PEBBLE PROJECT
ENVIRONMENTAL BASELINE DOCUMENT
2004 through 2008

CHAPTER 36.
MARINE NEARSHORE HABITAT
Cook Inlet Drainages

PREPARED BY:
PENTEC ENVIRONMENTAL/HART CROWSER, INC.

TABLE OF CONTENTS

LIST OF FIGURES

PHOTOGRAPHS

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

Arcuate	extending in an arc or curve
CIRCAC	Cook Inlet Regional Citizens Advisory Council
Colluvium	a loose accumulation of rock and soil at the toe of a slope
EVOS	*Exxon Valdez* Oil Spill Trustee Council
IIE	Iniskin/Iliamna Estuary
MHHW	mean higher high water
MLLW	mean lower low water
NOAA	National Oceanic and Atmospheric Administration
OCSEAP	Outer Continental Shelf Environmental Assessment Program
Sea stack	a vertical rock tower or column, usually with mostly vertical sides, that reaches above the high water line

36. MARINE NEARSHORE HABITAT

36.1 Introduction

Marine shorelines and intertidal habitats in the Iniskin/Iliamna Estuary (IIE) are highly diverse and range from sheltered mudflats to exposed rocky shores and offshore reefs. The mudflats extend over considerable tidal ranges from about mean higher high water (MHHW) to subtidal depths. Rocky habitats range from fractured rubble cobbles and bedrock in fairly sheltered areas to exposed rounded boulders and rocky benches. This chapter provides general descriptions of nearshore habitats in the IIE. Information is drawn from the marine investigators' long history of work in the area and from field observations during the 2004 through 2008 field seasons. More detailed information on specific habitat types sampled in the marine biological programs is provided in Chapter 42.

36.2 Study Objective

The objective of characterizing the marine nearshore habitats is to provide the physical context for descriptions of biological conditions observed in the study area.

36.3 Study Area

The study area for the marine nearshore-habitat study included all marine waters and shorelines in IIE (except inner Cottonwood Bay and inner Iniskin Bay) and including the reach of shoreline between Iniskin and Iliamna bays (Figure 36-1).

36.4 Previous Studies

Little scientific investigation had occurred on the west side of lower Cook Inlet or in the area of the IIE prior to the initiation of the National Oceanic and Atmospheric Administration's (NOAA's) Outer Continental Shelf Environmental Assessment Program (OCSEAP) in the mid-1970s. In 1976, Lees and Houghton (1977), investigators currently involved in the Pebble Project study, conducted an initial reconnaissance of intertidal habitats and their assemblages in Iniskin Bay. This aerial and ground reconnaissance survey on the west side of Lower Cook Inlet in 1976 found that Cottonwood, Iliamna, and Iniskin bays were dominated by mudflats. Cottonwood Bay had boulders scattered across the flats, and Iniskin Bay had finger reefs and rock outcrops along its eastern shore. Bedrock occurred near headlands. In 1978, NOAA established a field camp in Cottonwood Bay that allowed for more intensive, repeated sampling of several aspects of the environment of the IIE. Lees and Houghton continued their studies in the area leading a group of investigators that established several intertidal and subtidal stations within the IIE for further study under OCSEAP. These stations were sampled repeatedly in 1978 (Lees et al., 1980).

Other sites around the IIE for which information is available (Dames & Moore, 1979; Lees and Driskell, 1981; Lees et al. 1980) include a site near Right Arm in Iniskin Bay (intertidal), Cottonwood Bay (subtidal), Turtle Reef off South Head (intertidal and subtidal), Black Reef (subtidal), and Scott Island (subtidal).

During this time period (1978), Lees also led shallow subtidal diving surveys of invertebrate and fish habitats in and north of Kamishak Bay including the IIE (Dames & Moore, 1979; Lees and Driskell, 1981). The shorelines of White Gull Island were surveyed by Lees et al. (1980), who reported predominantly rocky shorelines with pockets of coarse cobble and pebbles, while Dames & Moore (1979) conducted baseline subtidal surveys around the island.

Lees and Houghton returned to the IIE again in 1996 (Pentec, 1996) conducting studies for the Cook Inlet Regional Citizens Advisory Council (CIRCAC). During these investigations, the researchers made notes and took photographs that have contributed to the general understanding of physical habitat conditions in the IIE as described in the following paragraph. More recently, CIRCAC has conducted fairly detailed mapping of the shorelines of Cook Inlet, including the IIE (CIRCAC and EVOS, 2005). They used a standardized aerial survey and photographic approach that has been used throughout the state to document a variety of shoreline characteristics including dominant morphology, sediment type, and vegetation types. Several maps from this database are provided in Appendix 36A. These maps are reproduced with permission from J. Harper, Coastal & Oceans Resources Inc., and with recognition of the financial contributions of CIRCAC and the *Exxon Valdez* Oil Spill Trustee Council (EVOS).

The body of work described above shows that in addition to physical habitat conditions (substrate, slope, elevation, wave and ice exposure), biological features and especially vegetation contribute to the structure and function of intertidal biological assemblages. Lees and Houghton (1977) reported that diatom films, algae, and patches of eelgrass were common on the mudflats of the IIE. Algal cover, consisting mostly of ribbon kelp, *Alaria*, and other laminarian kelps (e.g., *Laminaria* spp., now *Saccharina* spp.), was most abundant on rocky or boulder habitats at the headlands and along the western or northern sides of the bays. The strap kelp *Saccharina subsimplex* (reported as *L. groenlandica*) and the red alga *Palmaria hecatensis* (reported as *Rhodymenia palmata*) provided moderate cover on the rocky reefs of outer Iniskin Bay and around Knoll Head. As noted above, the CIRCAC and EVOS (2005) mapping include key vegetation characteristics, such as eelgrass and kelp, which are important determinants of habitat function.

36.5 Scope of Work

The scope of work for characterization of marine habitats for the Pebble Project draws on existing information, personal experience of the investigators, and observations made during marine biological field work conducted from 2004 through 2008 to provide a general level of characterization of marine habitats in the IIE.

36.6 Methods

A thorough search was made of literature related to the natural environment of Cook Inlet, with emphasis on the lower west side of the inlet. Information sources included the University of Alaska library system and reports from the OCSEAP under which a substantial body of data was collected during the 1970s and early 1980s. Additional information on Cook Inlet's physical and biological conditions was located in work sponsored by CIRCAC, the National Park Service, and others. Work funded by oil companies in the deeper portions of the lower inlet (e.g., Houghton et al., 1980; Lees and Houghton, 1980) also was reviewed.

In the 2004 through 2008 marine field surveys, observations of habitat features were recorded in waterproof field notebooks and were further documented qualitatively with photographs on many occasions. In August 2004, two of the marine study biologists took a float plane reconnaissance flight up Iniskin Bay and down Iliamna Bay. In July 2005, a field crew surveyed the shoreline by skiff from the west side of outer Iniskin Bay, around Knoll Head, and through Iliamna Bay north to Williamsport. The shoreline from Williamsport south along the west side to Diamond Point could not be accessed on the survey day because of low tides. Coordinates offshore of each major transition in shoreline type were recorded using a global positioning system (GPS) to ground truth the CIRCAC shoreline data (CIRCAC and EVOS, 2005) and to allow independent mapping of shoreline habitat types (Figure 36-2). Other marine habitat observations were made in conjunction with field work on other program elements that occurred in August 2004; May through August 2005; April, May, and September 2006; September and October 2007; and May through November 2008. In general, the skiff-based mapping, with repeated observations during subsequent field work provides a greater level of detail on habitat conditions than the more geographically extensive maps from the CIRCAC aerial surveys.

Sediment grain-size data from sampling in conjunction with the marine biological program are provided in Chapter 42.

36.7 Results and Discussion

The following discussion describes shore types and habitats in the IIE (Figure 36-1). Geographically, this description begins with the reefs and small islands south of Scott Island, proceeds counterclockwise around Iniskin Bay, crosses Knoll Head to North Head, and then moves counterclockwise around Iliamna Bay, to Diamond Point and the northeast side of Cottonwood Bay, crossing the mouth of Cottonwood Bay and continuing on to South Head (Figures 36-1 and 36-2). A limited amount of subtidal habitat information was available from earlier studies (e.g., Lees et al., 1980) and from diving conducted in 2004 and 2008 (Chapter 42).

36.7.1 Scott Island and Surrounding Reefs and Islets

Iniskin, Vert, and Scott Island are the largest of several islands and shoals guarding the center and east side of the entrance to Iniskin Bay (Figure 36-1). Iniskin and Vert are smaller islands south of Scott Island and are surrounded by flat to gently sloping reefs. Iniskin Island is the larger and farthest offshore of the two. The top of Iniskin Island is flat and well vegetated with maritime grasses and herbaceous species. A reef on the northeast side of the island slopes gently to the southeast and was only sparsely vegetated in spring 2008 (Photo 36-1); it appeared to have been polished by winter ice moving south along the western shore of Cook Inlet. In contrast, the sheltered reef to the north and west of Iniskin Island was well vegetated with a variety of kelp and red algae. Vert Island is slightly smaller than Iniskin Island, but includes several nearby islets and shoals. The reef surrounding Vert Island is flatter than that around Iniskin Island and was well vegetated, especially with red algae, during spring 2008 (*Palmaria* spp; Photo 36-2).

Scott Island is heavily wooded and is mostly surrounded by steep cliffs that extend down to the intertidal zone (Photo 36-3). The island's shorelines are mostly conglomerate bedrock, although small pockets of cobble/gravel beach are found. The south side of Scott Island is generally rocky (Photo 36-4; Appendix 36A, Figure 36A-1), although small pockets of coarse pebble/granule sediment are also present. Scott

Island is surrounded by a complex of reefs and islets, including the appropriately named Mushroom Islets to the west (Photo 36-5). These features partially protect the island and surrounding deeper water areas from oceanic swells crossing Cook Inlet, especially at low tide.

36.7.2 Iniskin Bay

Rocky cliffs at the foot of Mount Pomeroy border the east side of the entrance to Iniskin Bay (Photo 36-5). A moderately sized (approximately 200 meters long) southwest-facing pebble beach, called Blackie Beach by Lees and Houghton (1977) and in this document, is bounded by a forested peninsula of sloping conglomerate rock that juts to the southwest into the bay (Photo 36-6). This peninsula drops down to an intertidal rocky point extending several hundred meters farther to the west (called Blackie Reef by Lees and Houghton, 1977). South of this point and beginning at about mean lower low water (MLLW) on Blackie Beach lies a broad silty sand flat that at times supports multiple patches of eelgrass (*Zostera marina*) near the base of the steeper upper beach and laminarian kelp and other algae farther offshore where cobbles or boulders provide attachment (Photo 36-7).

North of Blackie Reef, Iniskin Bay is generally shallow, sloping gradually up to a steeper upper beach that begins at about +4 to +6 feet MLLW. Above this beach (Fossil Beach), low sedimentary cliffs contain a variety of fossil mollusks. The shallow east-central part of the bay is divided by a large reef, called Fossil Reef (Photo 36-8), which extends approximately a quarter of the way across the bay. Beyond this reef to the north, the lower intertidal shoreline and subtidal bottom of the bay are predominantly silty sand with occasional bedrock reefs or glacial erratic boulders. Long pebble beaches cover much of the upper shoreline north to Right Arm. CIRCAC and EVOS (2005) classified shorelines of this area as a sediment (sand) morphological type (Appendix 36A, Figures 36A-1 and 36A-5).

A broad sand/mudflat characterizes Right Arm, the area north of Right Arm, and the inner three-quarters of the western shore of Iniskin Bay (Photo 36-9). A meandering drainage channel conveys the Iniskin River and other drainages at low tide. On the west side of the bay, this flat meets the mountainside across a combination of cliffs and upper rubble beaches at an elevation that gradually drops toward the mouth of the bay. Near marine sampling station MPS2 (Photo 36-10), approximately 1 kilometer north of the west entrance to the bay (Figure 36-2), the transition from rubble to sandy/mudflat occurs at about +2 to +3 feet MLLW.

CIRCAC and EVOS (2005) classified the area around MPS2 as having rock-and-sediment morphology similar to that near MPS1 (Appendix 36A, Figures 36A-1 and 36A-3; see Section 36.7.3). While the upper shoreline is a near-vertical cliff (Photo 36-11) similar to that at MPS1, the habitat provided by the entire intertidal zone is actually very different from that at MPS1. Like MPS1, the upper beach near MPS2 is a rock cliff, at the top of which a steep slope ascends the east side of Knoll Head. However, the toe of the cliff does not extend to MLLW as it does at MPS1. Instead the toe of the cliff is in the upper-to-middle tide range (about +6 to +8 feet MLLW), below which a rocky/shingle beach (e.g., Photo 36-10), no doubt formed by rocks falling from the cliff and mountain above, extends down to the mudflat at about +2 to +3 feet MLLW (Photo 36-11). Cobble- and boulder-sized rocks on the upper beach are angular, indicating relatively little movement by waves.

The CIRCAC and EVOS (2005) mapping shows patchy eelgrass beginning just north of the MPS2 area and continuing north along much of the west side of Iniskin Bay (Appendix 36A, Figure 36A-7). Field

surveys at MPS2 in 2004 through 2008 documented scattered individual eelgrass blades or small patches (1 to 2 meters maximum dimension), but no beds *per se*. Eelgrass presence at a given place in the IIE has been shown to be quite variable over time (e.g., Blackie Beach; Chapter 42).

In 2004 and 2008, limited diving was conducted in the subtidal area in front of MPS2 and at Station MPS1B, to the south. Depths surveyed ranged from about –11 to –34 feet MLLW, and substrate was found to be sand, silt, and gravel throughout.

36.7.3 MPS2 to Y Valley Lagoon

Between marine station MPS2 and Entrance Rock (Figure 36-1), the shoreline consists of a series of fairly steep pebble/cobble beaches delineated by rocky outcrops and offshore rock reefs and sea stacks (Photo 36-12). High wave action on these beaches has rounded the beach pebbles and cobbles. The beaches are backed by near-vertical rock cliffs and numerous natural arches with several waterfalls present during periods of snowmelt or rainfall.

Marine station MPS1 is located on the eastern flank of Knoll Head approximately half way between MPS2 and Entrance Rock. The cliff face southwest of MPS1 is broken by a series of intertidal arches formed in a near-vertical cliff face (Photo 36-13). The terrain at the top of the cliff extends steeply up the side of Knoll Head. Few trees are present and riparian/upland vegetation consists of grasses, forbs, and shrubs. In front of the arches, a bedrock point extends well offshore to form Entrance Rock, with cobble and bedrock beaches to the west.

Station MPS1A (Photos 36-14 and 36-15) lies along the complex rocky shore east of the entrance to a small rock-bound lagoon (known as “Y Valley Lagoon”; Photos 36-16 and 36-17) at the opening to the large valley known as the “Y Valley.” At MPS1A (Photo 36-14), the terrain above the cliff is much more gentle leading into the east side of the Y Valley than on the slopes above the sea cliffs to the east. Copses of spruce (*Picea* spp.) and cottonwood (*Populus balsamifera* ssp. *tricocarpa*) are found where pockets of soil have developed. Sediment, when found within pocket beaches, is composed of predominantly coarse sand and angular gravel or cobbles recently broken or eroded from the cliffs or slopes above (Appendix 36A, Figures 36A-4 through 36A-6).

CIRCAC and EVOS (2005) mapped this shoreline morphology along the entire reach between MPS2 and Y Valley as rock and sediment (Appendix 36A, Figures 36A-3), which reflects the mix of rocky cliffs, outcrops, sea stacks, and reefs interspersed with small areas of sand, gravel, or cobble pocket beaches (Photos 36-14 and 36-15). In keeping with the coarse sediment types, CIRCAC and EVOS (2005) reported no eelgrass in this vicinity (Appendix 36A, Figures 36A-7 and 36A-8), and none has been seen by Pebble Project researchers.

West of MPS1A, the complexity of rocky points, sea stacks, and arches increases near the entrance to the Y Valley lagoon. Sea birds heavily use sea stacks in this area as nesting sites (Photo 36-16). The Y Valley lagoon (Photo 36-17) is well protected from waves and swells by its narrow and sea-stack-studded entrance. Because of this sheltering, the lagoon has areas of a “mixed-soft” sediment type: a mix of sand and cobbles in a silt (mud) matrix; these mixed-soft beaches are interspersed with rocky reefs.

West and south of the Y Valley lagoon, the primary stream draining the Y Valley enters the marine environment after passing through a perched semi-tidal lagoon that can be entered by skiff on the highest

tides. Otherwise, the shoreline to the southwest is much the same as that to the east: a mix of near vertical rock, offshore reefs and shoals, and an occasional cobble pocket beach (Photo 36-18). Biota on these rock faces is much impoverished compared to other areas of comparable substrate and elevation and is composed of early successional species over large portions of the shoreline. It is presumed that this reflects the abrasive effects of ice scour. The generally steep, rocky shoreline extends around a rocky point under North Head and into the east side of Iliamna Bay.

Lees and Driskell (1981) conducted shallow subtidal diving surveys of invertebrate and fish habitats in and north of Kamishak Bay, including the IIE, in 1978. Off Knoll Head (Y Valley lagoon), they reported smooth bedrock and boulders sloping gently from the mid-intertidal range to a depth of –10 to –22 feet MLLW, where rock was replaced by gravel. In August 2004, diving surveys from approximately –11 to –50 feet MLLW off MPS1 encountered a substrate of mixed sand and silt over gravel. A second transect in –15 to –17 feet MLLW encountered primarily gravel. Each of these surveys was looking at a slightly different area, indicating the high variability in substrate along this piece of shoreline.

36.7.4 Iliamna Bay

CIRCAC and EVOS (2005) mapped the area from the base of North Head and around past marine station MPS4 as including a sediment geomorphic type flanked on either side by a rock-and-sediment geomorphology (Appendix 36A, Figure 36A-2). Sediment type at MPS4 was described in the CIRCAC and EVOS maps as sand and gravel (Appendix 36A, Figure 36A-4), but based on recent field observations, it appears to be more complex. On the west side of the small peninsula at the north entrance to Iliamna Bay, the upper beach is a mix of bedrock and broken rock rubble. To the north, the upper elevation in a south-facing bight on the west side of North Head (near MPS4) has an arcuate pocket beach of pebble-sized gravel that is contained to the west by a rocky outcrop (Photo 36-19). The lower beach sediment is a mix of cobbles and boulders in a sand matrix (Photo 36-20). Eelgrass has not been reported here in previous studies (Appendix 36A, Figure 36A-8) and was not seen during the Pebble Project research.

Divers surveyed the area off MPS4 in August 2004 and again in July 2008; they encountered a series of large boulders below –8 feet MLLW with increasing amounts of sand bottom down to –20 feet MLLW.

The entire eastern shore of Iliamna Bay, except for the area near AC Point, lies at the foot of steep mountainsides. The upper beach, like that on the west side of Iniskin Bay (Photo 36-21), is either broken boulders and cobbles fallen from the mountains (coarse colluvium) or steep rock cliffs. Northwest of MPS4, the middle to lower beach consists of a mudflat that broadens to the north. The CIRCAC mapping (CIRCAC and EVOS, 2005) accurately identified this as a sedimentary shoreline morphology, including rock and sediments (Appendix 36A, Figure 36A-2), and a dominant sediment type of sand and gravel (Appendix 36A, Figure 36A-4). Most of the rock has fallen from adjacent mountainsides. Below about MLLW, the bottom becomes increasingly muddy.

AC Point is a spit that has formed a relatively broad, flat gravel bar or bench with approximately 6.5 acres at elevations above the extreme high water line. This upland is vegetated with a mix of upland and riparian colonizing species. The upper shore around AC Point is a steep cobble beach on the west, angling around to finer sediments on the sheltered north side where a shallow pebble/sand channel leads to a small tidal lagoon that lies within the elevated gravel bench of AC Point (the lagoon occupies

approximately 1.5 acres of the 6.5-acre bench; Photo 36-22). This shallow lagoon (AC Point Lagoon) receives snowmelt and runoff from the adjacent mountainside; at tides above about +13 feet MLLW, the small outlet channel to the north reverses flow, flooding the lagoon with water from the bay. This brackish lagoon is unique in the IIE—it retains approximately 0.5 meters of water depth during low tides and comprises a unique ecological niche. The soft silt bed of the lagoon supports sparse but widespread eelgrass along with several species of algae and abundant seasonal fish. North of this lagoon, a gravel spit connects a small rocky offshore island with the shoreline.

North of a line from AC Point to Diamond Point, a mudflat extends across the entire bay except for a central drainage channel, occasional offshore rocks and reefs, and two rocky islands (Photo 36-23). Relatively few pocket beaches or valley outwash deltas of pebbles and cobbles are present; several of these beaches were sampled in the beach seine program (Chapter 43).

Twin rocky points considerably narrow Iliamna Bay just southeast of Williamsport (Figure 36-1). North of the western rocky point, a channel has been dredged through the mudflat to improve navigation access to the beach at Williamsport (Photo 36-24). This channel and beach constitute the only man-made alterations to the shorelines of the study area. Just south of the western rocky point, a small island rises above the mudflat and shelters inner sand and gravel beaches. Limited amounts of eelgrass are present around the island. Northeast of Williamsport, the inner bay is shallow and strewn with boulders (Photo 36-25).

The west side of Iliamna Bay is much like the east side, with generally angular rubble or rocky upper beaches transitioning to mudflats at middle tidal elevations. Marine sampling station MPS3 is at the base of Diamond Point at the north entrance to Cottonwood Bay from Iliamna Bay. The shoreline here was accurately classified by CIRCAC and EVOS (2005) as rock and sediment (Appendix 36A, Figure 36A-2) and, in that regard, is somewhat similar to the west side of Iniskin Bay. A rather extensive rock buttress projects into the intertidal zone from the base of a high cliff at the face of Diamond Point (Photo 36-26). At the base of this rock habitat, at about –2 feet MLLW, a sand/mud flat extends to the west into Cottonwood Bay and to the north into Iliamna Bay. CIRCAC and EVOS (2005) did not record eelgrass in the immediate area of MPS3 (Appendix 36A, Figure 36A-8); however, substantial patches of eelgrass were identified during the 2004 field survey on the Cottonwood Bay side of Diamond Point.

36.7.5 Outer Cottonwood Bay

West of the steep rocky cliffs of Diamond Point, lies a relatively large gravel outwash plane formed primarily of material from past slides and stream erosion from the mountainside above. The southeast shore of this relatively flat plane is an extended (approximately 0.8 mile long) reach of pebble and sand beach. The western half of this beach is a spit formed by predominant waves from the south and east; a westerly component of winds has formed a smaller spit that hooks back to the north and encloses a sheltered lagoon (Photos 36-27 and 36-28). This lagoon is about 5 acres at high tide, but drains completely at low tide.

West of this outwash plane and lagoon, Cottonwood Bay is a shallow mudflat at low tide. During low tide, a central channel carries the outflow from Cottonwood Creek, and a lesser channel carries outflow from a small unnamed creek on the south side of the bay to the central channel (Photo 36-27).

A smaller lagoon or stream-mouth slough is located just inside the southern entrance to Cottonwood Bay where a small unnamed stream enters the bay behind a substantial gravel bar (Photos 36-27 and 36-29). This bar has been built up by gravel and sand carried into the bay from the outer beaches east and south of the bay entrance. Depending on time of year and creek outflow rate, the portion of this stream behind the gravel bar may or may not retain ponded water during low tide. At high tide, the area floods from the bay.

36.7.6 Mouth of Cottonwood Bay to South Head

The outer Iliamna Bay shoreline south of the entrance to Cottonwood Bay consists of several long pebble beaches, separated by rocky headlands with high wave and surge exposure (Photo 36-30). This area was not observed closely except from offshore. CIRCAC and EVOS (2005) classified the morphology of this area as sedimentary with rock and sediment (Appendix 36A, Figure 36A-2). No eelgrass was reported south of the entrance to Cottonwood Bay (Appendix 36A, Figure 36A-8).

36.7.7 White Gull Island

Lees et al. (1980) reported predominantly rocky shorelines with pockets of coarse cobble and pebbles along the shorelines of White Gull Island. On the west side of the island, they reported the intertidal zone to be composed of moderately sloping gravel beaches and sheer rock faces. CIRCAC and EVOS (2005) confirmed this morphology, reporting generally rocky morphology on the exposed southeast shore, with rock and sediment around the remainder of the island (Appendix 36A, Figure 36A-2).

Based on subtidal surveys conducted around White Gull Island in 1978, Dames & Moore (1979) reported that, on the east side of the island, which is exposed to both long-fetch waves and tidal currents, a bedrock shelf extended from the intertidal range to a depth of about –5 feet MLLW, where a vertical face dropped to a depth of about –16 feet MLLW. Kelps did not extend over the edge of the vertical face. A steep slope of medium to large boulders, providing high relief, extended from the toe of the vertical face to a depth of about –40 feet MLLW.

In 2004, divers from the University of Alaska Fairbanks swam a transect (–3.5 feet to –27 feet MLLW) off the southeast side of the island. They recorded boulders in the shallower part of the transect, transitioning to gravel at the deeper end.

36.8 Summary

The shorelines of the IIE study area include a diversity of habitats ranging from steep rocky cliffs to very low-gradient sand and mud flats. Cobble and pebble beaches along Knoll Head between the bays are characterized by well-rounded particles, while pebbles and cobbles with similar grain sizes are much more angular on more sheltered beaches in the inner bays. Wave and surge energy is high at the headlands and is also surprisingly high along the outer portions of the bays during high tides. Substantial swell was encountered during beach seining (Chapter 43) as far up as Fossil Beach on the east side of Iniskin Bay and AC Point on the east side of Iliamna Bay. At lower tides, swells are damped considerably, first by the systems of reefs and islets at the bay entrances and second, by the low-gradient mudflats. Eelgrass is found at a number of locations and habitats around the IIE although a substantial temporal variability has been noted in some areas. Eelgrass, along with macroalgae, is an important substrate for spawning by Pacific herring (Chapter 43).

Subtidal habitat is similarly varied, ranging from mud and sand within central portions of the bays to a variety of gravel, boulder, and rock in channel bottoms swept by strong currents, subject to high wave action, or too steep to accumulate sediment.

These ranges of substrate type, slope, and exposure create a diversity of niches for biological assemblages that are discussed in greater detail in Chapters 42, 43, and 44.

36.9 References

Blackburn, J.E., K. Anderson, C.I. Hamilton, and S.J. Starr. 1980. "Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System." Published in U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Final Report 17 (Biological Studies), pp. 107-450.

Cook Inlet Regional Citizens Advisory Council (CIRCAC) and *Exxon Valdez* Oil Spill Trustee Council (EVOS). 2005. Dominant Morphology; Sediment Type, Eelgrass. Obtained from: http://imf.geocortex.net/mapping/cori/ launch2.html.

Dames & Moore. 1979. "A Preliminary Assessment of Composition and Food Webs for Demersal Fish Assemblages in Several Shallow Subtidal Habitats in Lower Cook Inlet, Alaska." Published in U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Final Report 17 (Biological Studies), pp. 383-450. (Appendix II of Blackburn et al., 1980.)

Houghton, J.P., R.P. Britch, R.C. Miller, A.K. Runchal, and C.P. Falls. 1980. "Drilling Fluid Dispersion Studies at the Lower Cook Inlet COST Well." Pp. 285-305 *in* Proceedings of Symposium/Research on Environmental Fate and Effect of Drilling Fluids and Cuttings. Washington, D.C.: American Petroleum Institute.

Lees, D.C., and W.D. Driskell. 1981. "Investigations on the Shallow Subtidal Habitats and Assemblages in Lower Cook Inlet." Pp. 419-610 *in:* H.M. Feder, A.J. Paul, M.K. Hoberg, and S.C. Jewett, eds., Appendix IV of Distribution, Abundance, Community Structure and Trophic Relationships of the Nearshore Benthos of Cook Inlet, Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, Final Report 14 (Biological Studies).

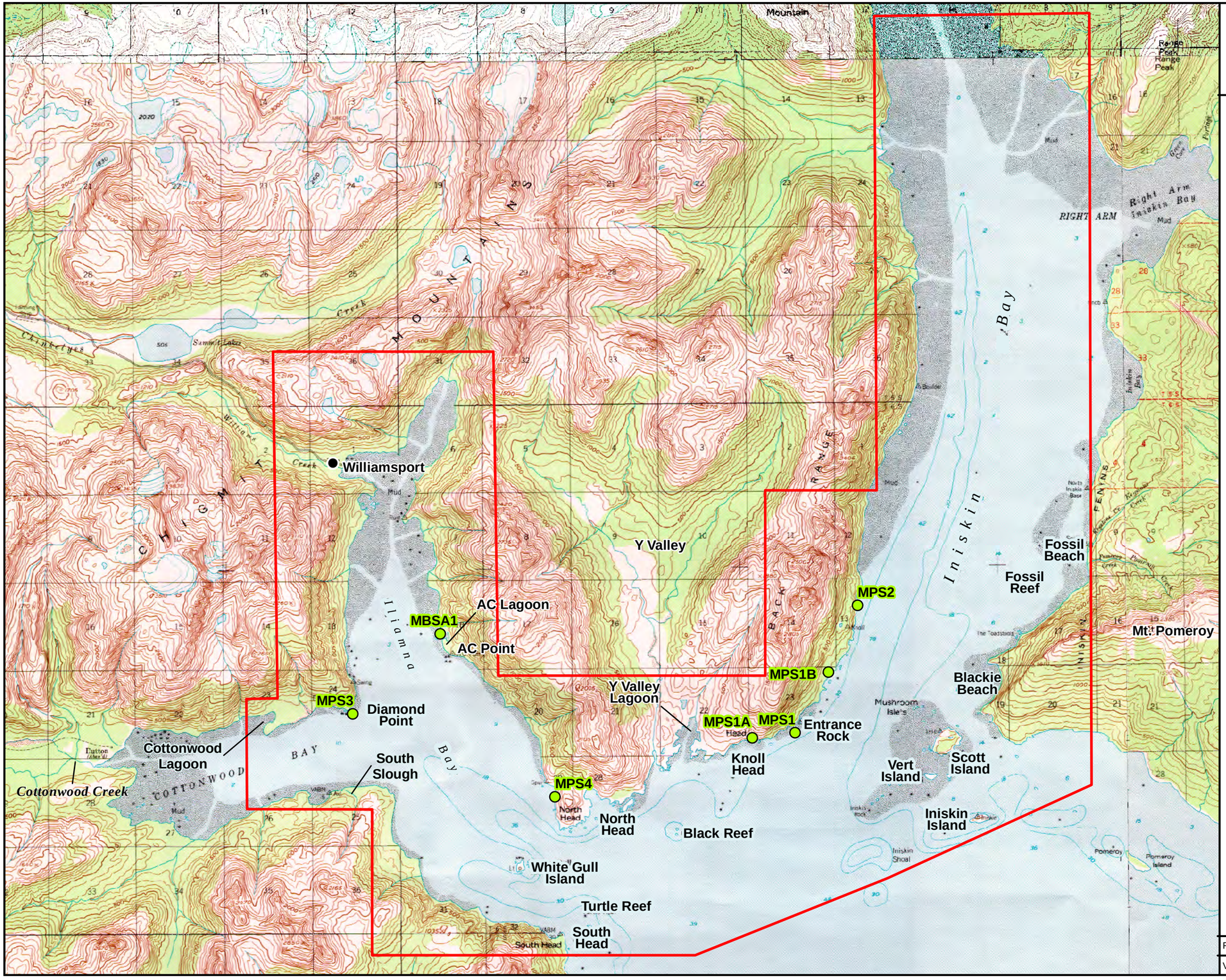
Lees, D.C., and J.P. Houghton. 1980. "Effects of Drilling Fluids on Benthic Communities at the Lower Cook Inlet COST Well." Pp. 309-346 *in* Proceedings of Symposium/Research on Environmental Fate and Effect of Drilling Fluids and Cuttings. Washington, D.C.: American Petroleum Institute.

———. 1977. "Reconnaissance of the Intertidal and Shallow Subtidal Biotic, Lower Cook Inlet." Published in U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Final Report 3 (Biological Studies), 1978, pp. 179-506.

Lees, D.C., J.P. Houghton, D.E. Erikson, W.D. Driskell, and D.E. Boettcher. 1980. "Ecological Studies of Intertidal and Shallow Subtidal Habitats in Lower Cook Inlet, Alaska." Published in U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Final Report 44, 1986, pp. 1-436.

Pentec Environmental, Inc. 1996. A Survey of Selected Cook Inlet Intertidal Habitats. Revised Report, Project Number 82-004. Prepared for Cook Inlet Regional Citizens Advisory Council.

FIGURES



THE pebble PARTNERSHIP

Figure 36-1
Marine Nearshore Habitat Study Area

Legend

- Marine Sample Stations
- Study Area

0 0.5 1 1.5 2 2.5 3 Miles

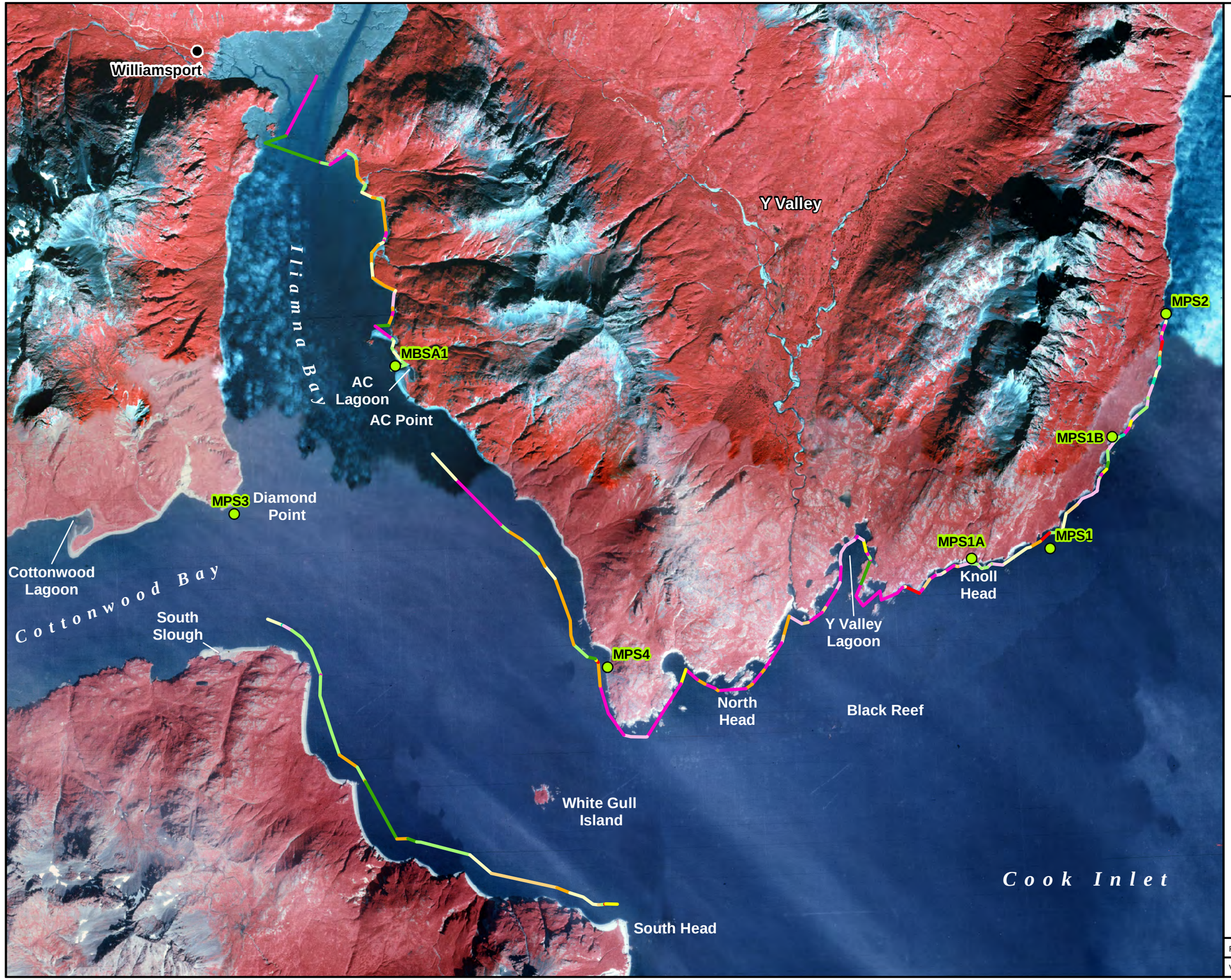
0 1 2 3 4 Kilometers

Scale 1:70,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_SA_Fig36-1_11X17L_1of1_D08.mxd	Date: June 9, 2011
Version: 8	Author: RDI-LS



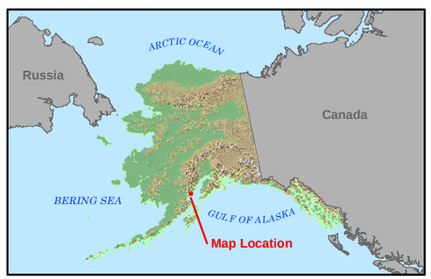
THE pebble PARTNERSHIP

Figure 36-2
Shoreline Habitat Types
Observed by Boat July 2005

Legend

- Sand
- Pebble
- Pebble/cobble mixed
- Pebble/cobble/bedrock
- Cobble
- Cobble/boulder mixed
- Boulder
- Vertical cliff/bedrock
- Offshore rock
- Caverns
- Marine Sample Stations

Note: Habitat types shown are projections of habitat types as seen from a boat.



0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

Scale 1:38,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_SLHabitat_Fig36-2_11X17L_1of1_D08.mxd	Date: June 9, 2011
Version: 8	Author: RDI-LS

PHOTOGRAPHS

Photo 36-1: From Iniskin Island, view of rocky beach; note smooth rocks polished by ice. June 2008.

Photo 36-2: Vert Island with well vegetated intertidal habitat; note abundance of red algae (*Palmaria* spp.). June 2008.

Photo 36-3: Scott Island with wooded uplands and steep cliffs to intertidal zone. June 2008.

Photo 36-4: Rocky bench and sea stacks, south side of Scott Island, looking west. April 2006.

Photo 36-5: Looking east from Scott Island at one of the Mushroom Islets with Blackie Beach in the background and Mt. Pomeroy on the right. May 2006.

Photo 36-6: Blackie Beach looking north toward base of rocky peninsula that extends westward (on the left). May 2006.

Photo 36-7: Sandy flat west of Blackie Beach and south of rocky peninsula. July 2005.

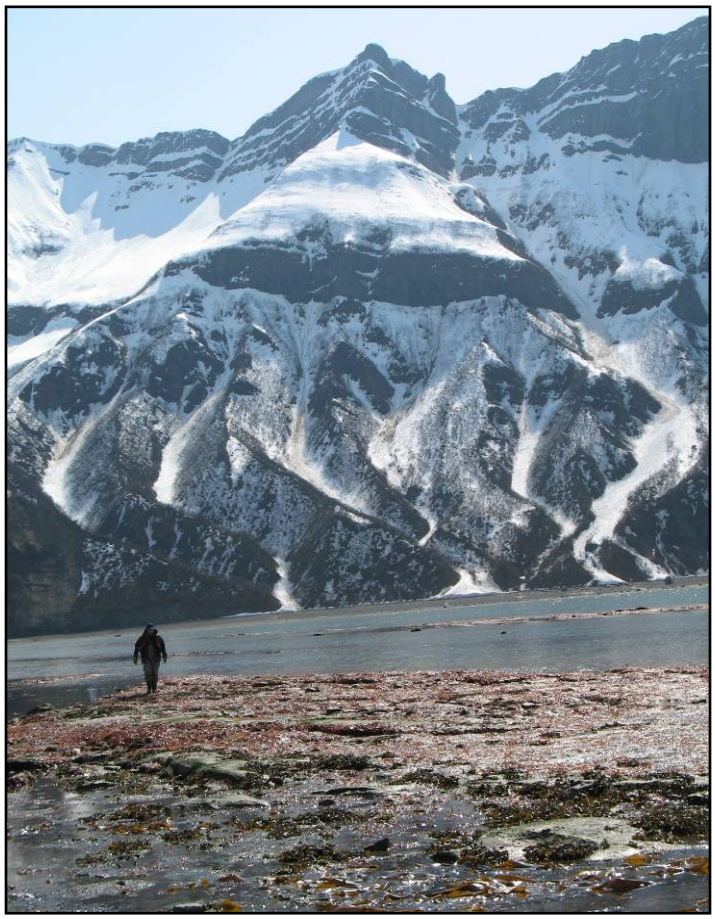


Photo 36-8: Fossil Reef looking southeast toward Fossil Beach and the north flank of Mt. Pomeroy. May 2006.

Photo 36-9: Western side of Iniskin Bay looking north. August 2004.

Photo 36-10: Middle and upper beach just north of Port Site 2, looking south. August 2004.

Photo 36-11: Lower beach mudflat at Port Site 2, looking southwest. August 2004.

Photo 36-12: Interspersed rock and peddle beach habitats at Port Site 1 (Station MPS1B), looking west. May 2006.

Photo 36-13: Low rocky beach at MPS1B, looking northwest toward series of arches at the base of Knoll Head. August 2004.

Photo 36-14: Mid-elevation rocky beach at Station MPS1A, looking northeast at pebble/sand pocket beach. May 2006.

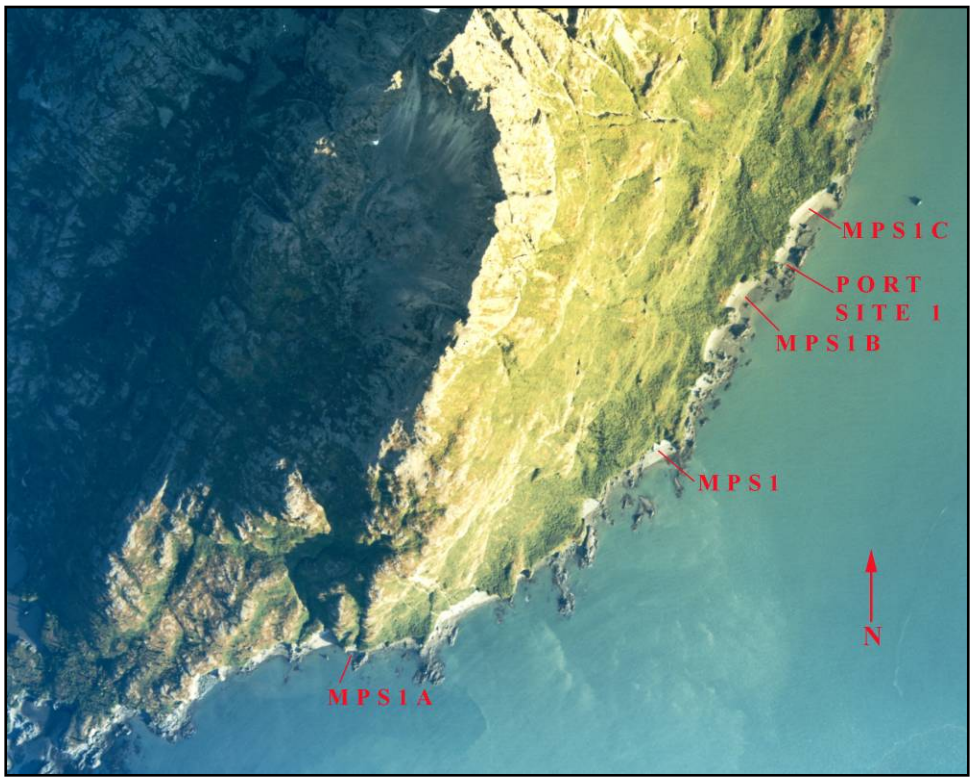


Photo 36-15: Aerial view of coastline from southwest of Station MPS1A northeast past Port Site 1. September 2008.

Photo 36-16: Sea stacks at the entrance to the Y Valley lagoon, looking north. August 2004.

Photo 36-17: Y Valley Lagoon (left side of image) from the air. August 2004.

Photo 36-18: Y Valley stream and adjacent shoreline, looking northwest. May 2006.

Photo 36-19: Port Site 4 upper pebble beach looking west. August 2004.

Photo 36-20: Port Site 4 lower boulder cobble beach looking south past North Head to tip of South Head. July 2005.

Photo 36-21: East side of Y Valley Lagoon near Knoll Head showing high-tide line, cobble beach, and vegetated backshore. November 2008.

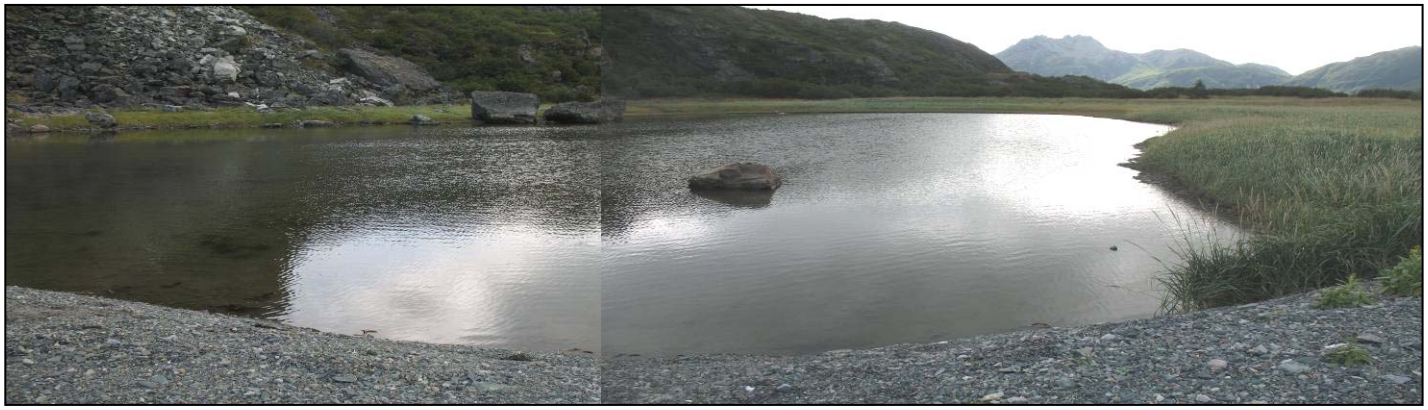


Photo 36-22: AC Point with tidal lagoon and gravel bench. September 2007.

Photo 36-23: Inner Illiamna Bay mudflat and central drainage channel, looking northeast. August 2004.

Photo 36-24: Williamsport shoreline (foreground) and channel, looking east toward inner Illiamna Bay. August 2004.

Photo 36-25: Mud and gravel flat looking northeast into head of Illiamna Bay. August 2004.

Photo 36-26: Low rock and mud habitat at Port Site 3, looking northeast past Diamond Head toward head of Illiamna Bay. July 2005.

Photo 36-27: Aerial view of Cottonwood Bay. September 2008.

Photo 36-28: Cottonwood lagoon with sand spits. June 2008.

Photo 36-29: South Slough. June 2008.

Photo 36-30: Illiamna Bay shoreline south of entrance to Cottonwood Bay (on right), looking west. August 2004.

APPENDIX

APPENDIX 36A

CIRCAC Habitat Maps

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)

Dominant Morphology

CIRCAC 2005

Places

- Land

Western Lower Cook Inlet - Dominant Morphology

- Rock
- Rock + Sediment
- Sediment
- Wetland
- Manmade
- Channels
- Land

N

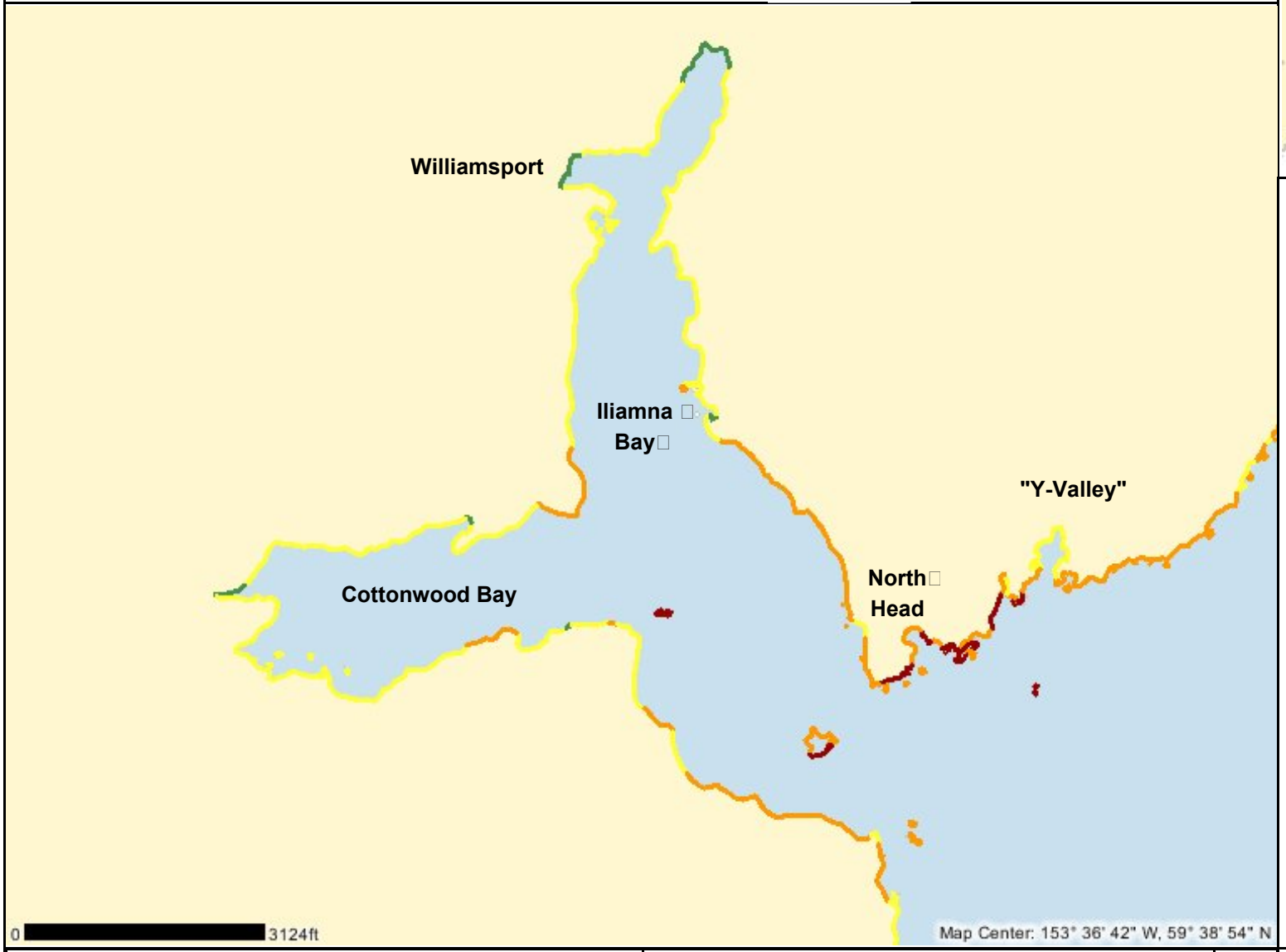
This PDF was generated at: http://imf.geocortex.net/mapping/cori/launch.hml

Figure 36A-1

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)

Dominant Morphology

CIRCAC 2005



Places
Land

Western Lower Cook Inlet - Dominant Morphology

Rock
Rock + Sediment
Sediment
Wetland
Manmade
Channels
Land

N

This PDF was generated at: http://maps.geocortex.net/imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-2

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)

Dominant Morphology

CIRCAC 2005

Places

Land

Western Lower Cook Inlet - Dominant Morphology

- Rock
- Rock + Sediment
- Sediment
- Wetland
- Manmade
- Channels
- Land

N

This PDF was generated at: http://maps.geocortex.net/imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-3

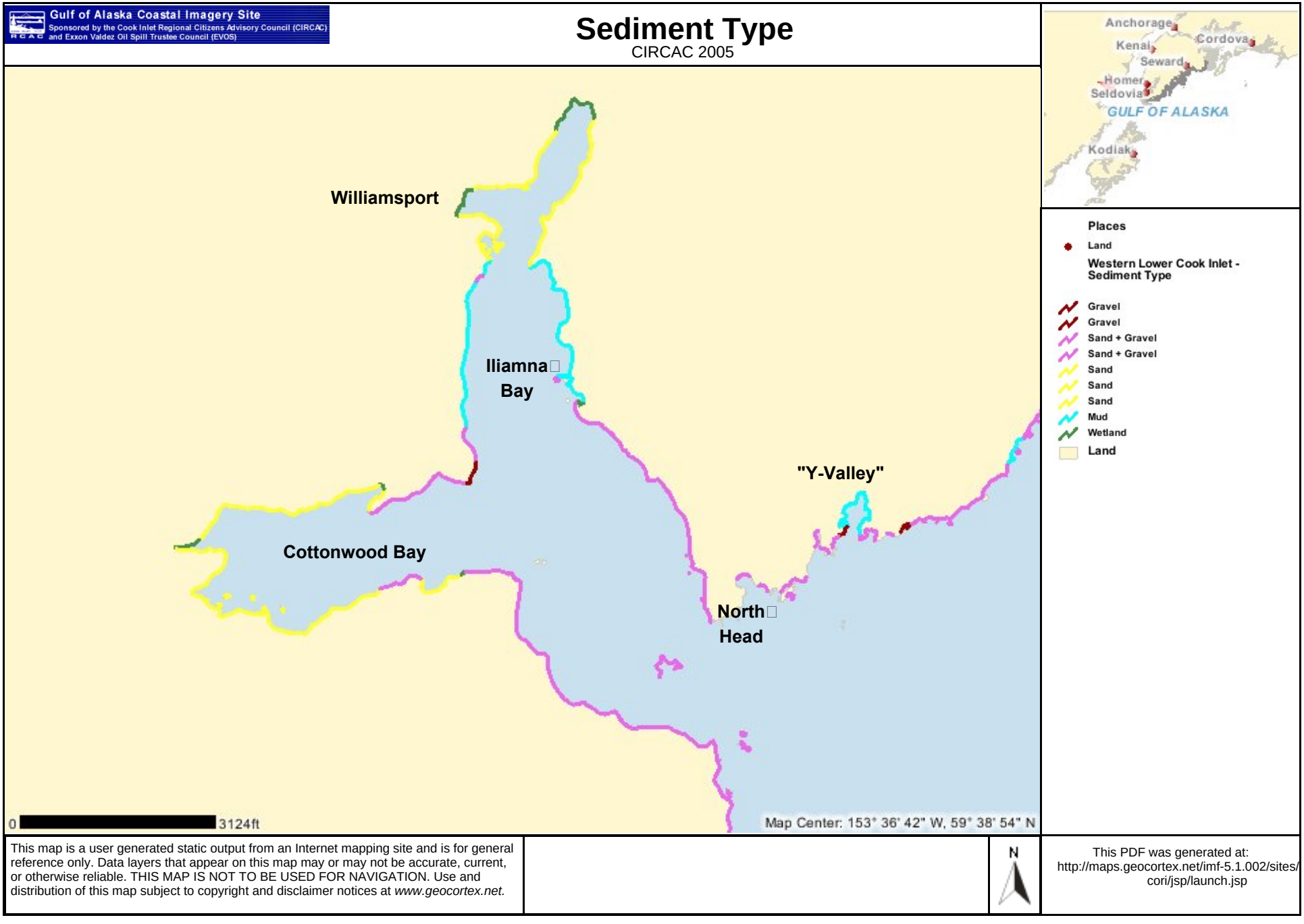

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Sediment Type
CIRCAC 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Williamsport
Iliamna Bay
"Y-Valley"
Cottonwood Bay
North Head
Places
Land
Western Lower Cook Inlet - Sediment Type
Gravel
Gravel
Sand + Gravel
Sand + Gravel
Sand
Sand
Sand
Mud
Wetland
Land
0
3124ft
Map Center: 153° 36' 42" W, 59° 38' 54" N
This map is a user generated static output from an Internet mapping site and is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION. Use and distribution of this map subject to copyright and disclaimer notices at www.geocortex.net.
N
This PDF was generated at: http://maps.geocortex.net/imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-4

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)

Sediment Type

CIRCAC 2005

Places

Land

Western Lower Cook Inlet - Sediment Type

- Gravel
- Gravel
- Sand + Gravel
- Sand + Gravel
- Sand
- Sand
- Sand
- Mud
- Wetland
- Land

N

This PDF was generated at: http://maps.geocortex.net/imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-5

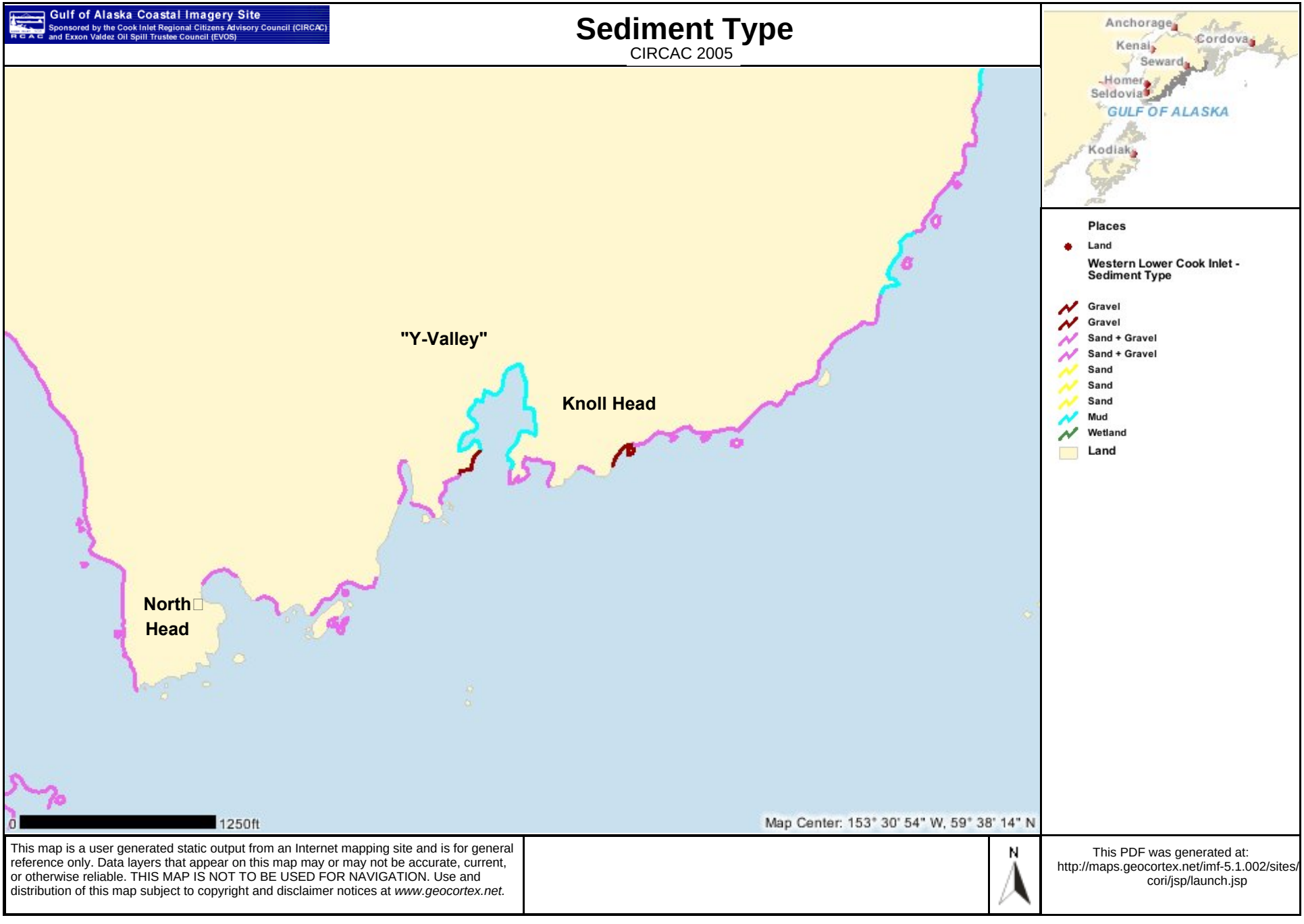
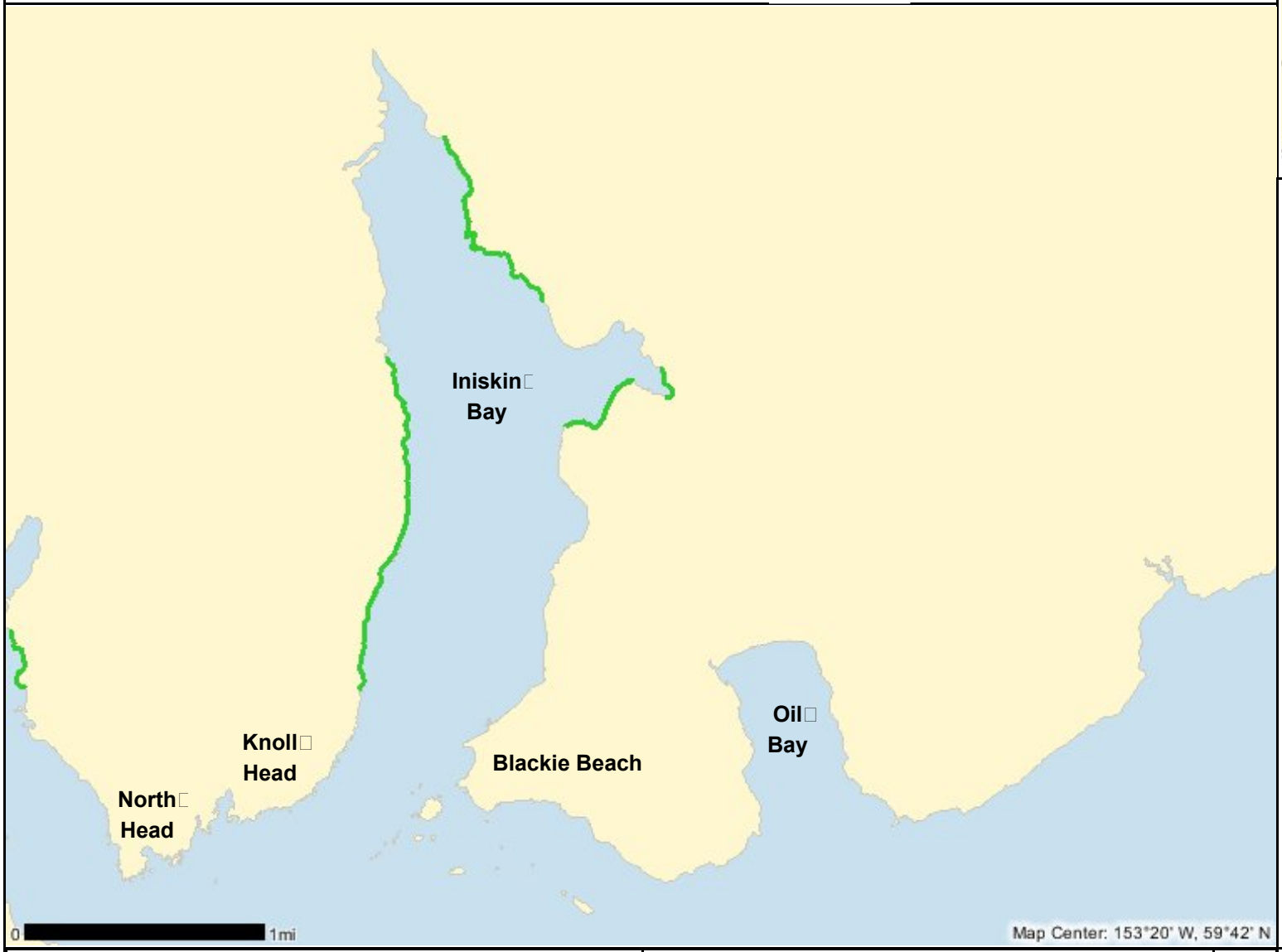

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Sediment Type
CIRCAC 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
"Y-Valley"
Knoll Head
North Head
Places
Land
Western Lower Cook Inlet - Sediment Type
Gravel
Gravel
Sand + Gravel
Sand + Gravel
Sand
Sand
Sand
Mud
Wetland
Land
0
1250ft
Map Center: 153° 30' 54" W, 59° 38' 14" N
This map is a user generated static output from an Internet mapping site and is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION. Use and distribution of this map subject to copyright and disclaimer notices at www.geocortex.net.
N
This PDF was generated at: http://maps.geocortex.net/imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-6

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)

Eelgrass

CIRCAC 2005



Places

Land

Western Lower Cook Inlet - Eelgrass

Continuous

Patchy

Land

N

This PDF was generated at:
http://maps.geocortex.net/
imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-7

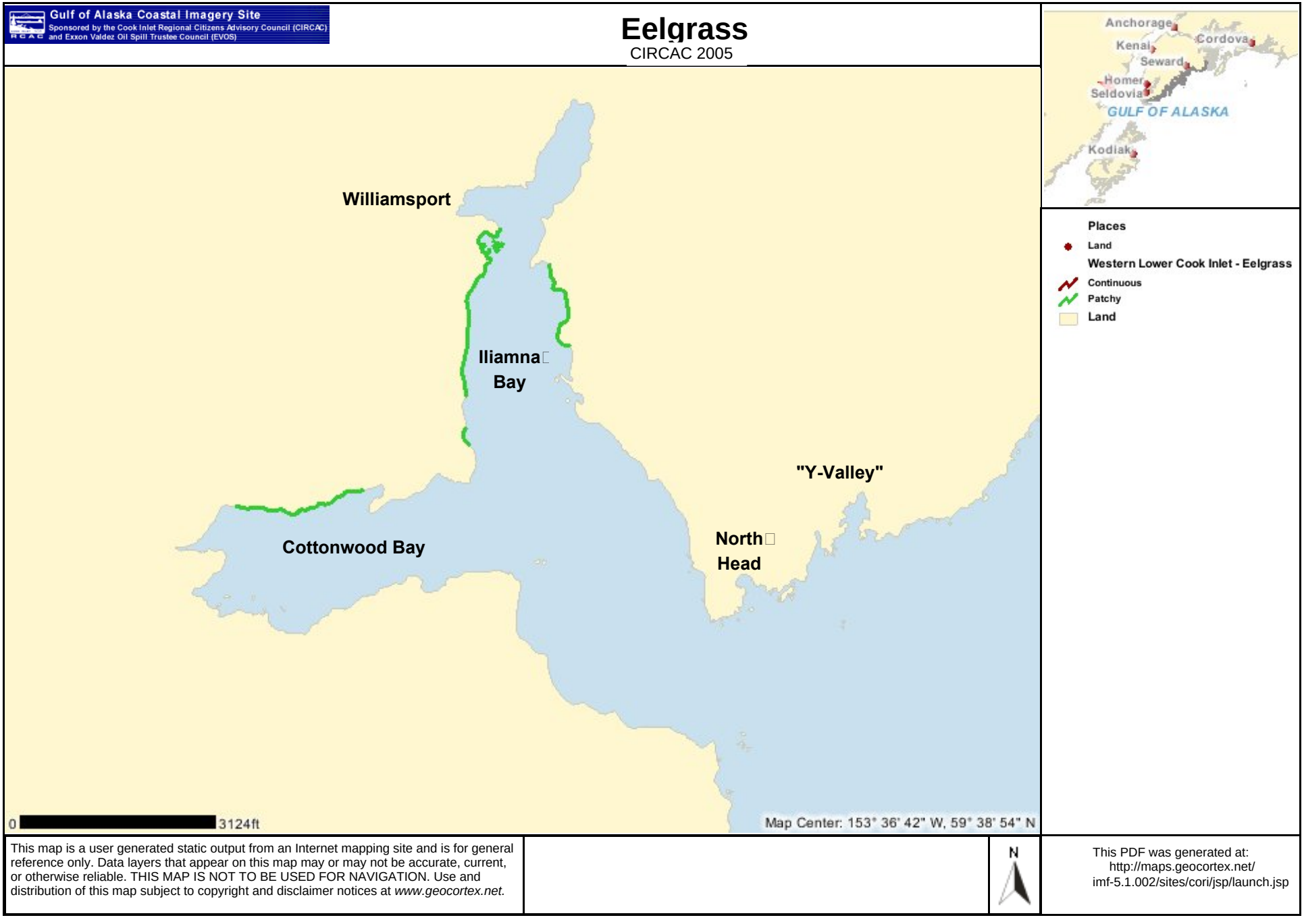

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Eelgrass
CIRCAC 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Williamsport
Iliamna Bay
"Y-Valley"
North Head
Cottonwood Bay
Places
Land
Western Lower Cook Inlet - Eelgrass
Continuous
Patchy
Land
0
3124ft
Map Center: 153° 36' 42" W, 59° 38' 54" N
This map is a user generated static output from an Internet mapping site and is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION. Use and distribution of this map subject to copyright and disclaimer notices at www.geocortex.net.
N
This PDF was generated at:
http://maps.geocortex.net/
imf-5.1.002/sites/cori/jsp/launch.jsp

Figure 36A-8