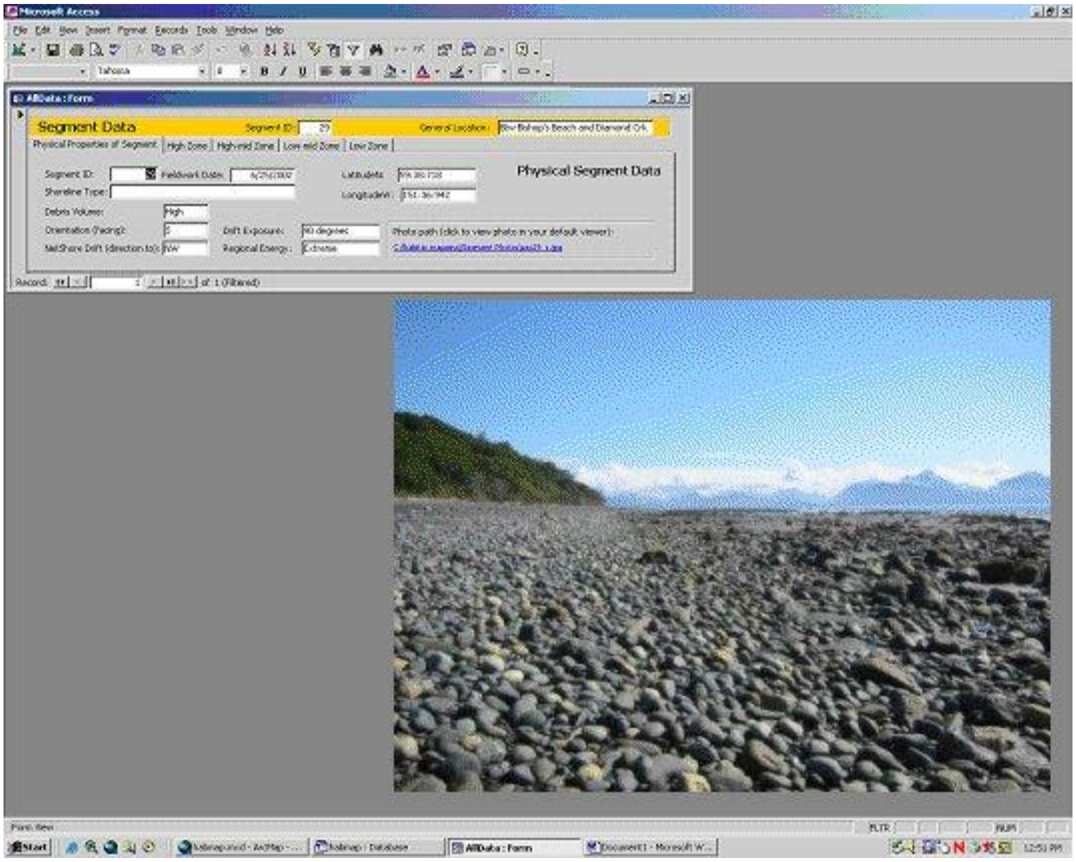


Figure 6. The linked data provides general habitat characteristics and specific characteristics for each of the four tidal zones. Clicking on the link provides the segment photograph.

Salt Marsh Map

Salt marshes within Homer city limits were mapped in a different manner than other portions of the intertidal zone (as described above). This is because the physical substrate is generally covered by vegetation, and subtle changes in elevation and salinity result in a mosaic of habitats, rather than a series of ordered tidal zones along the shore.

Salt marshes were mapped following the methods developed by Gerald Tande for Lake Clark National Park (Tande 1996). Plant communities were first delineated on 1:25,000 scale black and white aerial photographs in stereo pairs. These initial delineations were based on visible differences in plant communities and changes in elevation. Fieldwork included checking the accuracy of the lines produced, and assessing each plant community polygon within each wetland. Vegetation plots were established in at least one polygon representing each unique plant community within every salt marsh. At each vegetation plot, plant species and percent cover were recorded. Notes on human and animal use, site moisture, and vegetative growth form were taken, along with two photos of each plot (one looking across the plant community, and one looking down at the plot).

Plant specimens were collected to produce herbarium specimens and for further identification in the lab, when necessary.

The polygons produced in the initial delineation were refined based on the fieldwork and digitized for incorporation into the final GIS project. Each polygon was assigned a plant community type and linked to representative photos (Figure 7). All plot locations were entered into the GIS project as points. In addition to the GIS project, a proposed protocol for monitoring the salt marshes was also provided (Appendix A), as well as representative herbarium specimens of the most important plant species.

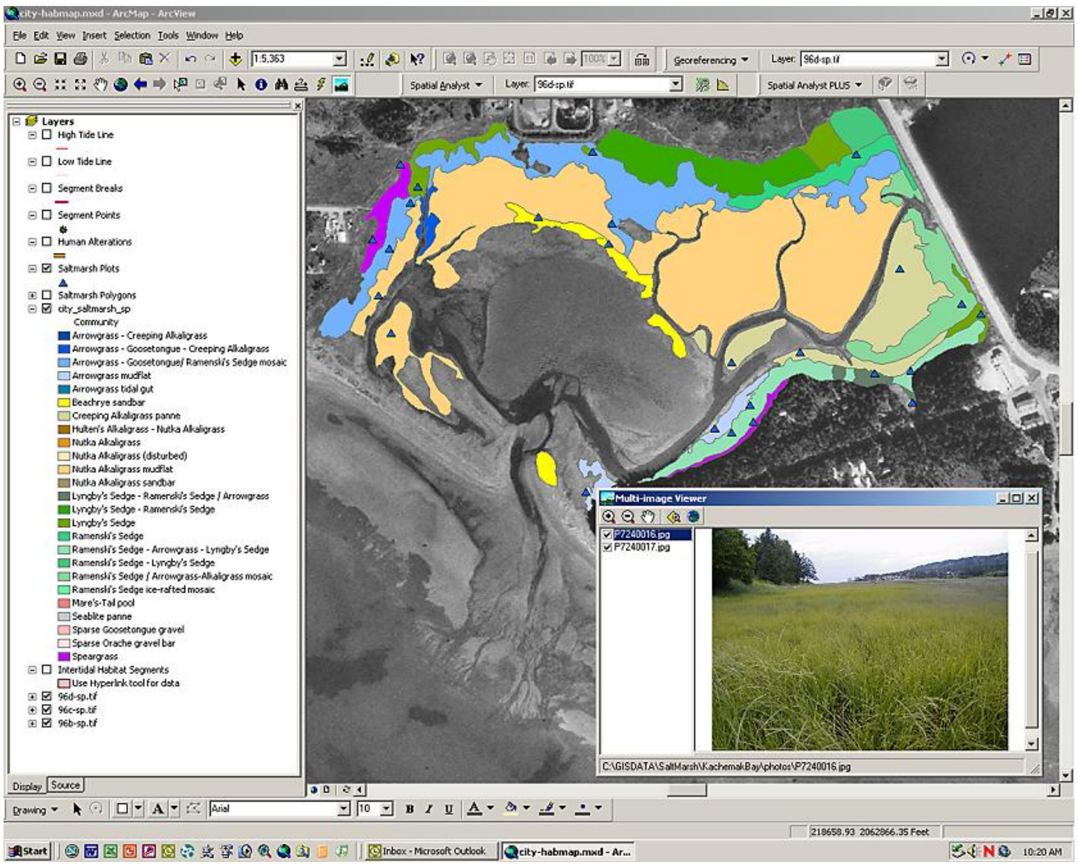


Figure 7. A screen shot of the salt marsh mapping GIS project. The colors correspond to plant community types within each marsh. Photos can be accessed by clicking on the map.

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