# APPENDIX A

## ENVIRONMENTAL RESOURCES
## KENAI BLUFF EROSION
## TECHNICAL REPORT
## KENAI, ALASKA

### Environmental Documents

Invertebrate Sampling

Bird and Marine Mammal Survey

Cultural Resources

ADF&G Baseline Fisheries Assessment

CEPOA-EN-CW-ER (1105-2-10b) 3 July 2003

MEMORANDUM FOR RECORD

SUBJECT: Kenai Bluff Erosion Project Benthic Invertebrate Sampling

**1. Introduction.** Intertidal habitat near the mouth of the Kenai River was sampled for benthic invertebrates on 3 April 2003. Chris Hoffman and Ashley Reed, biologists, U. S. Army Corps of Engineers, Alaska District, conducted the surveys. Mark Willette, fisheries biologist, Alaska Department of Fish and Game, operated the skiff and provided assistance with attempts to obtain subtidal samples on 4 April 2003. This sampling effort was performed as part of a study to investigate existing habitat and potential impacts from bluff stabilization and trail creation near the mouth of the Kenai River. With the exception of one site (R3 lower, see figure 1) on the bank opposite the buff, no benthic invertebrates were detected. Sample locations are depicted in figure 1 and sample site details and results are presented in table 1.

**2. Methods.** Seven sample sites were selected along the bluff, each approximately 200 meters apart. Two samples were taken at each site; an upper intertidal (U1-U7) sample 10 meters from the toe of the bluff and a lower intertidal (L1-L7) sample 40 meters from the toe of the bluff. Additional samples were taken from the opposite bank (samples R1-R3, see figure 1). Samples R1-R3 were taken at various distances from the vegetation line (see table 1) because the distances used on the bluff side were not appropriate due to a different bank profile. All samples were taken during the period surrounding a low tide. Samples were collected from shore with a trowel and a rectangular template to yield a 0.1-meter$^3$ sample (10 cm sample depth). Samples were placed in a labeled bucket for analysis.

a. All samples were washed on the same day they were collected using a two-tiered sieve and a garden hose with very low water pressure. The coarse sieve contained ~1-centimeter mesh and was placed ~20 centimeters above the fine sieve, which was made from ~1-milimeter mesh. Much of the substrate was composed of fine silt, so care was taken to gently dissolve all clumps so invertebrates were not damaged or overlooked. Samples were preserved in 10% neutral-buffered formalin and then transferred to isopropyl alcohol for preservation and subsequent identification.

**3. Results and Discussion.** Invertebrates were only found in one (R3 lower) of the 20 samples. This sample contained 21 small clams (*Tellina nuculoides*) ranging in size from 0.4 to 1.3 centimeters. Ice was present below the silt at both R3 sample sites, but not at any other site.

a. We attempted to collect subtidal samples but were unsuccessful. We used a 0.1 meter$^3$ Van Veen dredge, but the tide and current were too strong to obtain a valid sample despite working at slack tide and on an incoming tide immediately after slack tide. Another attempt to obtain subtidal samples was made in May 2003 with a heavier sampling device. This attempt was also unsuccessful due to a combination of current, tide and the fact that the bottom is highly compacted. Some samples were obtained for sediment analysis from the large shoal located offshore of R3, but a cursory investigation of the sample revealed only *Tellina spp*. clams. The material on the shoal is composed of coarse sand and therefore probably provides good habitat for these small clams. The highly compacted nature of the river bottom likely makes it unsuitable benthic invertebrate habitat. Additional studies are planned to survey the epibenthic invertebrates in the river.

b. On 17 April we obtained some sediment samples from R3 for part of a grain size analysis. Although we did not sieve for benthic invertebrates, we noticed one *Tellina spp*. clam and 2 marine polychaetes, which we collected, preserved and analyzed. These marine polychaetes were identified as *Neris spp*. and are most likely *Neris vexillosa*.

Encl

Christopher Hoffman
Biologist

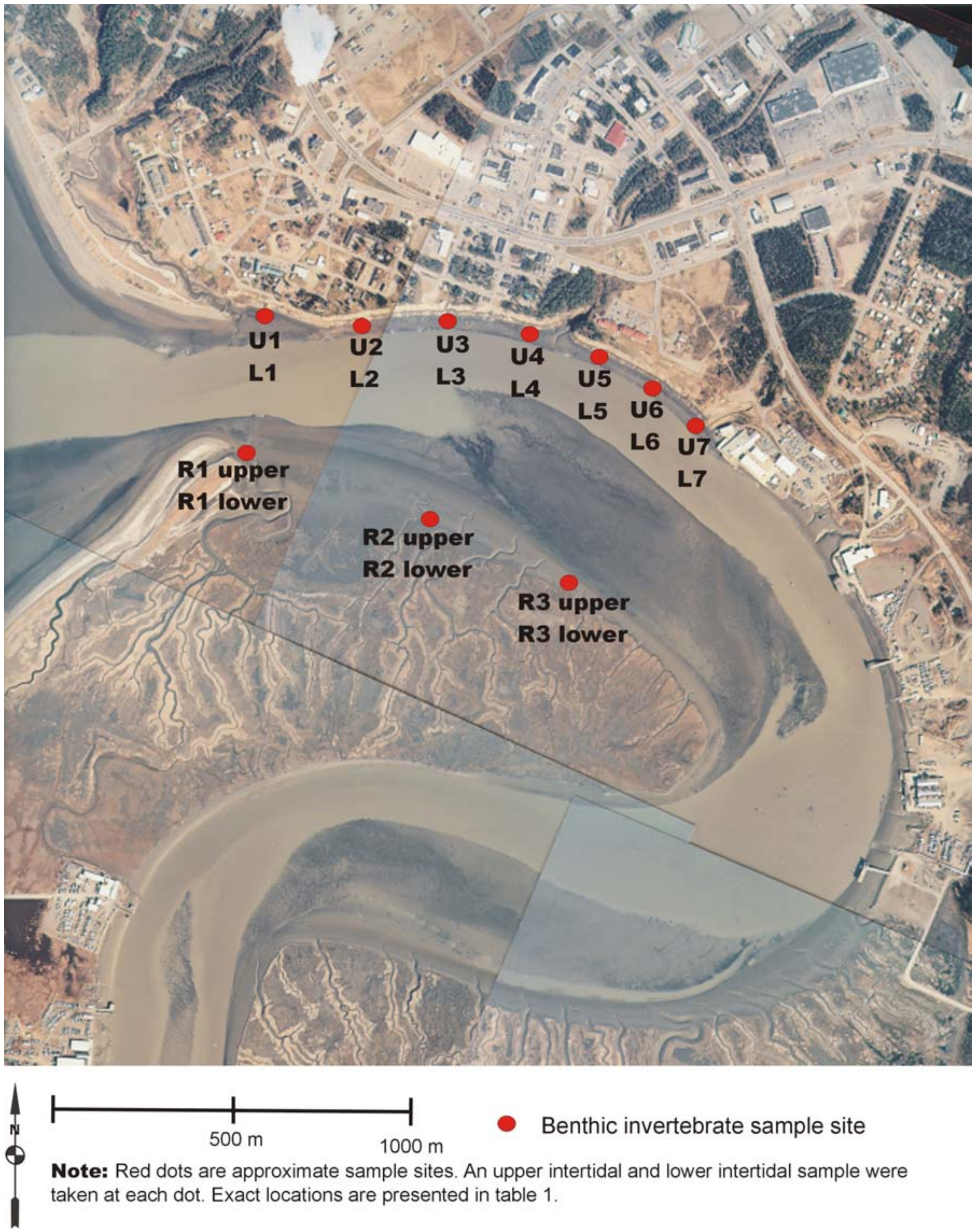

U1
L1
U2
L2
U3
L3
U4
L4
U5
L5
U6
L6
U7
L7
R1 upper
R1 lower
R2 upper
R2 lower
R3 upper
R3 lower
N
500 m
1000 m
Benthic invertebrate sample site
**Note:** Red dots are approximate sample sites. An upper intertidal and lower intertidal sample were taken at each dot. Exact locations are presented in table 1.

Figure 1.

**KENAI RIVER OUTLET BENTHIC INVERTEBRATE SURVEYS**

| DATE | STATION | TIME | LATITUDE Degrees | Minutes | Seconds | | LONGITUDE Degrees | Minutes | Seconds | | LOCATION DESCRIPTION | SUBSTRATE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/3/2003 | U1 | 9:45 | 60 | 33 | 5 | N | 151 | 15 | 22 | W | 10 m from bluff | Sand |
| 4/3/2003 | U2 | 10:00 | 60 | 33 | 8 | N | 151 | 15 | 9 | W | 10 m from bluff | Sand/silt |
| 4/3/2003 | U3 | 10:10 | 60 | 33 | 10 | N | 151 | 15 | 0 | W | 10 m from bluff | Cobble/sand/silt |
| 4/3/2003 | U4 | 10:21 | 60 | 33 | 11 | N | 151 | 14 | 46 | W | 10 m from bluff | Sand/silt |
| 4/3/2003 | U5 | 10:30 | 60 | 33 | 12 | N | 151 | 14 | 33 | W | 10 m from bluff | Sand/silt |
| 4/3/2003 | U6 | | 60 | 33 | 12 | N | 151 | 14 | 20 | W | 10 m from bluff | Cobble/sand/silt |
| 4/3/2003 | U7 | | 60 | 33 | 10 | N | 151 | 14 | 9 | W | 10 m from bluff | Sand |
| 4/3/2003 | L1 | | 60 | 33 | 3 | N | 151 | 15 | 21 | W | 40 m from bluff | Sand/cobble (0.5-2") |
| 4/3/2003 | L2 | | 60 | 33 | 8 | N | 151 | 15 | 9 | W | 40 m from bluff | Sand/cobble (1-3") |
| 4/3/2003 | L3 | | 60 | 33 | 9 | N | 151 | 14 | 59 | W | 40 m from bluff | Sand/cobble (1") |
| 4/3/2003 | L4 | | 60 | 33 | 11 | N | 151 | 14 | 45 | W | 40 m from bluff | Sand/cobble (<1") |
| 4/3/2003 | L5 | | 60 | 33 | 11 | N | 151 | 14 | 34 | W | 40 m from bluff | Sand/cobble (1-3") |
| 4/3/2003 | L6 | | 60 | 33 | 10 | N | 151 | 14 | 19 | W | 40 m from bluff | Cobble/silt |
| 4/3/2003 | L7 | | 60 | 33 | 9 | N | 151 | 14 | 10 | W | 40 m from bluff | Cobble/silt |
| 4/3/2003 | R1 Upper | 10:45 | 60 | 32 | 53 | N | 151 | 15 | 23 | W | 70 m from vegetation line | Silt |
| 4/3/2003 | R2 Upper | | 60 | 32 | 54 | N | 151 | 14 | 48 | W | 50 m from veg line, 570 m from bluff | Silt |
| 4/3/2003 | R3 Upper | | 60 | 32 | 53 | N | 151 | 14 | 25 | W | 10 m from veg line, 590 m from bluff | Silt |
| 4/3/2003 | R1 Lower | 10:50 | 60 | 32 | 54 | N | 151 | 15 | 24 | W | 120 m from veg line | Sand/gravel/cobble |
| 4/3/2003 | R2 Lower | | 60 | 32 | 56 | N | 151 | 14 | 48 | W | 520 m from bluff | Silt |
| 4/3/2003 | R3 Lower | | 60 | 32 | 53 | N | 151 | 14 | 25 | W | 575 m from bluff | Silt |

Notes: 1- All distances are slope distances, not horizontal distances.
2-Distances measured from bluff were measured from toe of bluff.
3-Distances from vegetation on southern bank differ because of varying bank profile.
4-Vegetation line (veg line) refers to the vegetation line on the southern side of the river.
5-Sample size was 0.1 meter$^3$.
6-Sampled using a frame and trowel.
7-On 4/17: Collected sediment samples at R3. Did not sieve for benthic invertebrates, but noticed one clam (Tellina nuculoides) and 2 marine polychaetes (Nereis sp., most likely vexillosa).

Table 1.

| DATE | STATION | SUBSTRATE CONSISTENCY | SPECIES BENTHIC INVERTEBRATES | NUMBER INVERTS | NOTES |
|---|---|---|---|---|---|
| 4/3/2003 | U1 | | | 0 | |
| 4/3/2003 | U2 | Muck | | 0 | Sediment sample site |
| 4/3/2003 | U3 | Muck | | 0 | |
| 4/3/2003 | U4 | Deep muck | | 0 | |
| 4/3/2003 | U5 | Deep muck | | 0 | |
| 4/3/2003 | U6 | Deep muck | | 0 | |
| 4/3/2003 | U7 | | | 0 | |
| 4/3/2003 | L1 | | | 0 | |
| 4/3/2003 | L2 | | | 0 | Sediment sample site |
| 4/3/2003 | L3 | | | 0 | |
| 4/3/2003 | L4 | | | 0 | |
| 4/3/2003 | L5 | | | 0 | |
| 4/3/2003 | L6 | Firm | | 0 | |
| 4/3/2003 | L7 | Muck | | 0 | |
| 4/3/2003 | R1 Upper | Firm | | 0 | Across from U1 |
| 4/3/2003 | R2 Upper | | | 0 | Across from v-notch |
| 4/3/2003 | R3 Upper | | | 0 | Across from U6 and U7. Ice at 2" |
| 4/3/2003 | R1 Lower | | | 0 | Across from U1 |
| 4/3/2003 | R2 Lower | | | 0 | Across from v-notch |
| 4/3/2003 | R3 Lower | | Tellina nuculoides | 21 | Ice at 6", clams 2-12 mm |

Table 1 Continued

CEPOA-EN-CW-ER (1105-2-10b)

MEMORANDUM FOR RECORD

SUBJECT: Kenai Bluff Erosion Project Bird and Marine Mammal Survey

1. **Introduction.** Bird and marine mammal surveys were conducted near Kenai, Alaska from April 2003 through March 2004. These surveys were conducted to determine the abundance and local distribution of bird and marine mammal species to address the impacts of potential erosion control measures along the Kenai Bluff. Chris Hoffman, biologist, Army Corps of Engineers, Alaska District conducted the surveys.

2. **Methodology.** Surveys were conducted from five locations along the bluff. Survey observation points and sectors are depicted in figure 1. An aerial photograph mosaic with bird survey boundaries is included in figure 2 to provide greater resolution than the topographic map. The survey area was divided into six sectors in order to describe bird and marine mammal distribution. The sectors were typically dictated by terrain except for two reference stakes used to delineate the limits of sector 3 due to lack of recognizable boundaries. The survey area included the face of the bluff as well as the shoreline and the water. Marine mammals were counted in each of the six sectors. In sector MM, all marine mammals are included, but shorebirds and waterfowl were only included when they were within range to allow identification. The MM sector is too large and the distances are too great to allow a complete bird survey. Therefore, bird numbers in sector MM are not indicative of the total number of birds using this sector.

**a.** The goal of the survey is to provide a "snap shot" of bird and marine mammal distribution. This is in contrast to a survey with equal-sized sectors and a discrete time spent on station. Enough time is spent at each observation point to allow a thorough count of all birds and marine mammals present. Ample time is allocated to allow diving birds and mammals to complete a few dive cycles. Since much of the habitat use is dependent on tide stage, the survey is designed to be completed in a short time span so all sectors can be observed with minimal tidal fluctuation. The survey protocol was designed assuming that it would be more advantageous to complete two surveys per day at different tide levels than one survey lasting for several hours. Additionally, gulls, eagles, and seals move frequently and it would be difficult to avoid double counting the same animal if the survey lasted a long time in one area.

3. **Biological Observations.** A list of species observed and their four-letter abbreviation code is included in table 1. Bird and marine mammal sightings are included in tables 2 through 24. These tables include the general conditions of the survey, species observed, and numbers in each of the six sectors. Graphs of selected species abundance over time are presented in figures 3 through 6. The spatial distributions of predominant species observed during each survey are shown in figures 7 through 22.

a. The majority of bird observations occurred on the opposite side of the river from the bluff. One reason for this might be that the sediment is more loosely compacted and therefore is better suited for aquatic invertebrate prey species for birds. An invertebrate survey conducted in May 2003 found small clams (Telina species) located throughout these uncompacted areas. Another reason for bird location might be because the slope of the bank is much less steep and a greater surface area exists to feed on and for sediment to accumulate upon. The large sand/gravel bars that are exposed at relatively low tides are evident in Sectors 2 through 5 of the aerial photograph (figure 2). These sand/gravel bars are exposed to varying degrees as the tide goes out, thus probably explaining some of the large daily fluctuation in bird numbers in a particular sector at different times of the day.

b. Gulls were the most abundant birds observed on an annual basis. The majority of these gulls were herring gulls, although some mew gulls and glaucous-winged gulls were also observed. Herring gull numbers peaked in July and large numbers of these gulls were observed breeding on the wetlands across from the bluff. These wetlands have been termed the "inside bend wetlands" for the purpose of this survey and are depicted in figure 1. Breeding is possible on these wetlands in the summer months because the tides are not high enough during this time of year to inundate the wetlands. During the spring and fall, high tides routinely flood the inside bend wetlands. While walking these wetlands to collect sediments samples on 14 May 2003, I noticed that approximately 20% of the herring gull nests contained one egg. On 21 August 2003 I returned to the wetlands and observed that most (~90%) of the herring gulls had fledged. Accordingly, peak habitat use of the inside bend wetlands by herring gulls is from about early May until the end of August. Gulls are routinely present on ponds in this area in the spring and fall and along the perimeter of the inside bend wetlands all year long unless the river is frozen.

c. Bald eagles were most abundant in April and May and were practically absent in the summer. It is likely that eagles leave the mouth of the Kenai River in summer to breed and feed elsewhere since salmon are present in abundant quantities throughout many areas of south-central Alaska. Eagles would typically move onto the flats on the opposite side of the bluff and at the mouth of the river at low tide and then perch along the bank of the inside bend wetlands during higher tides.

d. Common goldeneye were present during February through April. Most goldeneye were observed in sector 5 in the area between the fish processing plant and upstream to the city dock. When these sectors were filled with ice, goldeneye were observed further downstream.

e. Along the face of the bluff and the shoreline below the bluff the most common birds observed were ravens, magpies and small numbers of herring gulls. Swallows were sometimes observed flying along the bluff, and while some holes along the banks (in sector 3) were seen, there was no indication of nesting. Eagles would often perch in spruce tress along the face of the bluff, presumably because it served as an excellent vantage point to observe the wetlands and the river. In June and July, gulls were commonly observed in sector 1 on both sides of the river, probably in part due to the presence of salmon carcasses from people who were dip-netting.

f. Harbor seals were routinely observed near the mouth of the Kenai River in small numbers. At low tide, seals were typically hauled out on large boulders in Cook Inlet near the mouth of the Kenai River. When not hauled out on the rocks, seals were sometimes observed in the river in each of the survey sectors. A beluga whale was observed in sector MM in April.

Christopher Hoffman
Biologist

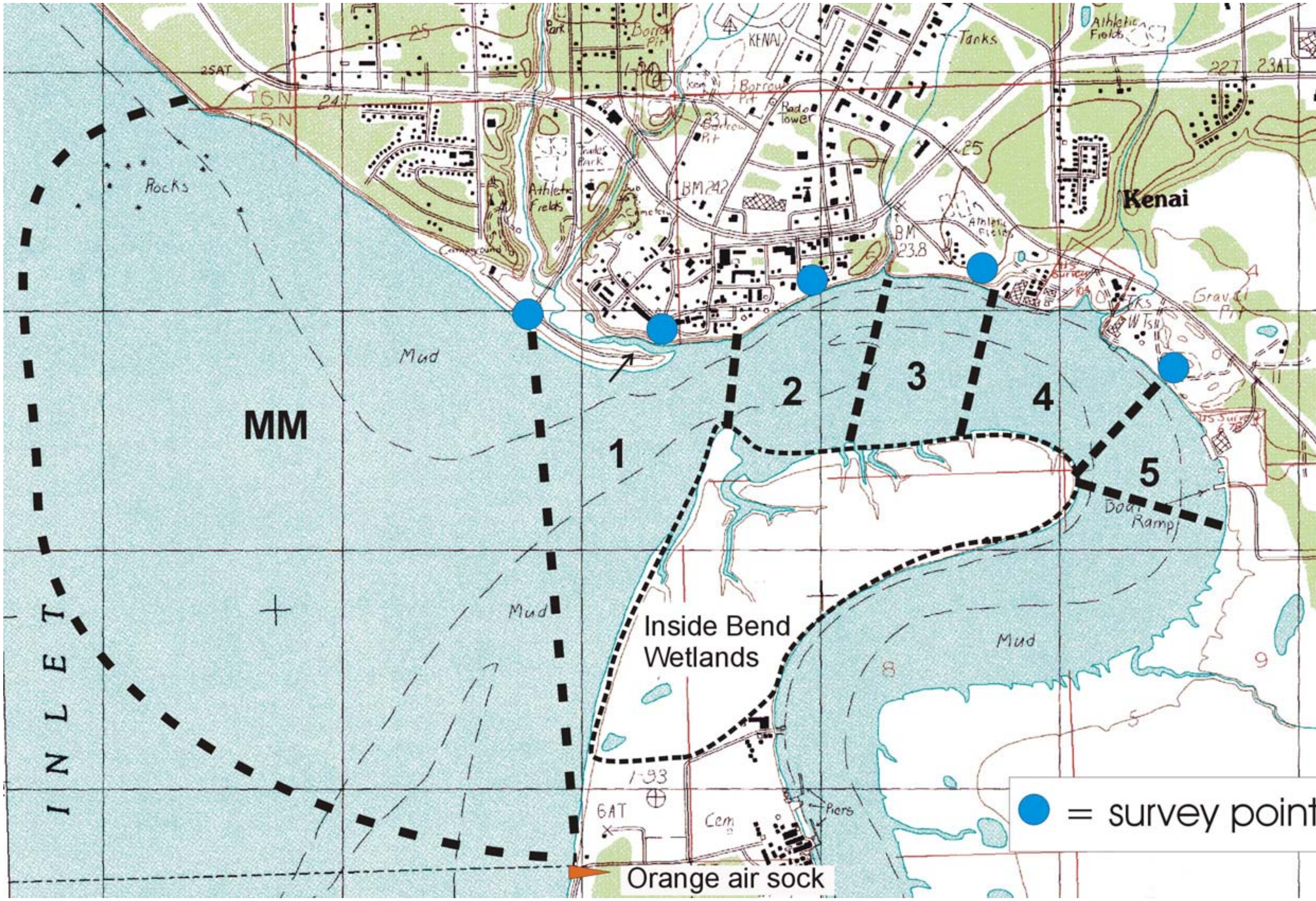


Figure 1. Survey sectors utilized for each survey.

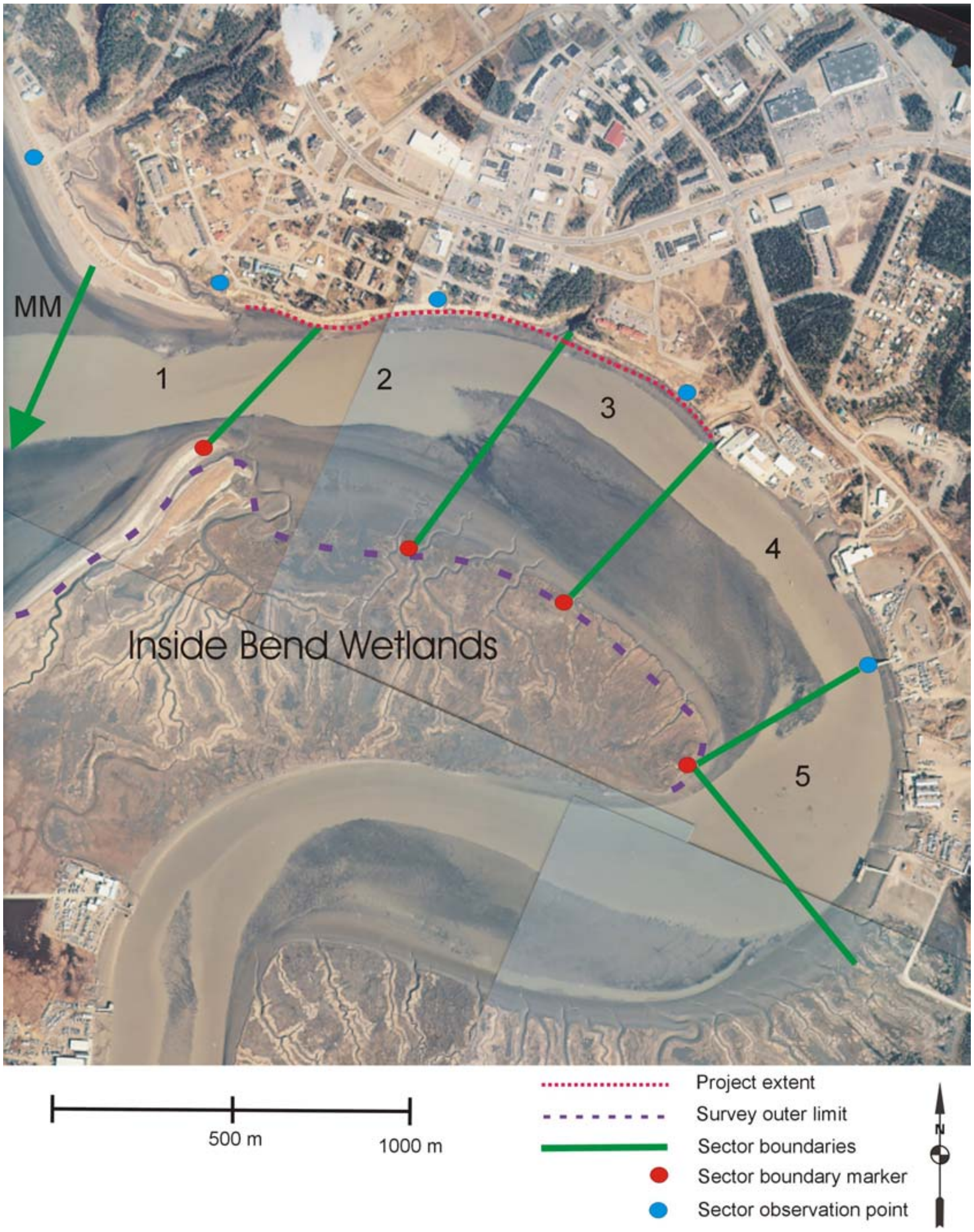



Figure 2. Aerial photograph of survey area. Note the exposed mudflats since this photo was taken on a low tide.

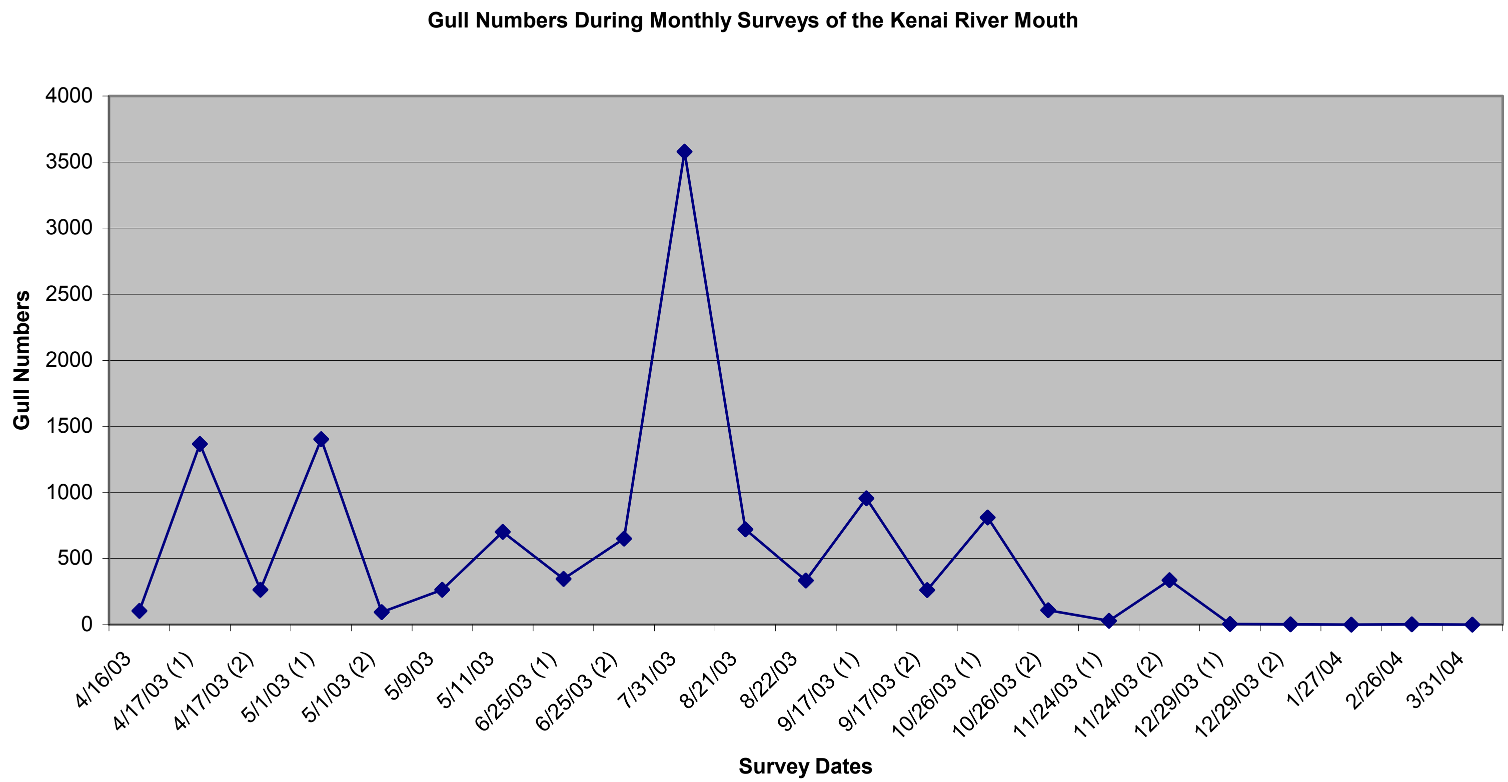



Figure 3. Gull Numbers During Monthly Surveys of the Kenai River Mouth.

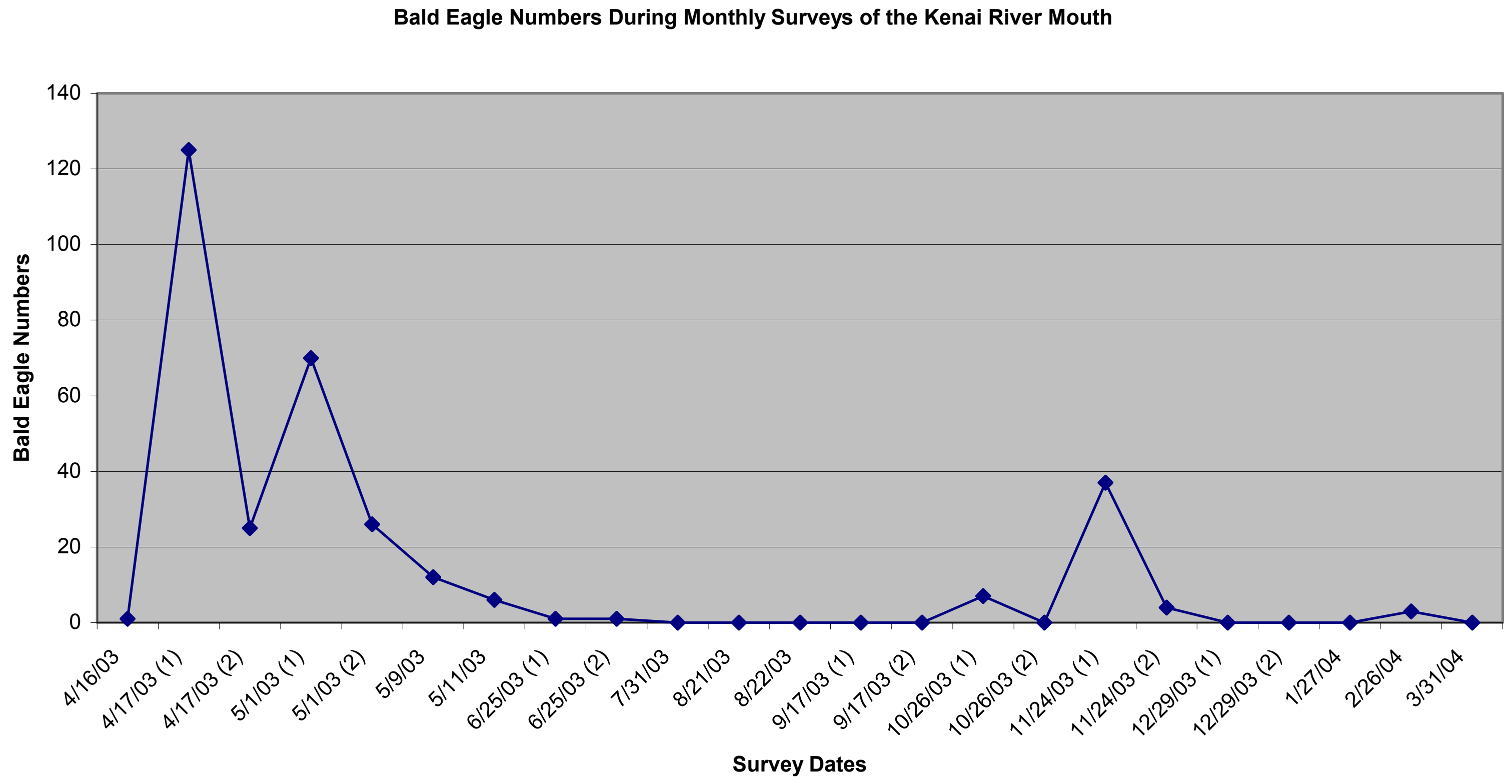



Figure 4. Bald Eagle Numbers During Monthly Surveys of the Kenai River Mouth.

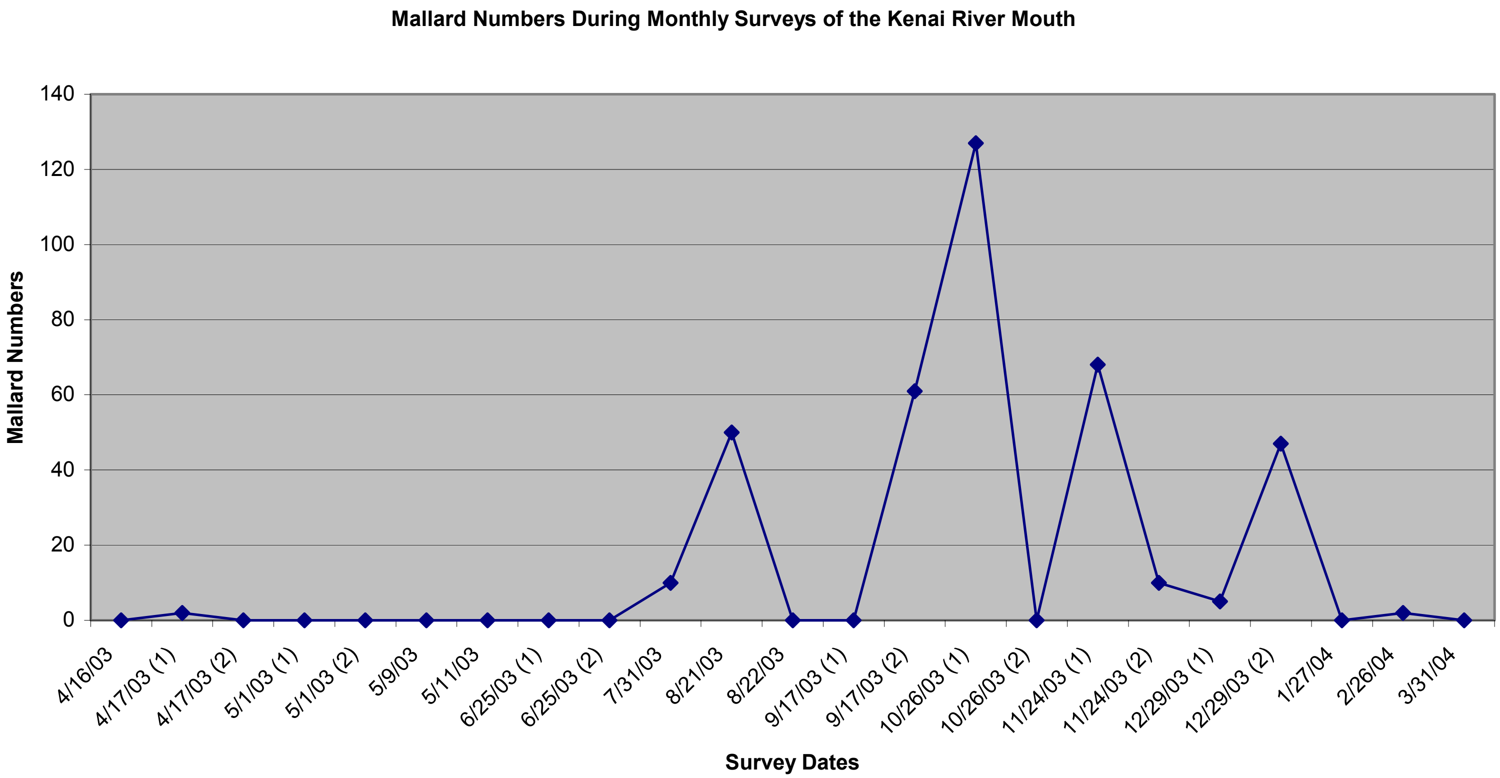



Figure 5. Mallard Numbers During Monthly Surveys of the Kenai River Mouth.

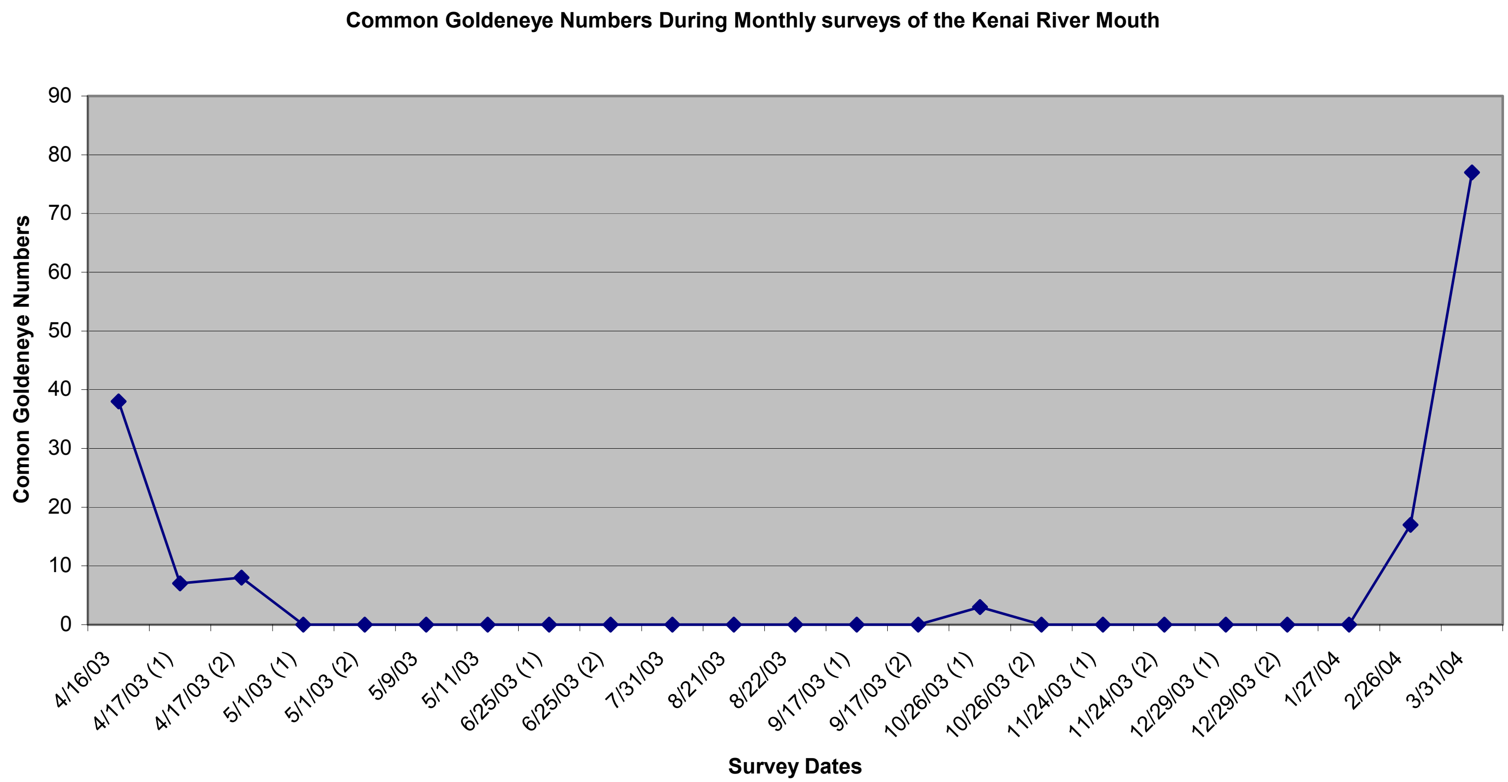



Figure 6. Common Goldeneye Numbers During Monthly surveys of the Kenai River Mouth.

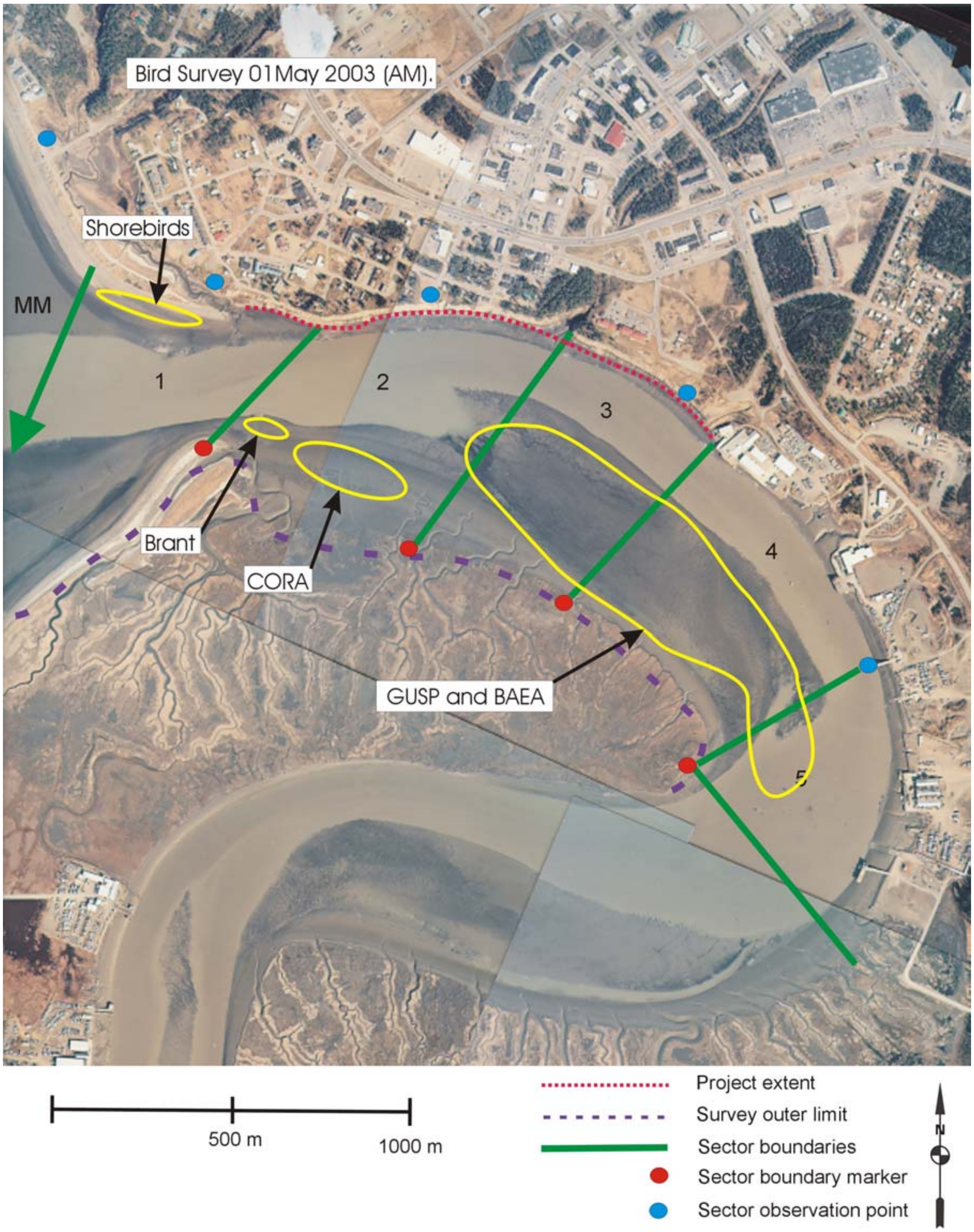



Figure 7. Bird distribution 1 May 2003 AM.

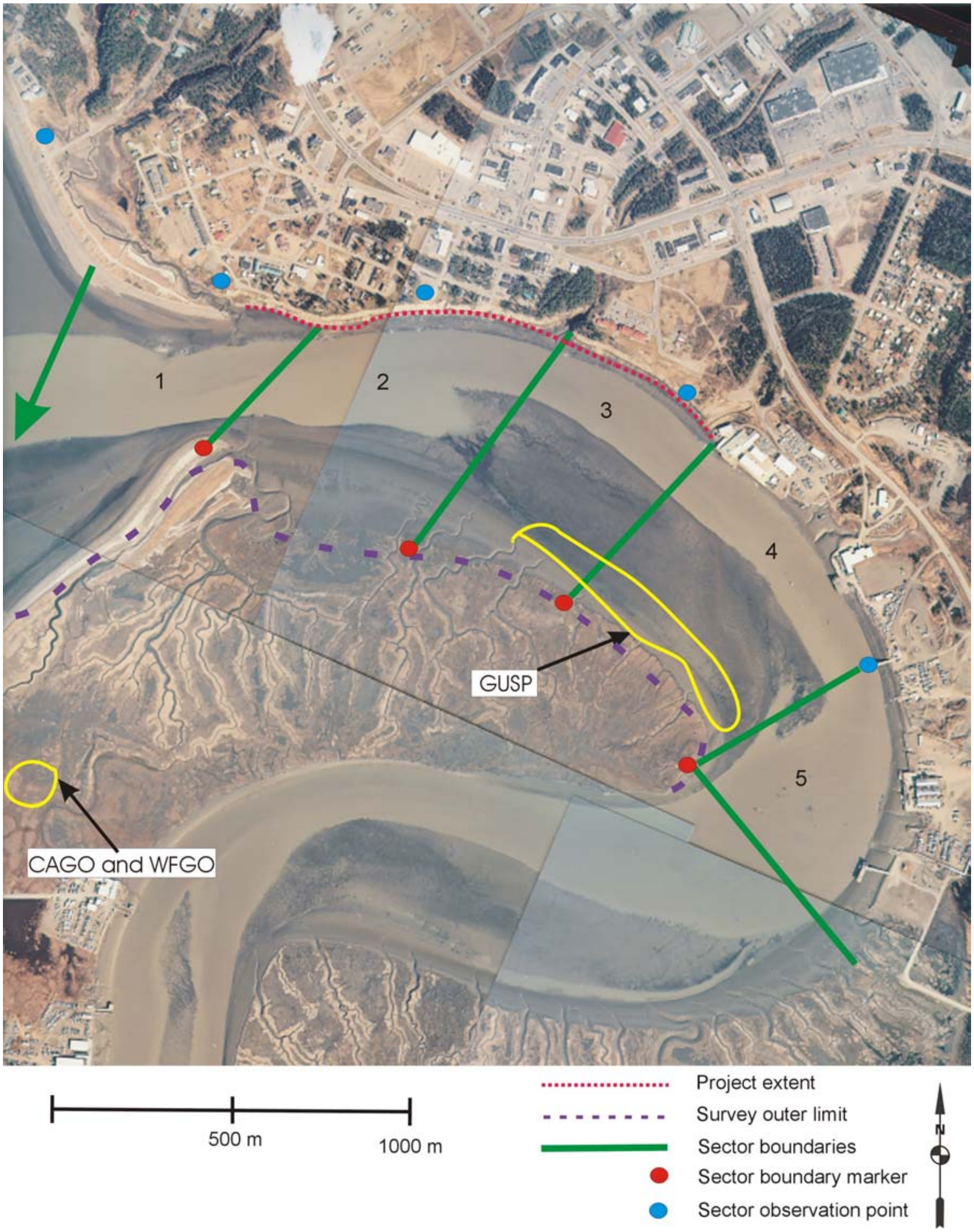



Figure 8. Bird distribution 9 May 2003 AM.

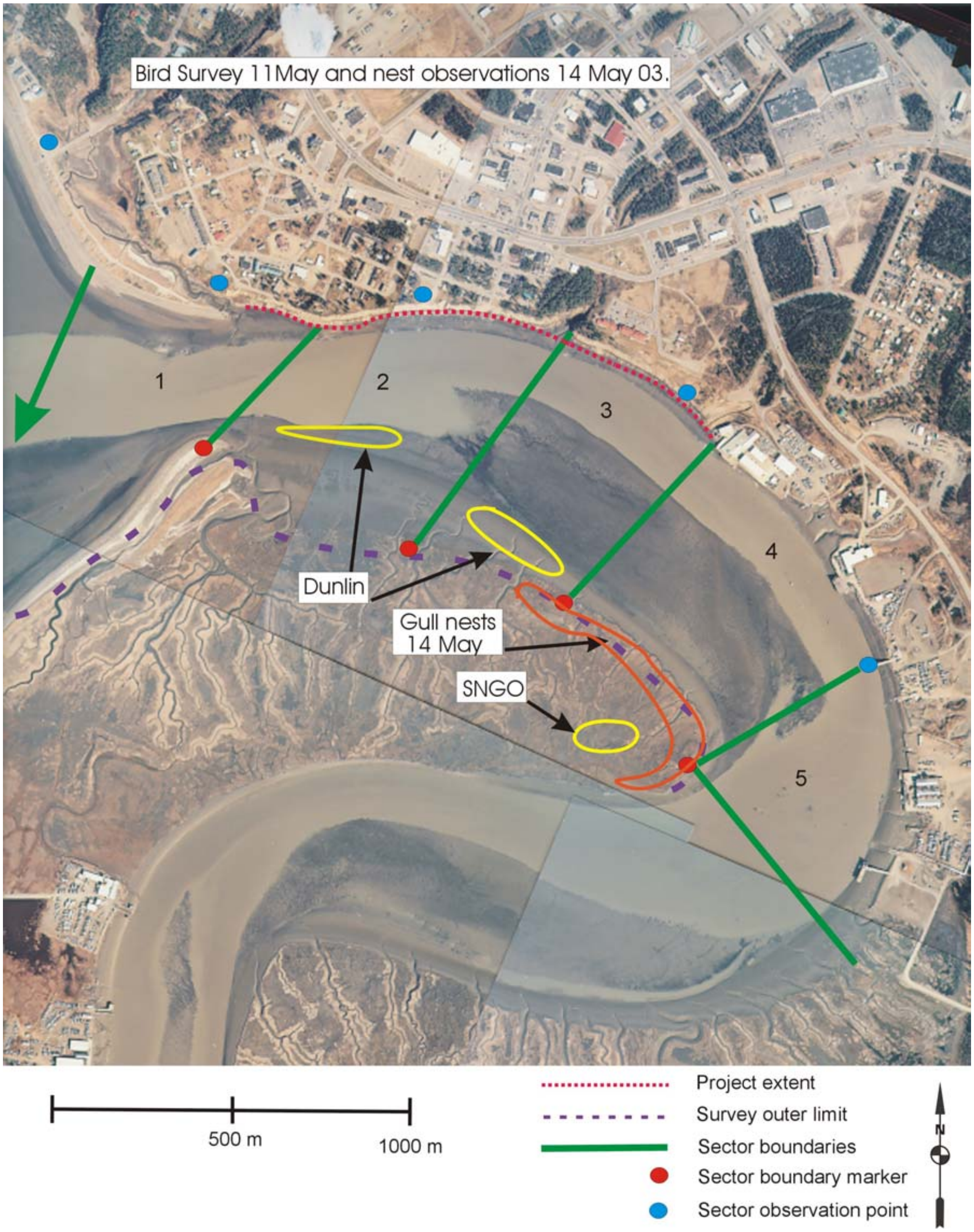



Figure 9. Bird distribution 11 May2003.

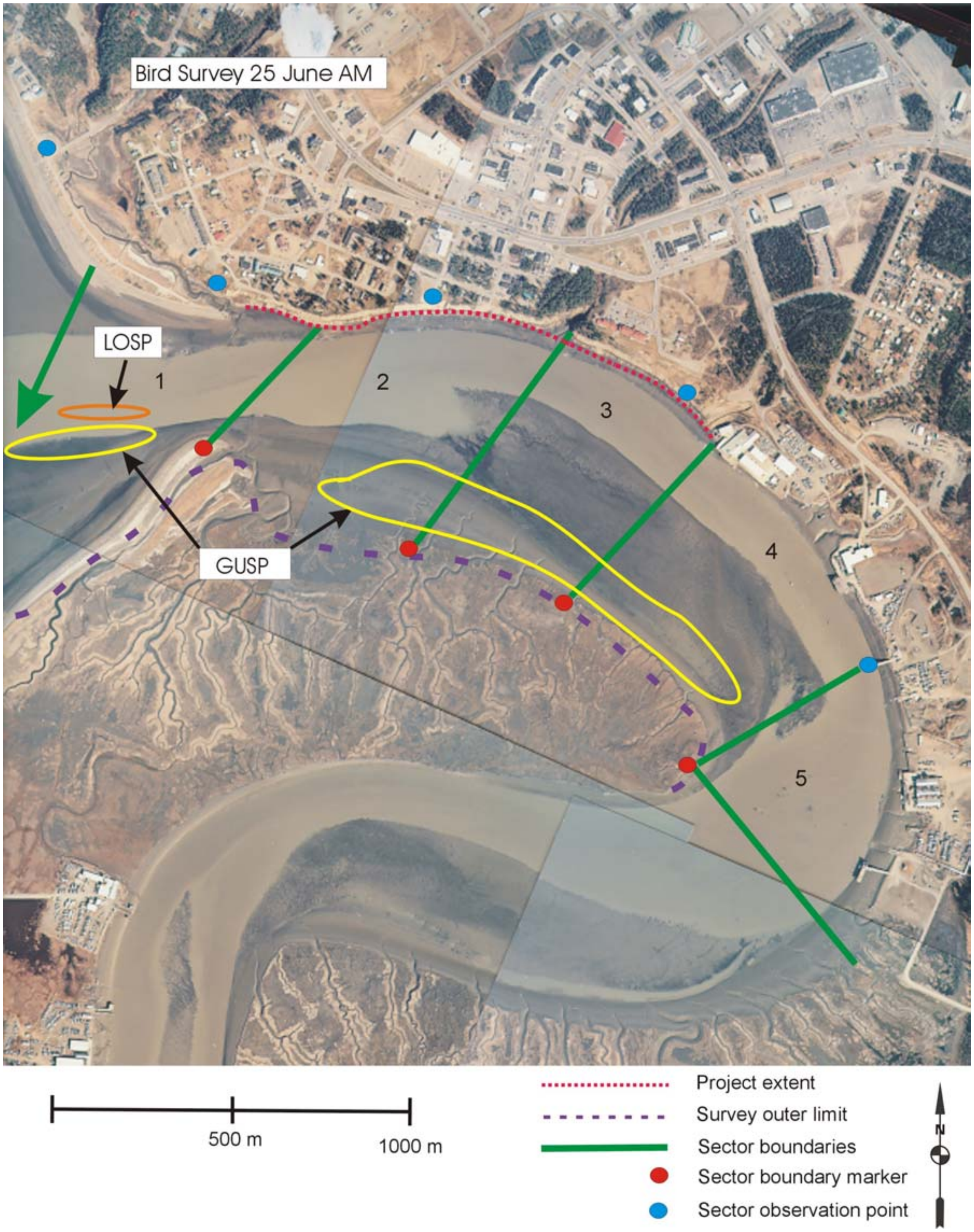



Figure 10. Bird distribution 25 June AM.

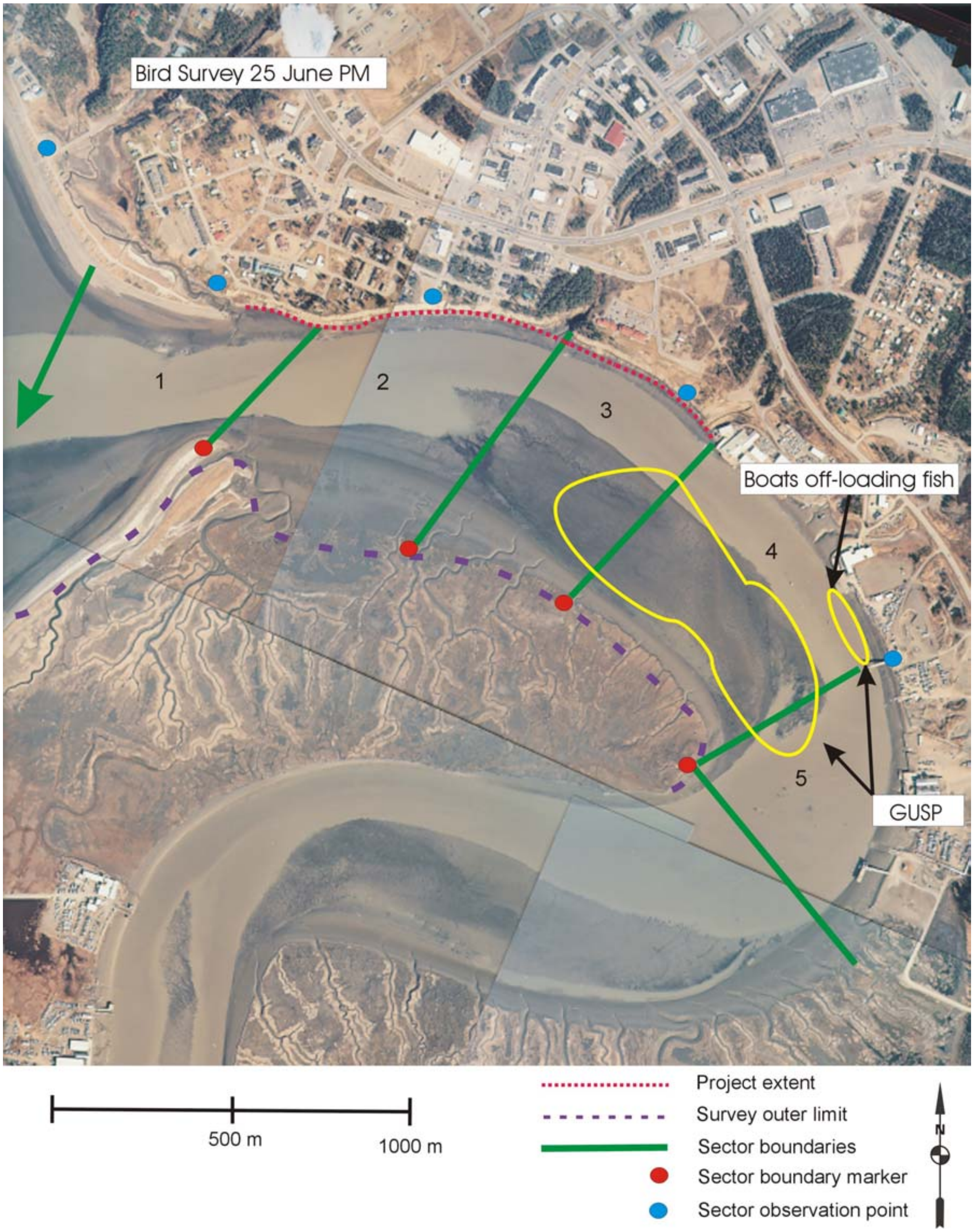



Figure 11. Bird distribution 25 June PM.

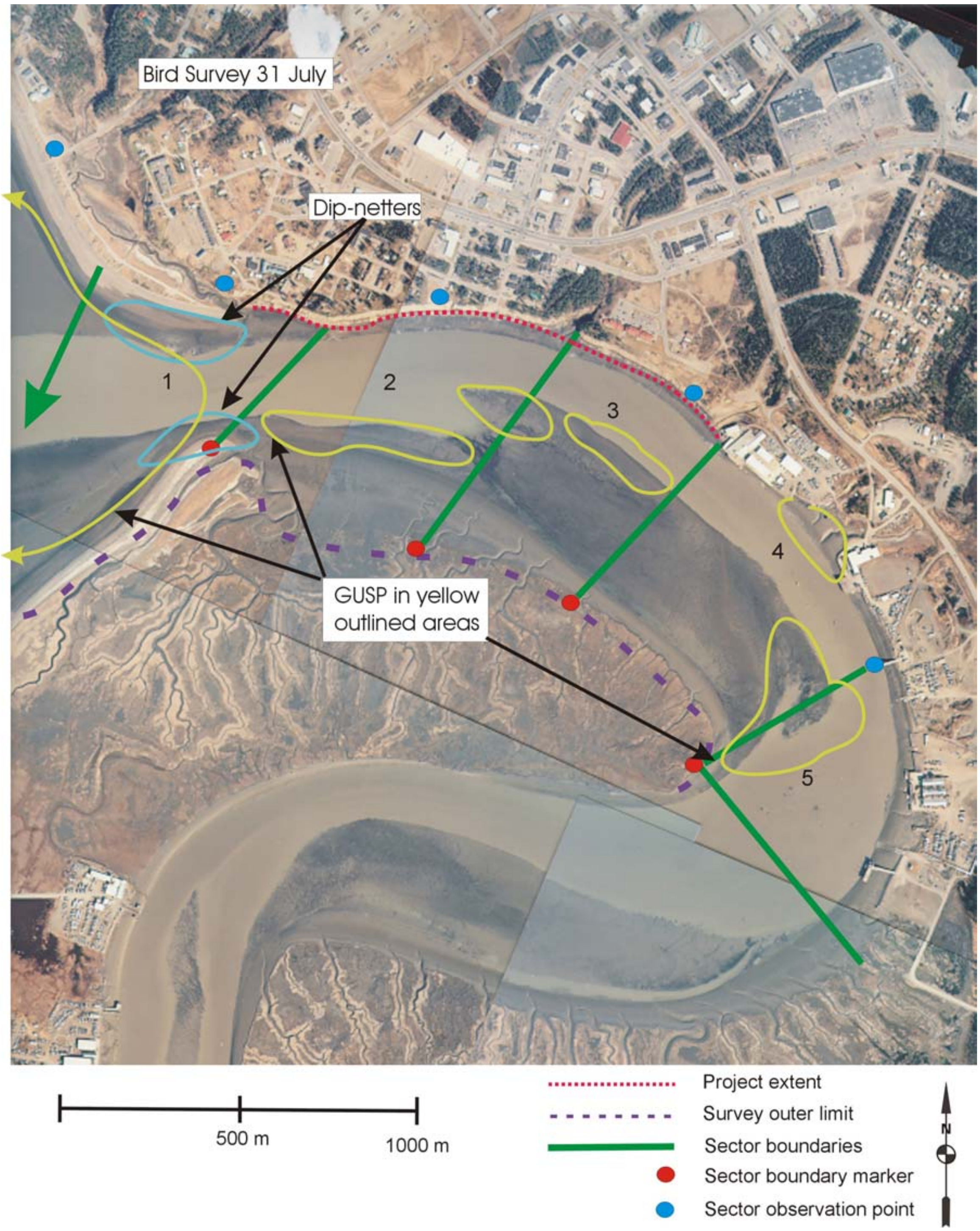



Figure 12. Bird distribution 31 July.

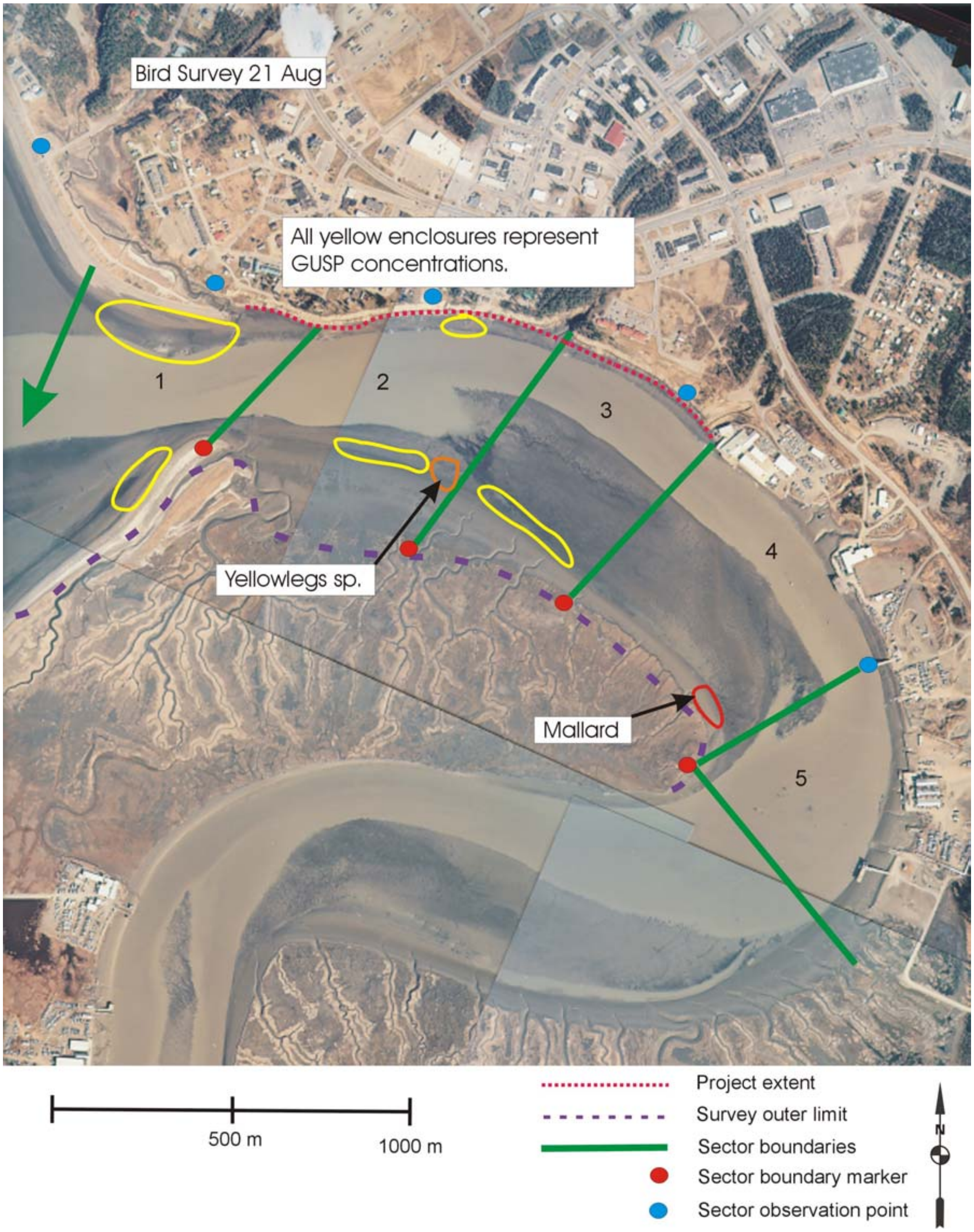



Figure 13. Bird distribution 21 August.

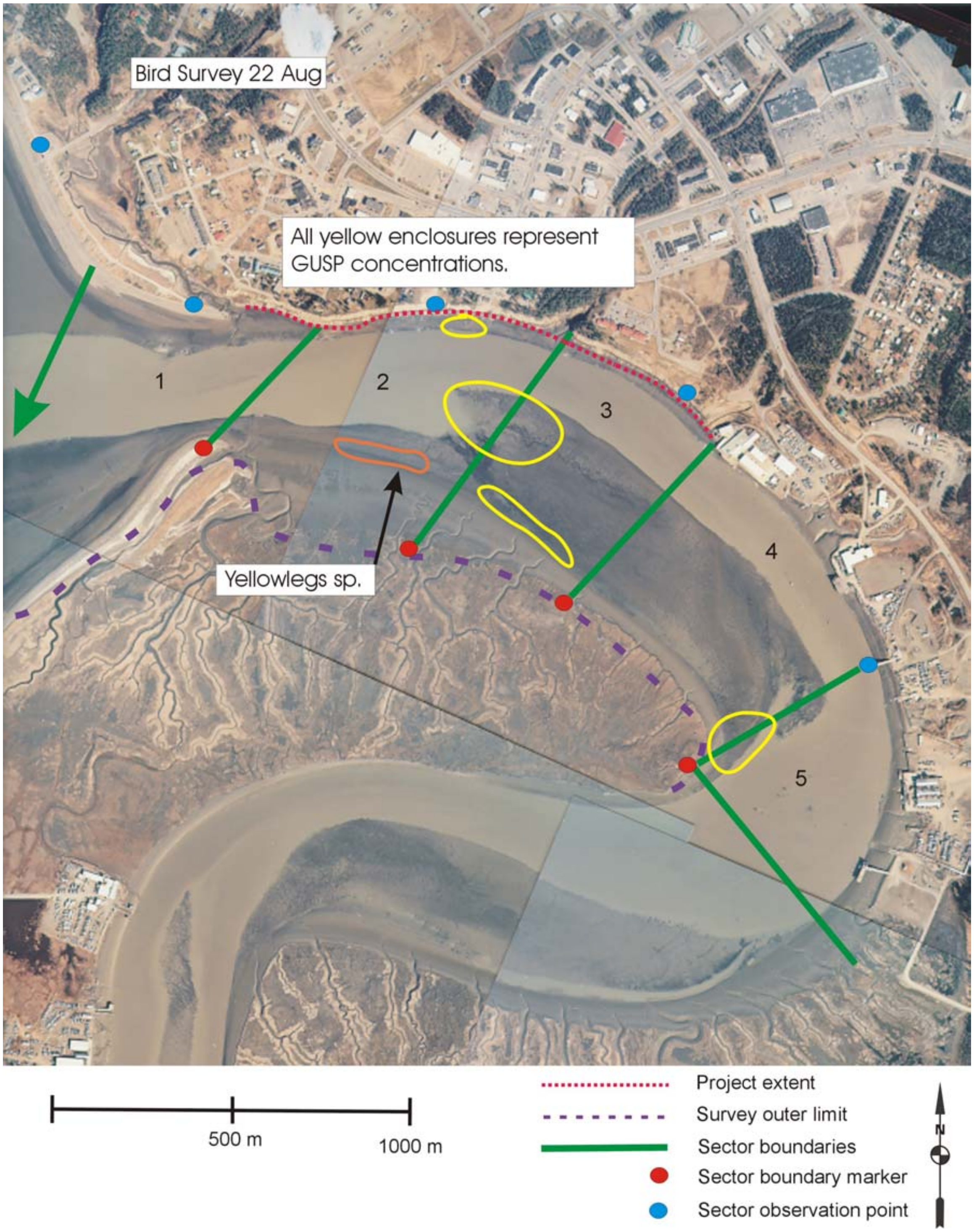



Figure 14. Bird distribution 22 August.

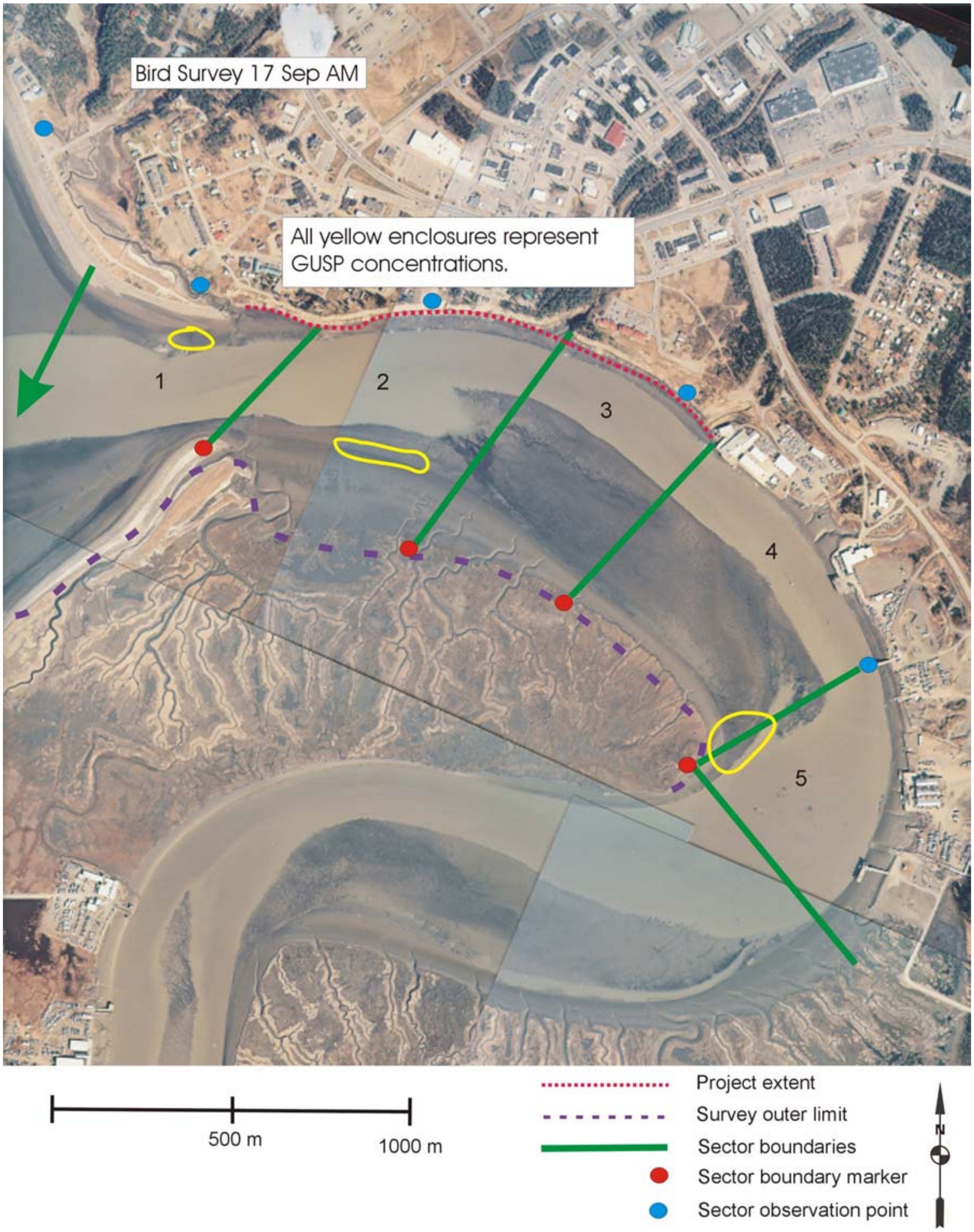



Figure 15. Bird distribution 17 September AM.

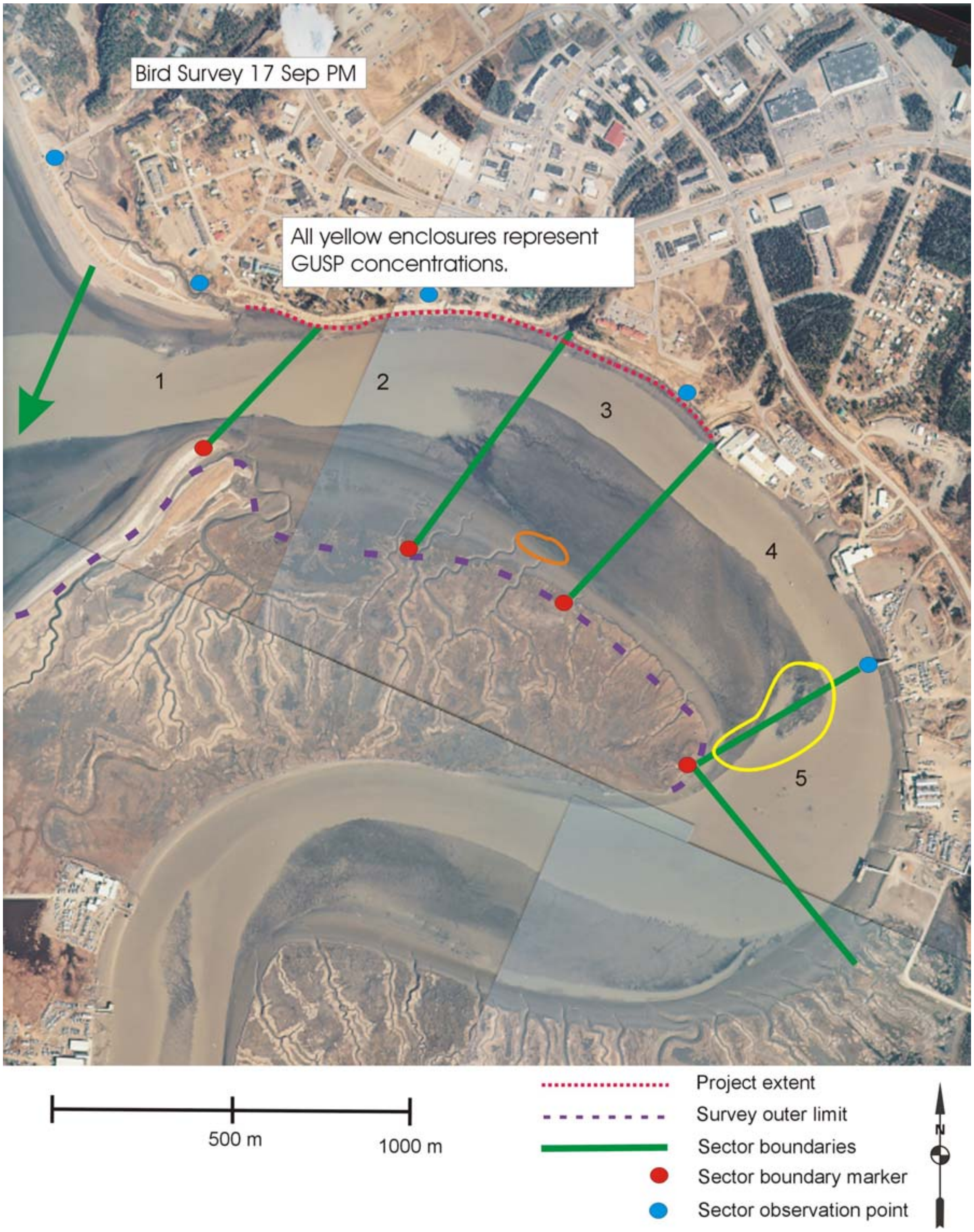



Figure 16. Bird distribution 17 September PM.

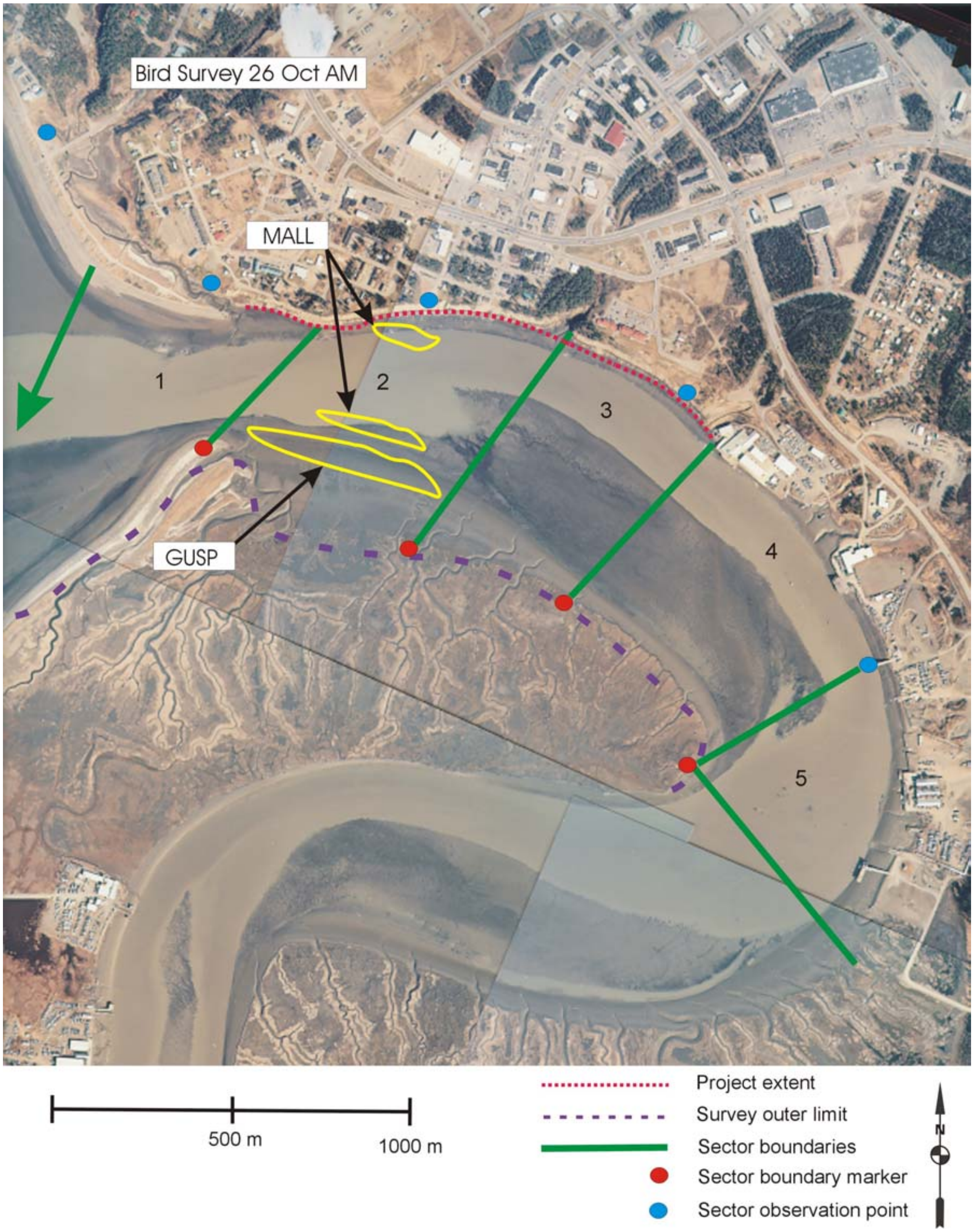



Figure 17. Bird distribution 26 October AM.

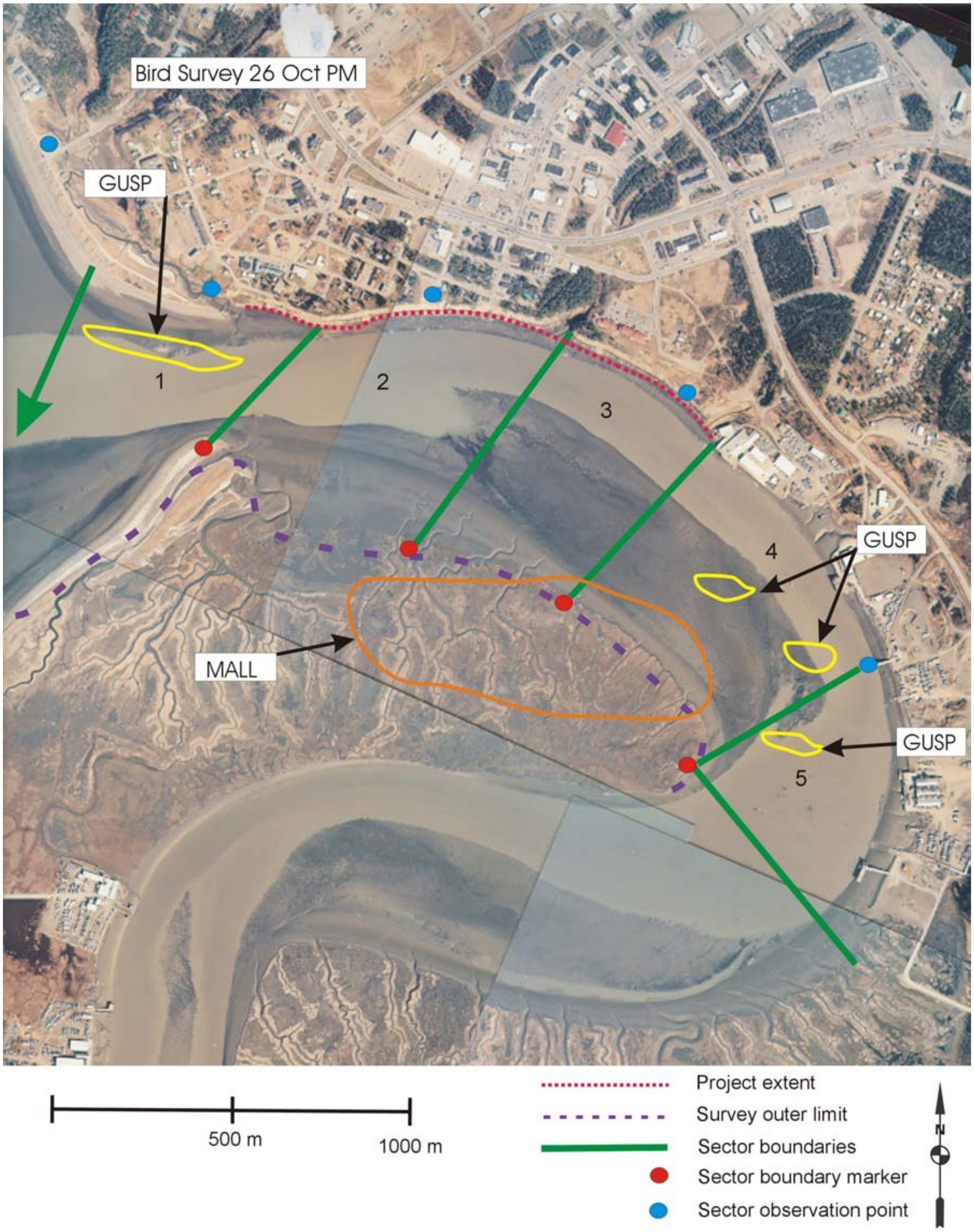



Figure 18. Bird distribution 26 October PM.

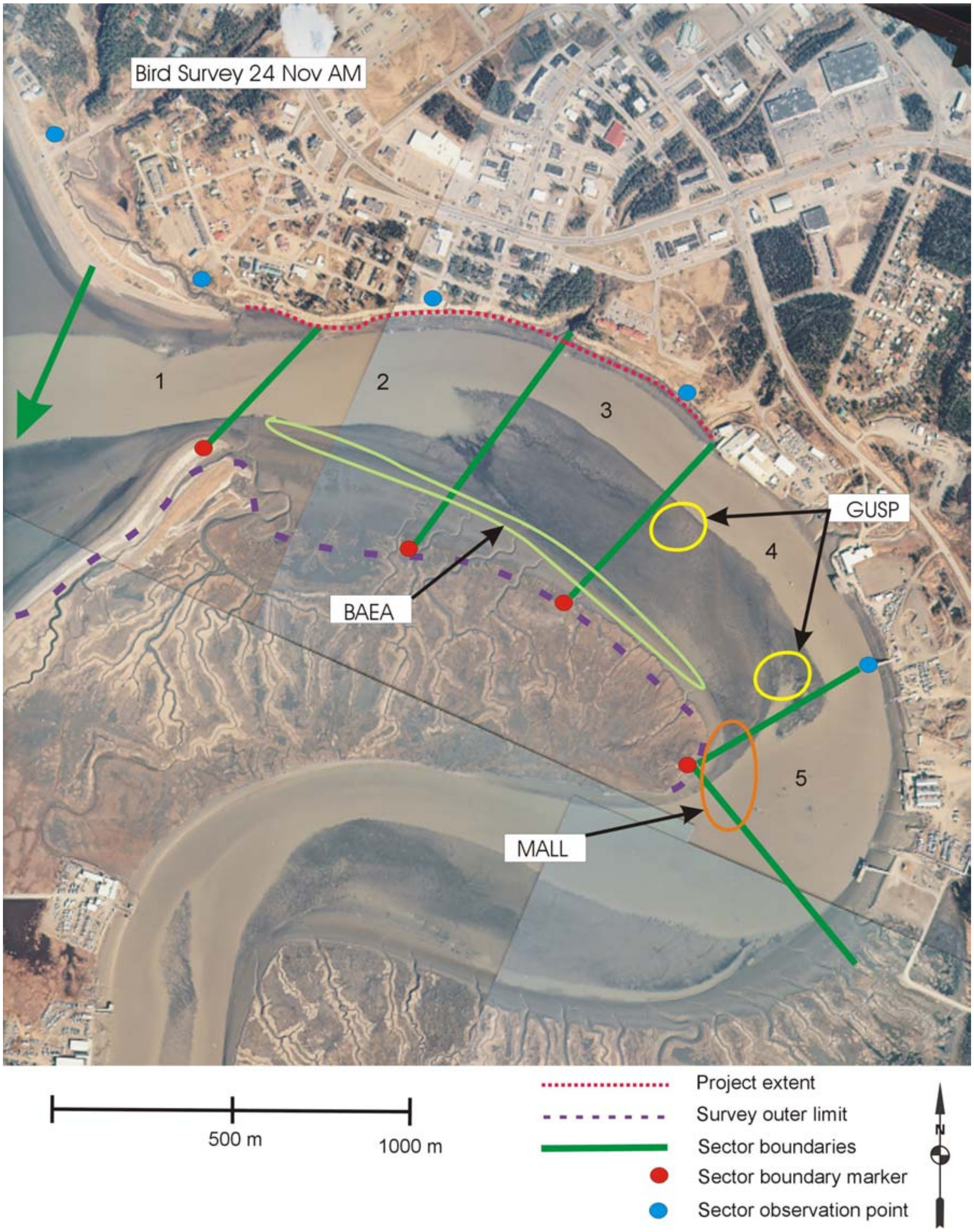



Figure 19. Bird distribution 24 November AM.

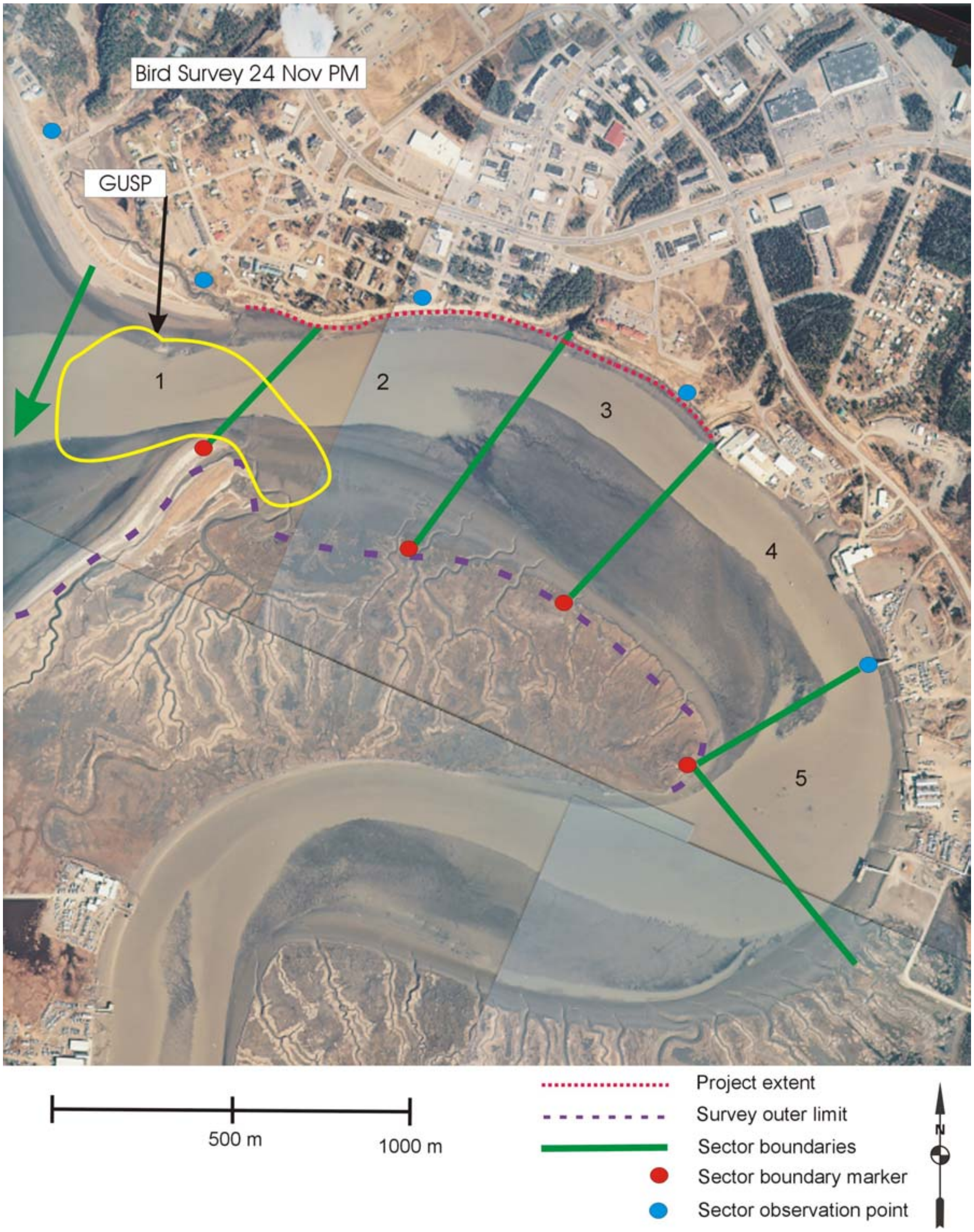



Figure 20. Bird distribution 24 November PM.

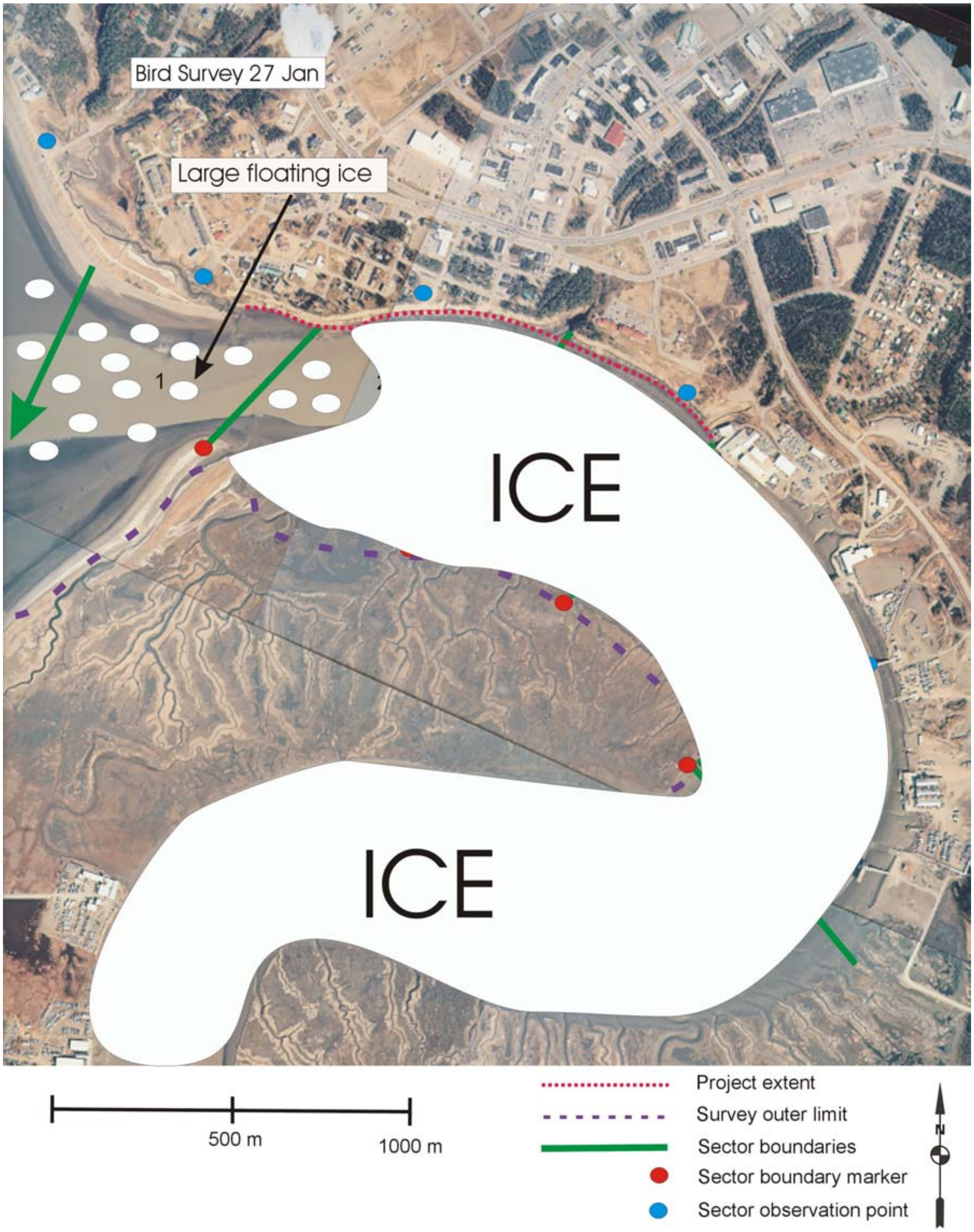



Figure 21. Bird distribution 27 January.

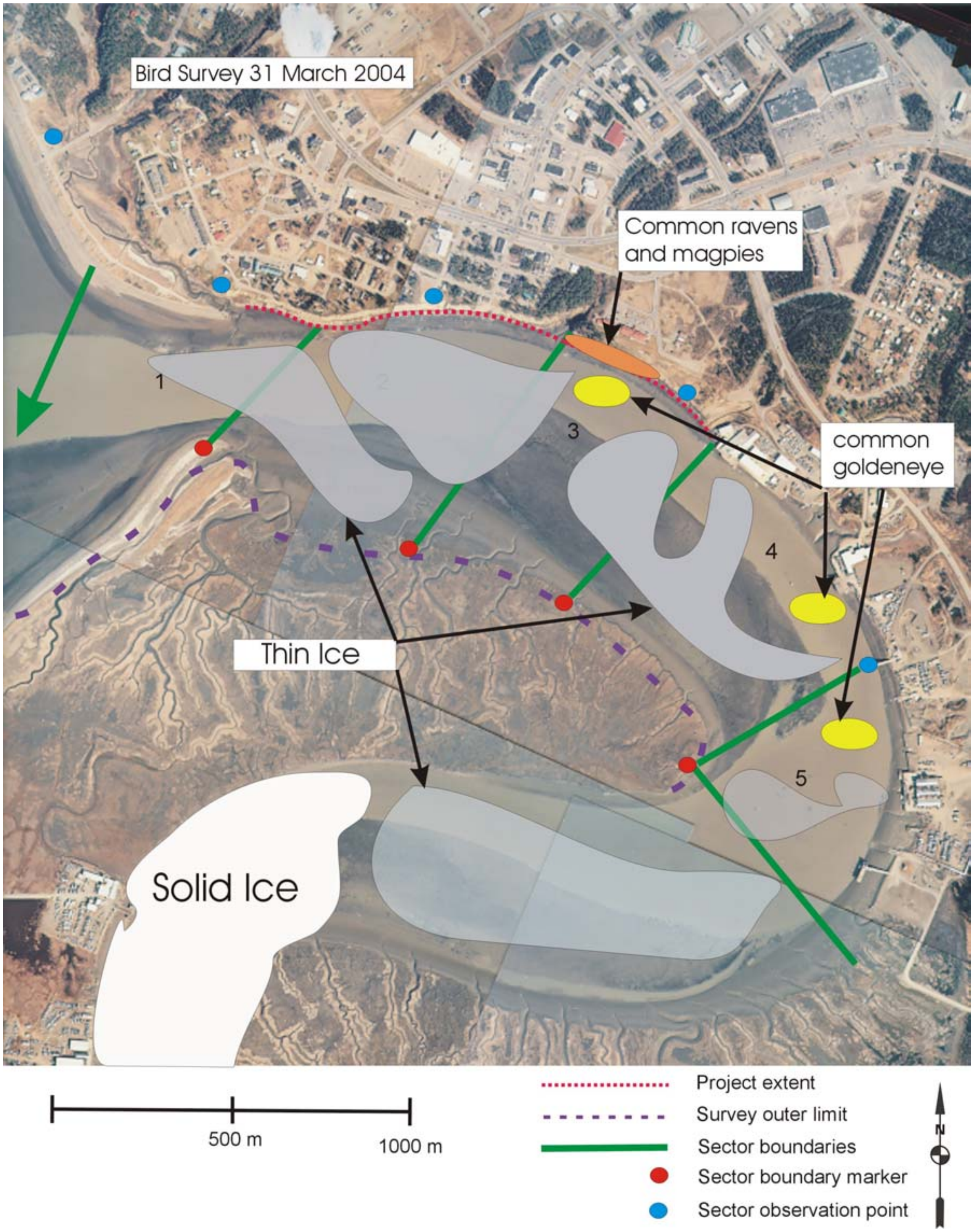



Figure 22. Bird distribution 31 March 2004.

# Table 1

Four letter abbreviation codes for birds observed on the Kenai River.

| | |
|---|---|
| ARTE | arctic tern |
| BAEA | bald eagle |
| COGO | common goldeneye |
| COME | common merganser |
| CORA | common raven |
| GUSP | gull species |
| GWTE | green-winged teal |
| HEGU | herring gull |
| LOSP | loon species |
| LTDU | long-tailed duck |
| MAGP | magpie |
| MALL | mallard |
| NOSH | northern shoveler |
| PAJA | parasitic jaegar |
| PINT | pintail |
| RBME | red-breasted merganser |
| ROSA | rock sandpiper |
| SUSC | surf scoter |
| WWSC | white-winged scoter |

Table 2

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 16-Apr-03 | Hoffman | Start Time: 1700 | End Time: 1805 | | 9:20:00 PM | 6:46:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C) | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 5-8 mph | West | 4.4 | 5 | Sunny to partly cloudy | -2.7 ft. (11:16) | 23.7 ft. (4:37) |

| Time Begin: | 1700 | 1717 | 1732 | 1750 | 1756 | 1800 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1710 | 1722 | 1738 | 1755 | 1800 | 1805 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 2 | 77 | 17 | 5 | 4 | **105** |
| BAEA | | 1 | | | | | **1** |
| CORA | | 1 | | | | | **1** |
| COGO | | | | | | 38 | **38** |
| Harbor Seal | | | 1 | | | 1 | **2** |

Inside bend wetlands: No vegetation obstructing view, good visibility. No snow geese. 75-100 Canadian geese in 2-3 groups. ~12 eagles, several hundred gulls.

Table 3

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 17-Apr-03 | Hoffman, Reed | Start Time: 907 | End Time: 10:38 | | 9:22:00 PM | 6:43:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C) | Max Temp (°C) | Weather: | Low Tide: | High Tide: |
| 5-15 mph | West | -2.0 | 11 | Overcast to partly sunny | -4.2 ft. (11:58) | 24.8 ft. (5:14) |

| Time Begin: | 907 | 930 | 948 | 1008 | 1025 | 1036 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 923 | 937 | 1000 | 1012 | 1036 | 1038 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 820 | 140 | 230 | 160 | 17 | **1367** |
| BAEA | | 67 | 15 | 3 | 39 | 1 | **125** |
| CORA | | | 9 | | 2 | | **11** |
| MALL | | | | | 2 | | **2** |
| COME | | | 4 | | 3 | | **7** |
| COGO | | | | | | 7 | **7** |
| Harbor Seal | 7 | 1 | 1 | 1 | 2 | | **12** |
| Beluga | 1 | | | | | | **1** |

Inside bend wetlands: No vegetation obstructing view, good visibility. No snow geese. Mostly gulls, some eagles.

Notes: 2 loons in marine mammal sector. Gulls on mudflat (~50) in front of observation point 1. Gulls are predominantly herring gulls.

Table 4

| Date: | Observers: | Order of Sectors Surveyed: MM-% | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 17-Apr-03 | Hoffman, Reed | Start Time: 1429 | End Time: 1517 | | 9:22 PM | 6:43 PM |
| Wind Speed: | Direction: | Min.Temp (°C) | Max Temp (°C | Weather: | Low Tide: | High Tide: |
| 5-15 mph | West | 3.9 | 5 | Overcast to partly sunny | -4.2 ft. (11:58) | 24.8 ft. (5:14) |

| Time Begin: | 1429 | 1441 | 1441 | 1452 | 1500 | 1510 | |
|---|---|---|---|---|---|---|---|
| Time End: | 1437 | 1444 | 1444 | 1457 | 1504 | 1514 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | **Total** |
| GUSP | | 37 | 128 | 24 | 74 | | **263** |
| BAEA | | 1 | | | 10 | 14 | **25** |
| CORA | | | 1 | | | | **1** |
| COGO | | | | | | 8 | **8** |
| Harbor Seal | 2 | 1 | | | 1 | 1 | **5** |

Inside bend wetlands: No vegetation obstructing view, good visibility. No snow geese. Mostly gulls (100's), some eagles.

Notes: 2 loons in marine mammal sector. Gulls on mudflat (~50) in front of observation point 1.
Gulls are predominantly herring gulls.

Table 5

| Date: | Observers: | Order of Sectors Surveyed: MM-5 | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 1-May-03 | Hoffman | Start Time: 1046 | End Time: 1308 | | 6:02:00 AM | 9:58:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 3-5 mph | variable | 10.0 | 11.7 | Overcast | -1.0 ft. (11:42) | 20.5 ft. (17:34) |

| Time Begin: | 940 | 1002 | 1034 | 1050 | 1102 | 1111 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 956 | 1012 | 1043 | 1055 | 1110 | 1115 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 650 | 93 | 110 | 390 | 160 | **1403** |
| BAEA | | 25 | 10 | 3 | 23 | 9 | **70** |
| CORA | | | 17 | 1 | 3 | 3 | **24** |
| PINT | | | | | | 2 | **2** |
| COME | | 2 | | | | | **2** |
| Harbor Seal | 30 | 4 | | | | | **34** |
| Brant | 5 | | | | | | **5** |
| Am Gol. Plover | 1 | | | | | | **1** |
| Bar-tail Godwit | 4 | 2 | | | | | **6** |
| Dowitcher spp. | 15 | 7 | | | | | **22** |

Inside bend wetlands: Some Vegetation obstructing view, good visibility.
~20 eagles, several hundred gulls.

Gulls are predominantly (~95 %) herring gulls. Other gull spp. include mew and glacous. 23 of the 30 harbor seals at the mouth of the river (sector MM) were hauled out on a large flat boulder.

Table 6

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 1-May-03 | Hoffman | Start Time:14:16 | End Time: 16:03 | | 6:02:00 AM | 9:58:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C | Weather: | Low Tide: | High Tide: |
| 5-10 mph | N | 13.3 | 13.9 | M. Cloudy | -1.0 (11:42) | 20.5 (17:34) |

| Time Begin: | 1200 | 1443 | 1504 | 1541 | 1556 | 1600 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1427 | 1449 | 1517 | 1545 | 1600 | 1603 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 17 | 10 | 10 | 47 | 10 | **94** |
| BAEA | | 1 | 8 | | 17 | | **26** |
| CORA | | 1 | 8 | 1 | | 1 | **11** |
| CAGO | | | | | 2 | | **2** |
| COLO | | 1 | | 1 | | | **2** |
| Harbor Seal | 2 | | | 1 | | | **3** |

Inside bend wetlands: No vegetation obstructing view, good visibility. ~ 24 CAGO. No snow geese or WFGO. ~30 eagles, several hundred gulls.

Notes:
Gulls are predominantly (~95 %) herring gulls. Other gull spp. include mew and glacous.

Table 7

| Date: | Observers: | Order of Sectors Surveyed: MM-5 | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 9-May-03 | Hoffman | Start Time:11:17 | End Time: 13:05 | | 5:38:00 AM | 10:25:00 PM |
| Wind Speed: | Direction: | Min Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 5 Mph G 15 | NE | 7.2 | 7.8 | M. Cloudy | 3.2 (5:33PM) | 16.0 (10:12AM) |

| Time Begin: | 11:17 | 11:14 | 12:08 | 12:42 | 12:54 | 13:00 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 11:35 | 11:53 | 12:19 | 12:49 | 12:59 | 13:05 | |
| Sector # | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 2 | 38 | 48 | 135 | 30 | 253 |
| BAEA | | 4 | 1 | 5 | 2 | | 12 |
| CORA | | 6 | | 1 | | | 7 |
| RBME | | 2 | | | | | 2 |
| ARTE | | | | 1 | 3 | 6 | 10 |
| Harbor Seal | 3 | 4 | 1 | 1 | 1 | | 10 |

South shore wetlands: ~60 CAGO, ~ 6 WFGO inland near bend in road. Also 1000+ GUSP and 50-60 BAEA.
3 SHCR flew over heading up towards bridge.
GUSP surveyed were primarily HEGU (~ 90 %). ~10% were MEGU.
1st survey of the season with ARTE present.

# Table 8

| Date: | Observers: | Order of Sectors Surveyed: MM-5 | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 11-May-03 | Hoffman | Start Time:16:29 | End Time: 17:54 | | 5:33:00 AM | 10:30:00 PM |
| Wind Speed: | Direction: | Min Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 10 Mph G 15 | W/SW | 8.9 | 9.4 | . Sunny/hazy | 2.3 (7:51PM) | 16.8 (1:05PM) |

| Time Begin: | 16:29 | 16:38 | 17:13 | 17:38 | 17:46 | 17:51 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 16:37 | 16:42 | 17:30 | 17:45 | 17:51 | 17:54 | |
| Sector # | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 210 | 45 | 76 | 280 | 90 | **701** |
| BAEA | | 2 | 1 | | 3 | | **6** |
| CORA | | | | | 1 | | **1** |
| Godwit sp. | | 12 | | | | | **12** |
| Dunlin | | | 70 | 75 | | | **145** |
| Harbor Seal | 1 | 5 | | 1 | 1 | | **8** |

Inside bend wetlands: 6 SNOG, 4 Godwit spp. 2000+ gulls, ~12 BAEA,
Gulls were primariliy HEGU.
1 coyote observed between the bridge and the public boat launch.

Sector 2 had several trucks and ATVs on the beach, possibly influencing bird count.

Sector 4. Most GUSP were on the shoal since the tide was out.

14 May 03 I walked the entire perimeter of the south shore wetlands to gather sediment samples.
Eggs were found in ~20 % of HEGU nests. All but one nest had only one egg in it. This was likely near the beginnig of the laying period.

Table 9

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 25-Jun-03 | Hoffman | Start Time: 0940 | End Time: 1115 | | 4:36:00 AM | 11:38 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | 12.8 | 13.3 | Mostly Cldy | 2.5 ft. (9:01) | 16.2 ft. (14:56) |

| Time Begin: | 940 | 1002 | 1034 | 1050 | 1102 | 1111 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 956 | 1012 | 1043 | 1055 | 1110 | 1115 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 220 | 33 | 57 | 35 | | **345** |
| BAEA | | | | | 1 | | **1** |
| CORA | | | | 1 | | | **1** |
| PINT | | | | 4 | | | **4** |
| COME | | | 1 | | | | **1** |
| Brant | | | | 1 | | | **1** |
| Yellowlegs spp. | 11 | | | | | | **11** |
| LOSP | | 4 | | | | | **4** |
| Swallow spp. | | | 35 | | | | **35** |
| Harbor Seal | 6 | | | | 1 | | **7** |

Inside bend wetlands:  Some vegetation obstructing view, good visibility.
Several thousand gulls (mostly HEGU), many sittting on nests. 1 BAEA, 1 Mallard.

Table 10

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 25-Jun-03 | Hoffman | Start Time: 1430 | End Time: 1533 | | 4:36:00 AM | 11:38 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 10 G 15 inc to 15 G 20 @ ~ 1500 | NE | 15.0 | 15.6 | Mostly Cldy | 2.5 ft. (9:01) | 16.2 ft. (14:56) |

| Time Begin: | 1430 | 1445 | 1505 | 1518 | 1524 | 1529 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1440 | 1450 | 1510 | 1524 | 1529 | 1533 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP* | | 2 | 32 | 115 | 450 | 52 | **651** |
| BAEA | | | 1 | | | | **1** |
| CORA | | | 2 | | | | **2** |
| PINT | | | | 4 | | | **4** |
| Harbor Seal | | | | | | | **0** |
| Brant | | | | 1 | | | **1** |
| LOSP | | | | | 1 | | **1** |
| SUSC | 18 | | | | | | **18** |
| ARTE | | 2 | | | 1 | | **3** |
| PAJA (dark morph) | | 1 | | | | | **1** |
| Swallow spp. | | 1 | | | | | **1** |

* GUSP in sector 4 were observed while a vessel was offloading fish at the pier (sector 4/5 boundary.)

No inside bend survey information. A male ruff (Philomachus pugnax) in breeding plumage was sighted in the wetlands near the boat launch and time ran out for surveying SSWL.

Table 11

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 31-Jul-03 | Hoffman | Start Time: 1340 | End Time: 1512 | | 5:39:00 AM | 10:41 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | 18.3 | 20 | Partly Sunny | -2.2 (1:04PM) | 21.3 (7:07PM) |

| Time Begin: | 1340 | 1400 | 1426 | 1446 | 1456 | 1510 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1355 | 1420 | 1438 | 1453 | 1509 | 1512 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 1000 | 600 | 80 | 1500 | 400 | **3580** |
| MALL | | | | 10 | | | **10** |
| Harbor Seal | 2 | | | | | | **2** |
| yellowlegs sp. | | | | 15 | | | **15** |

Most GUSP were HEGU. Large numbers of GUSP appeared to be associated with fish processing plants and dipnetting (at mouth). Inside bend wetlands: Several thousand gulls, mostly HEGU.

BAEA are essentially absent (1 sighted on inside bend wetlands). This agrees with observations of locals as well as situation in Dutch Harbor where BAEA drop from several hundred in winter to several dozen in summer. In Kenai, GUSP increase in summer and drop down in winter (opposite trend of BAEA).

~ 2,000 GUSP were observed in the MM survey area (see Corel map) since the survey was during low tide.

Table 12

| | | | | | | |
|---|---|---|---|---|---|---|
| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
| 21-Aug-03 | Hoffman | Start Time: 1512 | End Time: 1627 | | 6:31:00 AM | 9:42 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| ~ 5mph | SW | 15.6 | 16.7 | Mostly Sunny | 9.1 (6:06PM) | 14.4 (12:31PM) |

| Time Begin: | 1512 | 1531 | 1342 | 1601 | 1618 | 1625 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1523 | 1535 | 1551 | 1607 | 1624 | 1627 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 129 | 127 | 126 | 310 | 28 | **720** |
| MALL | | | 9 | 3 | 38 | | **50** |
| GWTE | | | | 2 | 10 | | **12** |
| Harbor Seal | 1 | | | | | | **1** |
| LOSP | 1 | | | | | | **1** |
| Godwit sp. | | | 2 | | | | **2** |
| yellowlegs sp. | | | 36 | | 1 | | **37** |

Inside bend wetlands: Several hundred GUSP, most but not all have fledged (later walk of the area confirmed this). Most GUSP are HEGU in this area.

Inside bend wetalnds walk: Godwits and Yellowlegs fedding rigt at waters edge. I dug in the mud near the waters edge and found more small clams (Tellina sp.).

Table 13

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 22-Aug-03 | Hoffman | Start Time: 1107 | End Time: 1223 | | 6:33:00 AM | 9:39 PM |
| Wind Speed: | Direction: | Min Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | 15.6 | 17.8 | Sunny | 5.1 (7:44AM) | 15.1 (2:11PM) |

| Time Begin: | 1107 | 1120 | 1130 | 1155 | 1215 | 1220 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1115 | 1125 | 1144 | 1205 | 1220 | 1223 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 85 | 55 | 88 | 92 | 14 | **334** |
| Bonapartes GU | | | | 1 | | | **1** |
| NOSH | | | 13 | | | | **13** |
| CORA | | | 42 | | | | **42** |
| Harbor Seal | 3 | 1 | | | | | **4** |
| LOSP | 3 | | | | | | **3** |
| Godwit sp. | | | 1 | | | | **1** |
| yellowlegs sp. | | | 69 | | | | **69** |

Inside bend wetlands: Several hundred HEGU, some still not fledged.

Table 14

| | | | | | | |
|---|---|---|---|---|---|---|
| Date: | Observers: | Order of Sectors Surveyed: I | | | Sun Rise: | Sunset: |
| 17-Sep-03 | Hoffman | Start Time:0947 | End Time: 1132 | | 7:36:00 AM | 8:20:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 5-10 mph | N | 4.4 | 10 | Sunny | 7.3 (3:09PM) | 16.7 (9:10AM) |

| Time Begin: | 947 | 1006 | 1033 | 1055 | 1120 | 1125 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 958 | 1014 | 1042 | 1102 | 1125 | 1132 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 317 | 470 | 16 | 47 | 105 | **955** |
| PINT | | | 3 | | | | **3** |
| Harbor Seal | 3 | | 1 | 3 | | | **7** |
| MAGP | | | | 1 | | | **1** |
| Sandpiper sp. | | | | | | 12 | **12** |

Inside bend wetlands: Several hundred GUSP (mostly HEGU) observed in open patches. No SNGO observed.

Table 15

| | | | | | | |
|---|---|---|---|---|---|---|
| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
| 17-Sep-03 | Hoffman | Start Time: 1452 | End Time: 1612 | | 7:36:00 AM | 8:20:00 PM |
| Wind Speed: | Direction: | Min Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | 11.7 | 12.8 | Sunny | 7.3 (3:09PM) | 16.7 (9:10AM) |

| Time Begin: | 1452 | 1514 | 1532 | 1543 | 1600 | 1608 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1502 | 1522 | 1537 | 1552 | 1607 | 1612 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 34 | 6 | 10 | 127 | 85 | **262** |
| MALL | | | | 48 | 13 | | **61** |
| Harbor Seal | 2 | | 1 | | | 1 | **4** |
| yellowlegs sp. | | | | 7 | | | **7** |

Inside bend wetlands: ~1500 GUSP, primatily HEGU with juvs. No BAEA observed today in or beyond the survey area.

Table 16

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 26-Oct-03 | Hoffman | Start Time: 0925 | End Time: 1054 | | 8:13:00 AM | 5:23 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 0-10 mph | NE | 0.6 | 3.3 | P. Cloudy | 0.7 ft (10:44) | 25.7 ft (16:22) |

| Time Begin: | 925 | 948 | 1010 | 1033 | 1042 | 1050 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 940 | 957 | 1017 | 1039 | 1050 | 1054 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 418 | 169 | 55 | 143 | 25 | **810** |
| MALL | | | 74 | 4 | 49 | | **127** |
| BAEA | | 5 | | 2 | | | **7** |
| CORA | | 9 | 1 | | | | **10** |
| COGO | | 3 | | | | | **3** |
| RBME | | 1 | | | | | **1** |
| Harbor Seal | 7 | | 1 | | | | **8** |

Inside bend wetlands: All of the ponds and low areas were flooded due to recent high tides, but no birds weere observed on the ponds.

Table 17

| | | | | | | |
|---|---|---|---|---|---|---|
| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
| 26-Oct-03 | Hoffman | Start Time:1524 | End Time: 1630 | | 8:13:00 AM | 5:23:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | 5.6 | 6.7 | overcast and light rain | 0.7 (1044) | 25.7 (1622) |

| Time Begin: | 1524 | 1548 | | | | | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1535 | 1559 | | | | | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 109 | See Note 1 below | | | | **109** |
| WWSC | | 5 | | | | | **5** |
| Harbor Seal | 1 | | | | | | **1** |

NOTE 1: Due to the high tide, this area was ~90% under water. Since survey boundaries were underwater, birds were counted for the entire area and their locations were maked on a survey map. There were ~ 560 mallards and 70 gulls (primarily HEGU).

Inside bend wetlands: All of the ponds and low areas were flooded due to recent high tides, but no birds were observed on the ponds.

Table 18

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
| 24-Nov-03 | Hoffman | Start Time: 1053 | End Time: 1209 | | 9:28:00 AM | 4:14 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | -5.6 | -6.1 | Overcast | 1.7 ft (10:23) | 25.5 ft (15:58) |

| Time Begin: | 1053 | 1122 | 1133 | 1156 | 1200 | 1205 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1112 | 1127 | 1140 | 1159 | 1205 | 1209 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 5 | | | 21 | 2 | **28** |
| MALL | | | | 4 | 23 | 41 | **68** |
| BAEA | | 8 | 10 | 10 | 9 | | **37** |
| CORA | | 5 | 1 | | 4 | | **10** |
| Trump swan | | | | | 1 | | **1** |
| Harbor Seal | 5 | | | 1 | 1 | 1 | **8** |

Inside bend wetlands: BAEA around the periphery, otherwise the interior was frozen and snow-covered.

Table 19

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 24-Nov-03 | Hoffman | Start Time: 1448 | End Time: 1548 | | 9:28:00 AM | 4:14 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | -4.4 | -5 | Overcast | 1.7 ft (10:23) | 25.5 ft (15:58) |

| Time Begin: | 1100 | 1120 | 1127 | 1134 | 1136 | 1140 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1114 | 1122 | 1130 | 1136 | 1139 | 1143 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | 240 | 64 | 22 | 10 | | **336** |
| MALL | | | | 10 | | | **10** |
| BAEA | | | | 2 | | 2 | **4** |
| Harbor Seal | | | | | | | **0** |

Inside bend wetlands: This area was heavily flooded by the tide, no birds were observed in the interior of the area that remained dry during the survey period.

Table 20

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 29-Dec-03 | Hoffman | Start Time: 1100 | End Time: 1143 | | 10:13:00 AM | 4:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 10-15 mph | N | 1.7 | 2 | Overcast | 4.9 ft (15:26) | 19.5 ft (9:01) |

| Time Begin: | 1100 | 1120 | 1127 | 1134 | 1136 | 1140 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1114 | 1122 | 1130 | 1136 | 1139 | 1143 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | | 5 | | | | **5** |
| MALL | | | | 4 | 1 | | **5** |
| CORA | | | 1 | | | | **1** |
| ROSA | | | | | | | **0** |
| BAEA | | | | | | | **0** |
| Harbor Seal | | | | | | | **0** |

Some mallards (20-30) in MM sector. Larege blocks of ice in river.
River frozen solid upstream of sector 5.

NO MAP MADE FOR THIS DAY DUE TO LACK OF BIRDS

Table 21

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 29-Dec-03 | Hoffman | Start Time: 1400 | End Time: 1449 | | 10:13:00 AM | 4:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 10-15 mph | N | 1.7 | 1.7 | Overcast | 4.9 ft (15:26) | 19.5 ft (9:01) |

| Time Begin: | 1400 | 1421 | 1427 | 1434 | 1439 | 1445 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1408 | 1423 | 1431 | 1439 | 1445 | 1449 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | | 1 | | 2 | | **3** |
| MALL | | | | | 47 | | **47** |
| BAEA | | | | | | | **0** |
| Harbor Seal | | | | | | | **0** |

Inside bend wetlands: No birds were found. Thus area was frozen and snow covered. Some blocks of ice have been deposited by the tide.

NO MAP MADE FOR THIS DAY DUE TO LACK OF BIRDS

Table 22

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 27-Jan-04 | Hoffman | Start Time: 1050 | | End Time: 1130 | 9:33:00 AM | 5:02 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| 20 mph | N | -10.6 | -10.6 | Overcast | 3.3 ft (14:40) | 20.6 ft (8:04) |

| Time Begin: | 1050 | 1113 | 1125 | | | | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1105 | 1118 | 1130 | | | | |
| Sector # | MM* | 1 | 2 | 3 | 4 | 5 | |
| GUSP | | | 1 | Not surveyed. Frozen solid. | | | 1 |
| MALL | | | | | | | 0 |
| BAEA | | | | | | | 0 |
| MAGP | | | | | | | 0 |
| ROSA | | | | | | | 0 |
| Harbor Seal | 35 | | | | | | 35 |

In MM sector there were about 35 rock sandpipers (ROSA). They were all riding a large ice floe down the river.

Inside bend wetlands: No birds were found. Thus area was frozen and snow covered.
Some blocks of ice have been deposited by the tide.

Table 23

| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
|---|---|---|---|---|---|---|
| 26-Feb-04 | Hoffman | Start Time: 1045 | End Time: 1131 | | 8:14:00 AM | 6:22:00 PM |
| **Wind Speed:** | **Direction:** | **Min.Temp (°C):** | **Max Temp (°C):** | **Weather:** | **Low Tide:** | **High Tide:** |
| calm | variable | -2.2 | -1.1 | Overcast | 3.1 (1436) | 19.8 (7:42) |

| Time Begin: | 1045 | 1055 | 1112 | 1122 | 1125 | 1129 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1055 | 1107 | 1116 | 1125 | 1129 | 1131 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | | 1 | 1 | | 1/2 covered with ice. No birds in open water | **2** |
| MALL | | | 2 | | | | **2** |
| BAEA | | 1 | 2 | | | | **3** |
| CORA | | | 3 | | | | **3** |
| COGO | | 5 | | 3 | 9 | | **17** |
| LTDU | | 3 | | | | | **3** |
| MAGP | | | 2 | | | | **2** |
| ROSA | | 35 | | | | | **35** |
| Harbor Seal | | | | | | | **0** |

Inside bend wetlands: No birds were found. Thus area was frozen and snow covered. Some blocks of ice have been deposited by the tide.

NO MAP MADE FOR THIS DAY DUE TO LOW NUMBERS OF BIRDS

Table 24

| | | | | | | |
|---|---|---|---|---|---|---|
| Date: | Observers: | Order of Sectors Surveyed: | | | Sun Rise: | Sunset: |
| 31-Mar-04 | Hoffman | Start Time: 1048 | End Time: 1145 | | 10:13:00 AM | 4:00:00 PM |
| Wind Speed: | Direction: | Min.Temp (°C): | Max Temp (°C): | Weather: | Low Tide: | High Tide: |
| calm | variable | -11.1 | -10 | M. cloudy | 8.4 (7:16) | 15.9 (1232) |

| Time Begin: | 1048 | 1108 | 1120 | 1129 | 1136 | 1141 | Total |
|---|---|---|---|---|---|---|---|
| Time End: | 1100 | 1111 | 1125 | 1136 | 1141 | 1145 | |
| **Sector #** | **MM** | **1** | **2** | **3** | **4** | **5** | |
| GUSP | | | | | | | **0** |
| COGO | 3 | | | 19 | 24 | 31 | **77** |
| CORA | | | | 12 | | | **12** |
| MAGP | | | | 8 | | | **8** |
| Harbor Seal | | 1 | 3 | | | | **4** |

Inside bend wetlands: A few scattered eagles were found. This area was frozen and snow covered. Some blocks of ice have been deposited by the tide near the edge of the river.

This day was vary cold for late March. Previous weeks had been -3 to 2 °c.

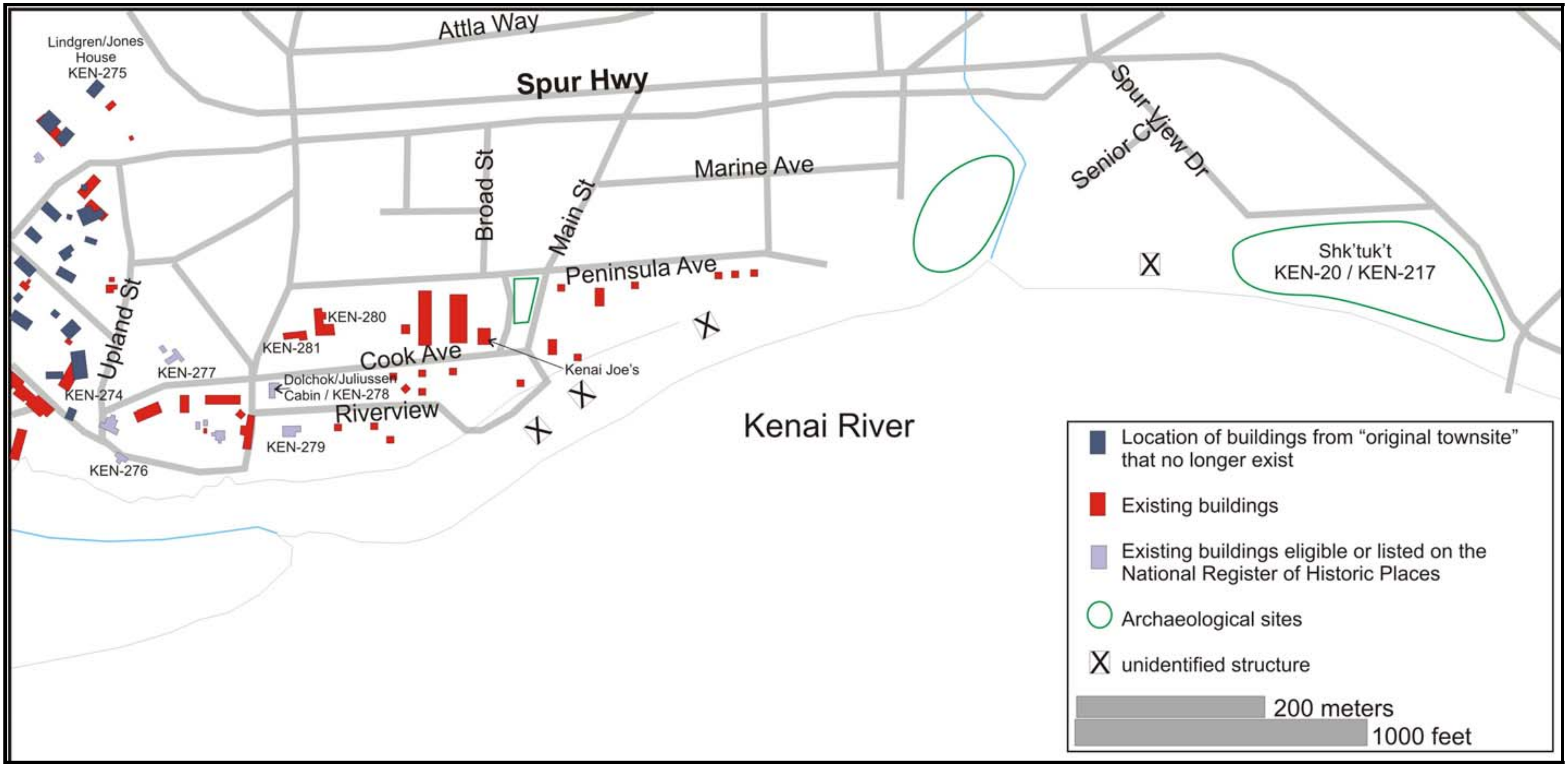
# Kenai River Cultural Resources

There are several cultural resources in the area of this project. There are the remains of 3 archaeological sites and at least 25 structures in the general area of the project (figure 1). Two of the archaeological sites are unnamed. The first is a semi-subterranean house pit in the woods on private property southeast of Central Peninsula Counseling Services. The second is a semi-subterranean house pit in the woods east of Kenai Joe's Bar. Dr. Alan Boraas, professor of anthropology at Kenai Peninsula College, stated that the third archaeological site (*Shk'ituk't,* KEN-00020) was the primary Dena'ina settlement in the area and was occupied until at least 1900. Although the site had reportedly been bulldozed, Boraas believes that intact deposits remain and that the site should be re-examined. He pointed out that local people had found recovered copper and stone artifacts from the site, indicative of intact deposits. He concluded that the site is considered a traditional cultural place by members of the Kenaitze Indian Tribe.

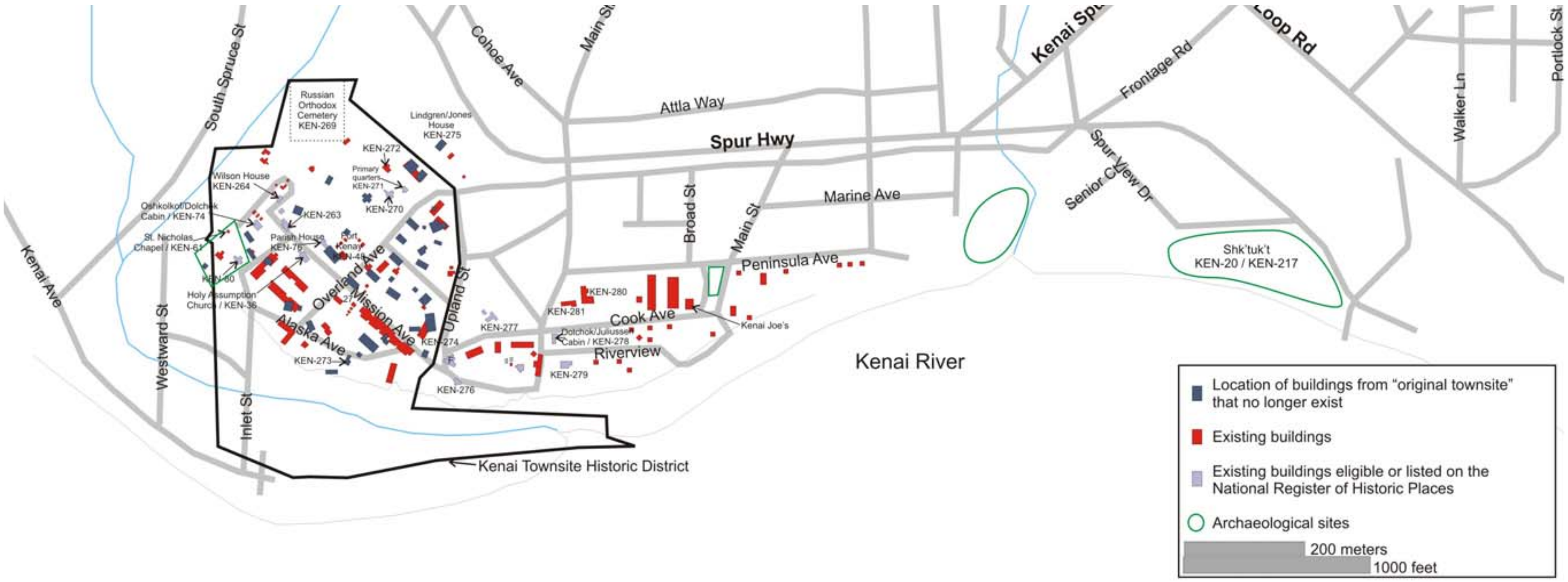
Of the approximately 25 structures, 7 are eligible for the National Register of Historic Places and the remainder must be evaluated for the Register. Four unidentified structures along the bluff face also must be evaluated. Two of the structures were square, had log sides approximately 4 feet long, and notched corners. The third structure, unlike the other three, had log corner posts and beams with corrugated metal siding. The fourth, eastern-most structure appeared to be made of milled lumber that was overlapped at the corners.

In addition, a portion of the project is within the boundaries of a locally designated historic district. Several structures along the bluff are included in the 1996 *Kenai Townsite Historic District Survey Report* (figure 2). There are also several buildings that were not evaluated in the 1996 report that may be historic.

If this project is built, four tasks need to be completed as required under Section 106 of the National Historic Preservation Act, the National Environmental Policy Act, and other federal and state laws. First, the buildings within the project area that have not been evaluated for the National Register of Historic Places need to be and the unknown log structures need to be examined more closely and then evaluated for the National Register. Second, *Shk'ituk't* (KEN-00020) and the two archaeological sites need to be evaluated for the National Register as an archaeological site and as traditional cultural properties. Third, after permission is obtained to enter private land, the project area needs to be surveyed for unreported archaeological sites. And finally, local people and elders need to be consulted and interviewed for information about cultural resources within the project area.



Attla Way
Spur Hwy
Lindgren/Jones House KEN-275
Marine Ave
Broad St
Main St
Spur View Dr
Senior Ct
Peninsula Ave
Shk'tuk't KEN-20 / KEN-217
Upland St
KEN-280
KEN-281
Cook Ave
Kenai Joe's
KEN-277
Dolchok/Juliussen Cabin / KEN-278
KEN-274
Riverview
KEN-279
KEN-276
Kenai River
Location of buildings from "original townsite" that no longer exist
Existing buildings
Existing buildings eligible or listed on the National Register of Historic Places
Archaeological sites
unidentified structure
200 meters
1000 feet



Russian Orthodox Cemetery KEN-269
Lindgren/Jones House KEN-275
KEN-272
Primary quarters KEN-271
KEN-270
Wilson House KEN-264
KEN-263
Oshkolkof/Dolchok Cabin / KEN-74
St. Nicholas Chapel / KEN-61
Parish House KEN-76
Holy Assumption Church / KEN-36
KEN-273
KEN-274
KEN-276
KEN-277
KEN-281
KEN-280
Dolchok/Juliussen Cabin / KEN-278
KEN-279
Kenai Joe's
Shk'tuk't KEN-20 / KEN-217
Kenai Townsite Historic District
Kenai River
South Spruce St
Kenai Ave
Westward St
Inlet St
Cohoe Ave
Main St
Attla Way
Spur Hwy
Marine Ave
Broad St
Peninsula Ave
Cook Ave
Riverview
Overland Ave
Mission Ave
Alaska Ave
Upland St
Kenai Spur
Loop Rd
Frontage Rd
Spur View Dr
Senior Center
Walker Ln
Portlock St
Location of buildings from "original townsite" that no longer exist
Existing buildings
Existing buildings eligible or listed on the National Register of Historic Places
Archaeological sites
200 meters
1000 feet

# Kenai River Estuary Baseline Fisheries Assessment

**T. M. Willette**
**J. M. Edmundson**
**R. D. DeCino**

**Regional Information Report No. 2A04-13**

**Alaska Department of Fish and Game**
**Commercial Fisheries Division**
**333 Raspberry Rd.**
**Anchorage, Alaska 99518-1599**

**March 2004**

[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or of the Commercial Fisheries Division.

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**ABSTRACT**

This report describes a baseline fisheries assessment focused on documenting the fish assemblage and some predator-prey interactions occurring in the Kenai River estuary. We sampled fishes and macroinvertebrates using five gear types during four sampling periods, and we conducted stomach content analyses and constructed partial food webs for finfishes. We also collected zooplankton samples and continuous measurements of water temperature and salinity during each sampling period. We documented the occurrence of 31 taxonomic groups of animals in the estuary, 19 of which are marine, 8 are anadromous, and 4 typically occur in estuaries but also in freshwater or coastal marine habitats. Epibenthic invertebrates (mostly *Crangon* spp., *Neomysis* spp., and *Saduria* spp.) dominated the fauna sampled in April. Eulachon dominated the fauna sampled in the water column in June and September. Six taxonomic groups of finfish were significantly more numerous in our catches in September than in previous sampling periods. Zooplankton densities in the estuary were low. The brackish water genera *Eurytemora* and the epibenthic genera *Harpacticus* occurred in zooplankton samples during every period. A partial food web for the estuary during April was based primarily upon benthic invertebrate prey, mostly amphipods. The complexity of the partial food web in June increased dramatically. Thirty-three percent of the finfishes sampled in June were benthic invertebrate feeders, while 40% were primarily piscivores, 13% planktivores, and 13% insectivores. The complexity of the partial food web decreased in September. While the total number of finfish taxonomic groups increased, the number of piscivores declined. Infaunal prey (primarily polychaetes and bivalves) were not important in these partial food webs during any sampling period. Coho salmon, chinook salmon, Pacific staghorn sculpin, Pacific tomcod, and starry flounder consumed juvenile salmon, but salmon were not a dominant prey in the diet of these fishes. Time series of temperature and salinity revealed the highly dynamic nature of the physical environment in the estuary. During all months except April, salinities near the bottom of the estuary dropped from greater than 20 ppt to near 0 ppt within 2-3 hours of high tide.

KEYWORDS: *Crangon* spp., *Neomysis* spp., *Eurytemora* spp., *Harpacticus* spp., Pacific salmon, *Oncorhynchus* spp., Eulachon, *Thaleichthys pacificus,* zooplankton, food webs.

# INTRODUCTION

The City of Kenai has proposed an erosion control project to stabilize a one-mile section of the bluffs fronting the city along the Kenai River. The proposed project plans received numerous comments from various agencies and local residents raising concerns regarding potential impacts to marine mammals, birds, and fishes that inhabit this area. The U.S. Army Corps of Engineers will be conducting studies designed to predict changes to the hydrology and sediment transport in the estuary that may result from the proposed project. These studies are expected to be complete by the spring of 2004. An interagency review team has determined that studies of the biological effects of the proposed project should be limited to baseline resource assessments until results from hydrology and sediment transport studies are available to help focus agency concerns regarding effects of the project. This report describes baseline studies focused on documenting the fish assemblage and some predator\prey interactions occurring in the Kenai River estuary. The study was limited to the area immediately adjacent to the bluffs fronting the City of Kenai, because this area will be most directly affected by the proposed bluff stabilization project.

Three fisheries studies have documented the occurrence of 6 freshwater species, 11 anadromous species, and 14 marine species of fish in the Kenai River estuary. Bendock and Bingham (1988a) sampled fishes using minnow traps, beach seines, and a substrate sampler between October 1986 and March 1987. They documented the presence of juvenile chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kitsutch*), slimy sculpin (*Cottus cognatus*), Pacific staghorn sculpin (*Leptocottus armatus*), threespine stickleback (*Gasterosteus aculeautus*), ninespine stickleback (*Pungitius pungitius*), longfin smelt (*Spirinchus thaleichthys*), Pacific herring (*Clupea harengus pallasi*), starry flounder (*Platichthys stellatus*), Pacific tomcod (*Microgadus proximus*), and snailfish (*Liparus spp*.) in the estuarine habitat. Bendock and Bingham (1988b) used these same gear types to sample fishes in the estuary between July and October, 1987. They documented the presence of these same 12 species, but also found pink salmon (*O. gorbuscha*), rainbow trout (*Oncorhynchus mykiss*), dolly varden (*Salvelinus malma*), round whitefish (*Prosopium cylindraceum*), Bering cisco (*Coregonus laurettae*), eulachon (*Thaleichthys pacificus*), and slender eelblenny (*Lumpenus fabricii*). Bendock and Bingham (1988b) concluded that juvenile salmonids increased and marine fishes decreased in abundance with distance upstream from the river mouth. In 1995 and 1996, the Alaska Department of Fish and Game (ADFG) sampled fishes in the Kenai River estuary using rotary screw traps and beach seines (Jeff Breakfield, ADF&G , personal communication). Sampling was conducted from June 28 – September 21, 1995 and from May 9 through September 7, 1996. In addition to the species previously documented in the estuary, they also found Pacific lamprey (*Lampetra tridentate*), Arctic lamprey (*L. japonica*), chum salmon (*O. keta*), Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), Pacific sandfish (*Trichodon trichodon*), Pacific sandlance (*Ammodytes hexapterus*), rock greenling (*Hexagrammus lagocephalus*), coastrange sculpin (*Cottus aleuticus*), sturgeon poacher (*Agonus acipenserinus*), rex sole (*Glyptocephalus zachirus*), and rock sole (*Lepidopsetta bilineata*). Juvenile sockeye salmon catches peaked in late June and early July, while juvenile chinook catches were highest in early August. Juvenile coho salmon comprised less than 5% of the total catch in both years.

Although, a wide variety of fishes were captured during these early studies in the Kenai River estuary, each of them utilized gear types that were designed primarily to capture juvenile salmon, and only one of the sampling stations was immediately adjacent to the bluffs fronting the City of Kenai. We utilized gear types designed to capture juvenile fishes, but also species and sizes of fish that may not have been vulnerable to the gears used previously. We sampled during late winter (April), the salmon smolt migration (June), autumn (September), and during the longfin smelt migration (December). We conducted stomach content analyses on finfishes and constructed partial food webs to aid in evaluating potential effects of habitat changes in the estuary.

We focused on the salmon smolt migration in June (Jeff Breakfield, ADFG , personal communication), because the transition from freshwater to marine habitats is a critical period in the life history of salmon. During this period, juveniles must develop the capability to osmoregulate in seawater, recognize and capture new prey items, and avoid new predator species that often aggregate near river mouths to prey on them (Beamish et al. 1992, Dobrynina et al. 1988). Since, several fish species known to prey on juvenile salmon have been found in the Kenai River estuary (Khorevin et al. 1981, Dobrynina et al. 1988, Thorsteinson 1962), we conducted limited food habits studies as a first step toward identifying potential predators on juvenile salmon as well as the salmon's prey in the estuary.

## OBJECTIVES

1. Estimate species composition, relative abundance, and size of fishes inhabiting the area immediately below the Kenai bluff each season.

2. Estimate the maturity, mean stomach fullness, and diet composition of fishes and construct partial food webs for the area immediately below the Kenai bluff each season.

3. Estimate the density and species composition of the zooplankton in the Kenai River estuary immediately below the Kenai bluff each season.

4. Determine the feasibility of using split-beam sonar to examine the distributions of salmon smolt along the Kenai bluff.

5. Continuously record temperature, salinity, and water depth in the area immediately below the Kenai bluff by tide cycle each season.

## METHODS

*Objective 1:* Species composition, relative abundance, and size of fishes

During 2003, the study site for this project was limited to the approximately 1-mile area of the estuary immediately adjacent to the bluffs fronting the City of Kenai with one additional station approximately 0.5 miles upstream (Figure 1). The maximum depth of the estuary in this area was about 6 m at mean low water. Fishes were sampled in this area during approximately one week in April, June, September, and December.

A stratified-systematic sampling design was employed to estimate relative abundance and species composition of fishes in the study site during each sampling event. As much as possible, sampling was stratified by stage of tide. Sampling was generally conducted during daylight hours. But in June, sampling was conducted during the 12 hours spanning the night, because juvenile salmon abundance and predation on salmon may be greatest at night (Dobrynina et al. 1988).

Five gear types were used to sample juvenile and adult fishes within each stratum during each week of sampling. Juvenile fish in the water column were sampled using a townet in mid channel and fishes along the shore were sampled using a small-mesh beach seine. The townet had a 3 x 6 m opening. The beach seine deployed in April was 30 x 2 m, while the seine deployed in June and September was 50 x 6 m. Adult fishes were sampled using longlines and variable-mesh (2, 4, 6, and 8 cm stretch mesh) monofilament sinking gillnets. Longlines were baited with herring. Gillnets deployed in April were 30 x 2 m, while those deployed in June and September were 70 x 5 m. Beach seine and variable-mesh gillnet sampling was conducted at 5 stations in the estuary (Figure 1). Tow net and longline sampling was conducted along transects in mid channel and variable-mesh gillnets were also drifted along the north shore. A screw trap was used to sample fishes in the water column in June, because this gear type had been used successfully during earlier studies to sample salmon smolt. The screw trap had a 2.5 m diameter opening and was moored near station 3.

All fish were identified to the lowest possible taxonomic level. If a large number of fish are caught, species composition was estimated from a random sample of about 200 individuals. Length was measured for a randomly selected subsample (up to n=20) from each species in each net set.

Several analyses of variance (ANOVA) were conducted to test whether mean catch per net set differed among sampling periods. Separate analyses were conducted for each taxonomic group and gear type. The dependent variable in each analysis was the natural-logarithm transformed catch per net set and the independent variable was sampling period. Catches in the townet, screw trap and variable mesh gillnets were expressed as catch per hour. Several ANOVAs were also conducted to test whether mean catch per net set in beach seines and variable mesh gillnets differed among sampling stations. Separate analyses were conducted for each taxonomic group, and the data from all sampling periods were pooled. Only beach seine and variable mesh gillnet catches from June and September were included in these analyses, because the configuration of these gears in April was different.

Length frequency distributions were constructed for each taxonomic group for which data were available during each sampling period.

*Objective 2:* Diet composition of fishes and partial food webs

A stratified-systematic sampling design was employed to estimate diet composition of fishes in the study site during each sampling event. Sampling was stratified by stage of tide. Processing of fish samples from each net set occurred in two stages following procedures outlined by Livingston (1989) and Dwyer et al. (1987). Samples (n=10) for stomach content analysis were randomly selected from each species in each stratum. In cases where distinct size classes occur within species, samples (n=10) were collected from each size class. Size related shifts in diet toward piscivory have been noted in Pacific cod (Livingston 1989) and walleye pollock (Dwyer et al. 1987). Juvenile fishes selected for stomach analysis were preserved whole in 10% formalin. The stomachs of larger fishes were removed, placed in cloth bags, and preserved in 10% formalin. Each specimen was labeled regarding location of capture, length, weight, sex, and sexual maturity (immature, mature, spent). Fish showing evidence of regurgitation were not included in the sample. Stomach contents analysis were conducted later in the laboratory.

In the laboratory, stomach contents wet weight was measured to the nearest gram for large fish and to the nearest milligram for juvenile fish. Invertebrate preys were generally identified to the family level. Fish in the gut were identified to the lowest possible taxonomic level and measured to the nearest millimeter. Diet composition was visually estimated as a proportion of total stomach content volume (Pearcy et al. 1984).

The Fisher Exact Tests were conducted to test whether the frequency of occurrence of individuals in three stages of maturity differed among sampling periods. Separate tests were conducted for each taxonomic group of fishes. Several ANOVA's were conducted to test whether mean stomach fullness (% body weight) differed among sampling periods. Separate analyses were conducted for each taxonomic group of fishes. The dependent variable in each analysis was the arcsin square-root transformed ratio of total stomach content weight to body weight and the independent variable was sampling period.

Partial food webs were constructed to examine mass flux among taxonomic groups during each sampling period. Food webs were not complete, since only finfishes sampled in this project were included. Diet composition of each finfish was calculated as the percent of total stomach contents weight in each of four prey classes (benthic invertebrates, insects, fishes, and zooplankton). Finfish taxonomic groups were then aggregated into four classes (benthic invertebrate feeders, insectivores, piscivores, and planktivores) dependent on the dominant prey in their diet. Preys were ranked within each class by the percent of total mass consumed by all finfish classes from each taxonomic group of prey. Mass flux within the food web was expressed as the percent of total mass consumed from each prey class by each finfish class. These food webs were based upon mass of prey sampled and do not account for total daily food consumption (gastric evacuation rate) or the biomass of each finfish group which was unknown. Mass flux in the actual system probably differed, but these food webs provide some insight into how the system was structured.

Length frequency distributions of prey fishes were constructed for each taxonomic group of predator fishes for which data were available. Data from all sampling periods were aggregated.

*Objective 3:* Density and species composition of zooplankton

Zooplankton density and species composition was estimated from samples collected from two horizontal tows made offshore of station 2 (Figure 1). Samples were collected with a 0.5 m diameter ring net (153 um mesh) towed just below the surface at a speed of 1 m $sec^{-1}$ through the water. The net was equipped with a flowmeter. Samples were preserved in 10% formalin. All samples were collected within 0.5 hours of high tide, except the sample collected on April 11 was taken 1.5 hours after low tide.

In the laboratory, each sample was rinsed into a graduated beaker, well mixed, and subsampled with a Stemple pipette. Zooplankton in each sample was generally identified to the family or genus level and enumerated. The density of animals in each taxonomic group was estimated from the ratio of abundance and volume of water filtered.

*Objective 4:* Feasibility study examining alongshore fish distribution

We evaluated the feasibility of using split-beam sonar to examine the alongshore distribution of salmon smolt on June 13. A Biosonics model DT6000 scientific 200 kHz echosounder was used to examine relative fish densities along a transect running perpendicular to the north shore at station two. A $6.6^{o}$ circular split-beam transducer was mounted in a side-looking orientation on a 2.0-m long sled. The sled was moved up and down the beach as the water level changed with the tide. Sampling was conducted over a 12-hour period spanning the night (8:00 pm – 8:00 am). Fish were acoustically sampled at 6 pings $sec^{-1}$, at ranges from 0-65 m, using a pulse width of 0.4 msec, and a –55 dB threshold. Data were stored on a laptop computer.

*Objective 5:* Temperature and salinity distributions and time series

A continuously recording conductivity-temperature-depth profiler (CTD) was moored about 2 m above the bottom offshore of station two in the deepest part of the channel. The CTD was operated continuously during each week of sampling. A CTD was also occasionally used to measure the vertical distribution of temperature, salinity, and turbidity from the surface to the bottom.

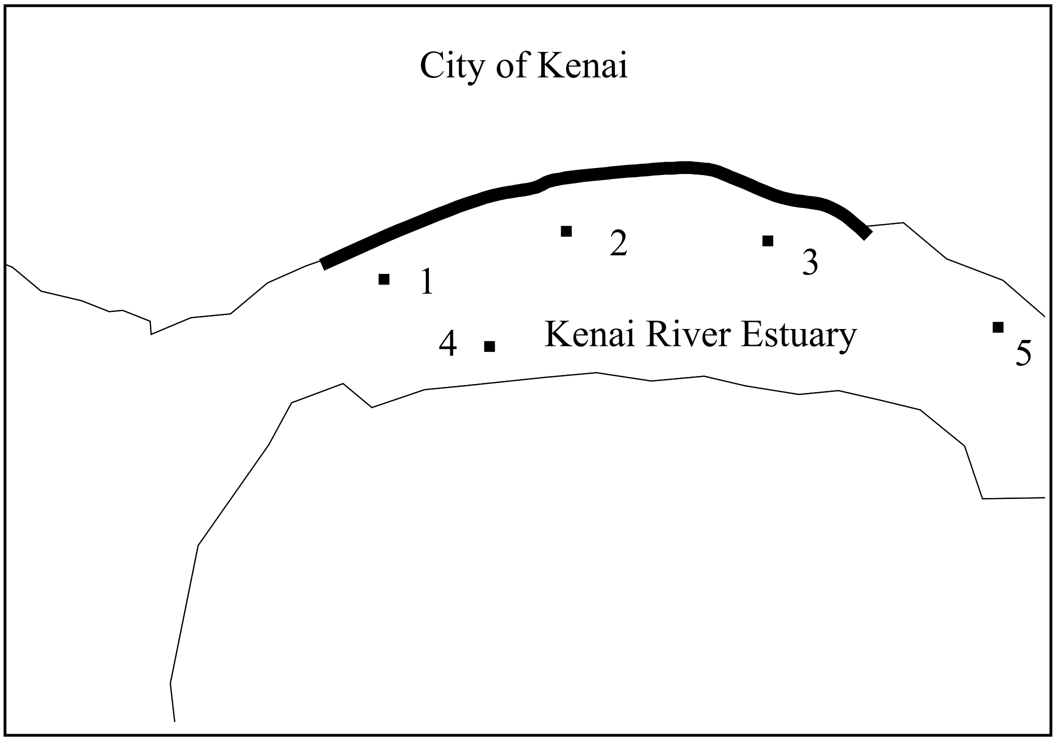


**Figure 1.** Location of Kenai bluff study site (bold line) and sample stations (solid squares) in the Kenai River estuary.

## RESULTS

*Objective 1:* Species composition, relative abundance, and size of fishes

Thirty-one taxonomic groups of animals were captured using five gear types in the Kenai River estuary during April, June, September, and December sampling periods (Table 1). Fifteen taxonomic groups were captured in April, 23 in June, and 27 in September. Epibenthic invertebrates (*Crangon* spp., *Neomysis* spp. and *Saduria* spp.) were the most frequently encountered and numerous animals in our catches during April (Table 2). Finfish were relatively rare in April, but of these, longfin smelt were the most numerous in townet catches. In June, finfish (particularly eulachon, sockeye salmon, coho salmon, and chinook salmon) were the most frequently encountered and numerous animals in the screw trap; whereas, Pacific staghorn sculpin, eulachon, snake prickleback, starry flounder were most numerous in seine and gillnet catches (Table 3). In September, finfish were again the most frequently encountered and numerous animals in our catches (Table 4). Six taxonomic groups of finfish were significantly more abundant in September than in previous sampling periods, while snake prickleback and the invertebrates *Neomysis* spp. and *Saduria* spp were less abundant (Table 5). Longlines captured spiny dogfish and starry flounder in June and September. Catch per net set in seines and gillnets were not significantly different among sampling stations.

Only 3 townet sets were completed during December. The City of Kenai boat launch was blocked by ice during this time, so a crane at Salamatof Seafoods was used to lift a skiff into the estuary. But, after the first day of operations, the crane froze and ice moved downstream in front of it preventing further sampling efforts. Three taxonomic groups were captured in December. Mean catch per net set and frequency of occurrence for these groups were: *Crangon* spp. (0.26, 1), *Gammarus* spp. (1.88, 2), and longfin smelt (0.26, 1).

Only catches of juvenile salmon were recorded since abundances of adult salmon in the estuary are well known. Adult salmon were captured in June and September and juvenile salmon were captured during all sampling periods except December. Eulachon smelt captured in April were adults greater than 150 mm in length, while those captured in June and September were mostly immature fish less than 150 mm (Figures 2-4). Starry flounder and Pacific staghorn scuplin exhibited the greatest range in sizes. A big skate captured in June was 3.9 m in length, whereas 14 spiny dogfish captured in June and September ranged in length from about 1.1-1.2 m.

**Table 1.** Thirty-one taxonomic groups of animals captured in the Kenai River estuary during April, June, September and December.

| Common Name | Scientific Name | Typical Habitat |
|---|---|---|
| Arrowtooth Flounder | *Atheresthes stomias* | Marine |
| Bering Cisco | *Coregonus laurettae* | Anadromous |
| Big Skate | *Raja binoculata* | Marine |
| Chinook Salmon | *Oncorhynchus tshawytscha* | Anadromous |
| Coastrange Sculpin | *Cottus aleuticus* | Estuarine |
| Coho Salmon | *Oncorhynchus kisutch* | Anadromous |
| *Crangon* spp. | *Crangon* spp. | Marine |
| Dolly Varden | *Salvelinus malma* | Anadromous |
| Eulachon Smelt | *Thaleichthys pacificus* | Anadromous |
| *Gammarus* spp. | *Gammarus* spp. | Marine |
| Longfin Smelt | *Spirinchus thaleichthys* | Anadromous |
| *Neomysis* spp. | *Neomysis* spp. | Marine |
| Pacific Cod | *Gadus macrocephalus* | Marine |
| Pacific Herring | *Clupea harengus pallasi* | Marine |
| Pacific Sandfish | *Trichodon trichodon* | Marine |
| Pacific Sandlance | *Ammodytes hexapterus* | Marine |
| Pacific Staghorn Sculpin | *Leptocottus armatus* | Estuarine |
| Pacific Tomcod | *Microgadus proximus* | Marine |
| Pandalus jordani | *Pandalus jordani* | Marine |
| Pink Salmon | *Oncorhynchus gorbuscha* | Anadromous |
| *Saduria* spp. | *Saduria* spp. | Marine |
| Sand Sole | *Psettichthys melanostictus* | Marine |
| Sawback Poacher | *Sarritor frenatus* | Marine |
| Silvergray Rockfish | *Sebastes brevispinis* | Marine |
| Smooth Lumpsucker | *Aptocyclus ventricosus* | Marine |
| Snailfish | Liparidae | Marine |
| Snake Prickleback | *Lumpenus sagitta* | Marine |
| Sockeye Salmon | *Oncorhynchus nerka* | Anadromous |
| Spiny Dogfish | *Squalus acanthias* | Marine |
| Starry Flounder | *Platichthys stellatus* | Estuarine |
| Threespine Stickleback | *Gasterosteus aculeatus* | Estuarine |

**Table 2.** Frequency of occurrence and geometric mean catch per net set for 15 taxonomic groups of animals captured using 4 gear types during April.

| | Gear Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Townet | | Seine | | Gillnet | | Longline | |
| Taxonomic Group | Mean | Freq. | Mean | Freq. | Mean | Freq. | Mean | Freq. |
| Bivalvia | 0.00 | 0 | 0.05 | 1 | 0.00 | 0 | 0.00 | 0 |
| Chinook Salmon | 0.00 | 0 | 0.21 | 2 | 0.00 | 0 | 0.00 | 0 |
| Coho Salmon | 0.00 | 0 | 0.08 | 1 | 0.00 | 0 | 0.00 | 0 |
| *Crangon* spp. | 309.11 | 8 | 2.23 | 7 | 0.00 | 0 | 0.00 | 0 |
| Eulachon Smelt | 0.58 | 1 | 0.00 | 0 | 0.05 | 2 | 0.00 | 0 |
| *Gammarus* sp. | 0.97 | 3 | 0.10 | 1 | 0.00 | 0 | 0.00 | 0 |
| Longfin Smelt | 1.63 | 2 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *Neomysis* spp. | 5.80 | 4 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pacific Cod | 0.00 | 0 | 0.05 | 1 | 0.00 | 0 | 0.00 | 0 |
| Pacific Herring | 0.26 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *Pandalus jordani* | 0.17 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pink Salmon | 1.31 | 3 | 0.08 | 1 | 0.00 | 0 | 0.00 | 0 |
| Polychaete | 0.44 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *Saduria* spp. | 3.47 | 4 | 0.18 | 2 | 0.00 | 0 | 0.00 | 0 |
| Threespine Stickleback | 0.58 | 2 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Total number of net sets | | 8 | | 14 | | 28 | | 2 |

**Table 3.** Frequency of occurrence and geometric mean catch per net set for 23 taxonomic groups of animals captured using 4 gear types during June.

| | Gear Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Screw Trap | | Seine | | Gillnet | | Longline | |
| Taxonomic Group | Mean | Freq. | Mean | Freq. | Mean | Freq. | Mean | Freq. |
| Arrowtooth Flounder | 0.00 | 0 | 0.04 | 1 | 0.00 | 0 | 0.00 | 0 |
| Big Skate | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.06 | 1 |
| Chinook Salmon | 4.28 | 8 | 1.16 | 10 | 0.50 | 5 | 0.00 | 0 |
| Coho Salmon | 4.24 | 10 | 0.00 | 0 | 0.05 | 1 | 0.00 | 0 |
| *Crangon* spp. | 0.97 | 8 | 0.26 | 4 | 0.00 | 0 | 0.00 | 0 |
| Spiny Dogfish | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.27 | 2 |
| Dolly Varden | 0.13 | 2 | 0.13 | 3 | 0.00 | 0 | 0.00 | 0 |
| Eulachon Smelt | 106.91 | 13 | 3.21 | 9 | 0.55 | 6 | 0.00 | 0 |
| *Gammarus* spp. | 0.02 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *Neomysis* spp. | 0.32 | 3 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pacific Cod | 0.15 | 2 | 0.00 | 0 | 0.14 | 2 | 0.00 | 0 |
| Pacific Herring | 0.00 | 0 | 0.04 | 1 | 0.00 | 0 | 0.00 | 0 |
| Pacific Sandfish | 0.04 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pacific Staghorn Sculpin | 0.34 | 4 | 5.07 | 16 | 2.05 | 13 | 0.00 | 0 |
| Pacific Tomcod | 0.44 | 6 | 1.16 | 8 | 0.36 | 4 | 0.00 | 0 |
| *Pandalus jordani* | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pink Salmon | 0.37 | 5 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| *Saduria* spp. | 0.04 | 1 | 0.04 | 1 | 0.00 | 0 | 0.00 | 0 |
| Sand Sole | 0.04 | 1 | 0.11 | 2 | 0.00 | 0 | 0.00 | 0 |
| Snake Prickleback | 0.21 | 1 | 2.59 | 8 | 10.15 | 22 | 0.00 | 0 |
| Sockeye Salmon | 5.09 | 8 | 0.29 | 4 | 0.70 | 6 | 0.00 | 0 |
| Starry Flounder | 1.05 | 9 | 1.14 | 10 | 2.48 | 15 | 0.74 | 8 |
| Threespine Stickleback | 0.69 | 8 | 0.46 | 7 | 0.00 | 0 | 0.00 | 0 |
| | | | | | | | | |
| Total number of net sets | | 13 | | 17 | | 26 | | 12 |

**Table 4.** Frequency of occurrence and geometric mean catch per net set for 26 taxonomic groups of animals captured using 4 gear types during September.

| | Gear Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Townet | | Seine | | Gillnet | | Longline | |
| Taxonomic Group | Mean | Freq. | Mean | Freq. | Mean | Freq. | Mean | Freq. |
| Bering Cisco | 0.00 | 0 | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 |
| Crab Megalops | 0.21 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Chinook Salmon | 0.00 | 0 | 0.25 | 1 | 0.00 | 0 | 0.00 | 0 |
| Coastrange Sculpin | 0.00 | 0 | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 |
| Coho Salmon | 0.00 | 0 | 6.99 | 10 | 0.11 | 1 | 0.00 | 0 |
| *Crangon* spp. | 40.58 | 7 | 4.03 | 6 | 0.25 | 2 | 0.00 | 0 |
| Spiny Dogfish | 0.00 | 0 | 0.00 | 0 | 0.12 | 1 | 0.44 | 2 |
| Dolly Varden | 0.00 | 0 | 0.12 | 2 | 0.00 | 0 | 0.00 | 0 |
| Eulachon Smelt | 509.84 | 8 | 7.21 | 9 | 3.50 | 7 | 0.00 | 0 |
| *Gammarus* spp. | 0.29 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pacific Cod | 0.32 | 1 | 0.10 | 1 | 0.70 | 3 | 0.00 | 0 |
| Pacific Herring | 37.05 | 8 | 2.96 | 4 | 0.08 | 1 | 0.00 | 0 |
| Pacific Sandfish | 4.06 | 6 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Pacific Sandlance | 0.96 | 3 | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 |
| Pacific Staghorn Sculpin | 0.43 | 1 | 3.48 | 10 | 1.04 | 5 | 0.00 | 0 |
| Pacific Tomcod | 3.18 | 3 | 3.99 | 10 | 1.55 | 5 | 0.00 | 0 |
| Pink Salmon | 0.00 | 0 | 0.20 | 2 | 0.00 | 0 | 0.00 | 0 |
| *Saduria* spp. | 0.00 | 0 | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 |
| Sand Sole | 0.00 | 0 | 0.00 | 0 | 0.10 | 1 | 0.00 | 0 |
| Sawback Poacher | 0.59 | 2 | 0.21 | 2 | 0.00 | 0 | 0.00 | 0 |
| Silvergray Rockfish | 0.00 | 0 | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 |
| Smooth Lumpsucker | 0.00 | 0 | 0.06 | 1 | 0.00 | 0 | 0.00 | 0 |
| Snailfish | 0.69 | 2 | 0.00 | 0 | 0.08 | 1 | 0.00 | 0 |
| Snake Prickleback | 0.92 | 2 | 1.35 | 4 | 0.00 | 0 | 0.00 | 0 |
| Sockeye Salmon | 0.00 | 0 | 1.82 | 5 | 0.00 | 0 | 0.00 | 0 |
| Starry Flounder | 3.25 | 5 | 3.24 | 11 | 0.86 | 5 | 0.26 | 3 |
| Threespine Stickleback | 0.00 | 0 | 0.19 | 3 | 0.00 | 0 | 0.00 | 0 |
| Total number of net sets | | 8 | | 12 | | 12 | | 9 |

**Table 5.** Geometric mean catch per net set for taxonomic groups of animals that exhibited statistically significant differences in relative abundance among sampling periods.

| Gear Type | Taxonomic Group | Month April | June | September |
|---|---|---|---|---|
| Townet | Eulachon Smelt | 0.58 | - | 509.84 |
| | *Neomysis* spp. | 5.80 | - | 0.00 |
| | Pacific Herring | 0.26 | - | 37.05 |
| | Pacific Sandfish | 0.00 | - | 4.06 |
| | *Saduria* spp. | 3.47 | - | 0.00 |
| | Starry Flounder | 0.00 | - | 3.25 |
| Seine | Coho Salmon | - | 0.00 | 6.99 |
| | *Crangon* spp. | - | 0.26 | 4.03 |
| | Pacific Herring | - | 0.40 | 2.96 |
| | Sockeye Salmon | - | 0.29 | 1.82 |
| | Starry Flounder | - | 1.14 | 3.24 |
| Gillnet | *Crangon* spp. | - | 0.00 | 0.25 |
| | Eulachon Smelt | - | 0.55 | 3.50 |
| | Snake Prickleback | - | 10.15 | 0.00 |

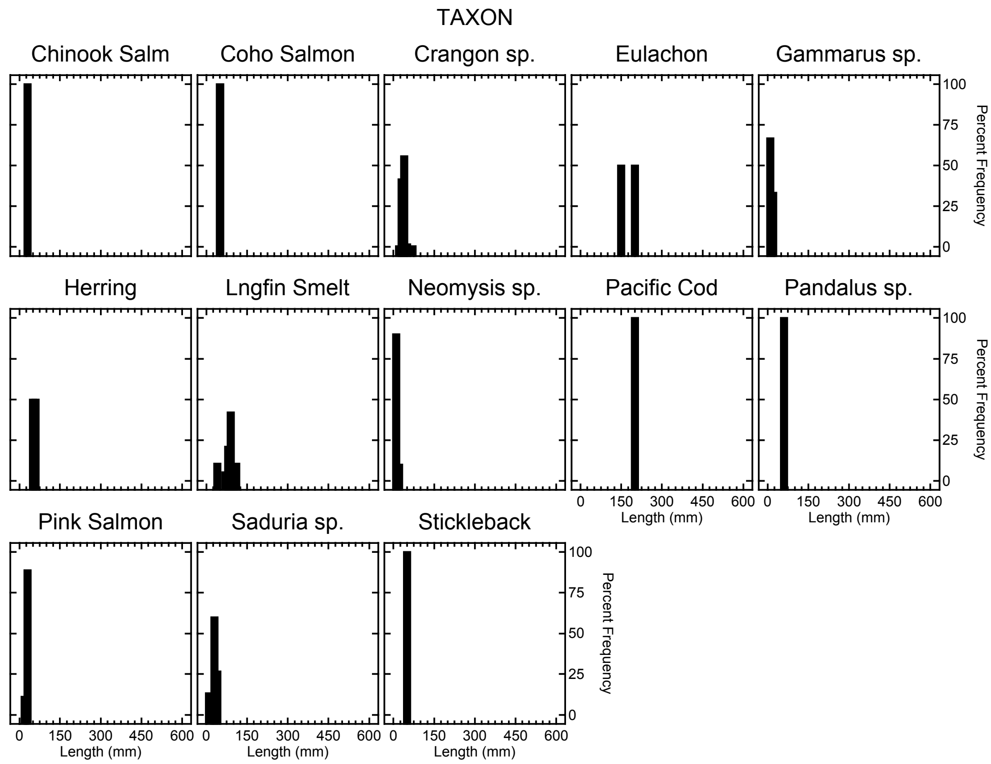


**Figure 2.** Length frequency distributions for 13 taxonomic groups of animals captured during April.

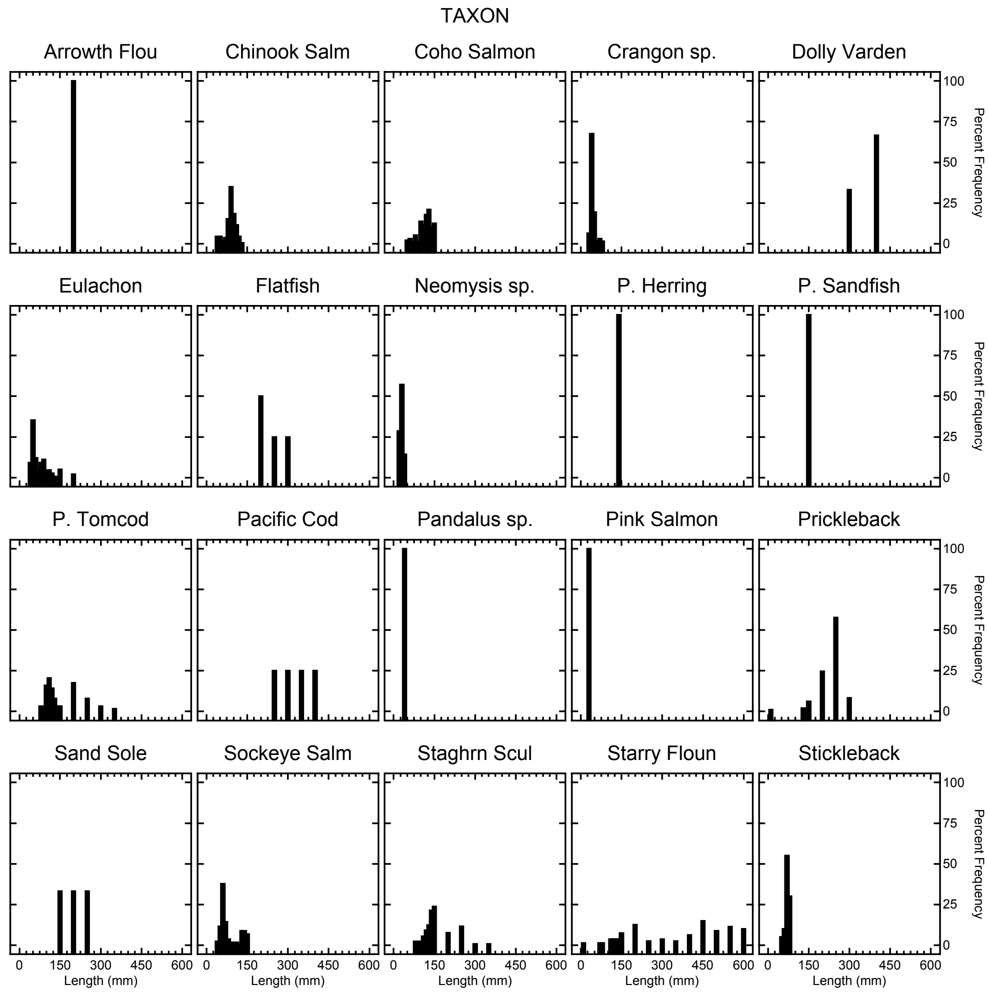


**Figure 3.** Length frequency distributions for 20 taxonomic groups of animals captured during June.

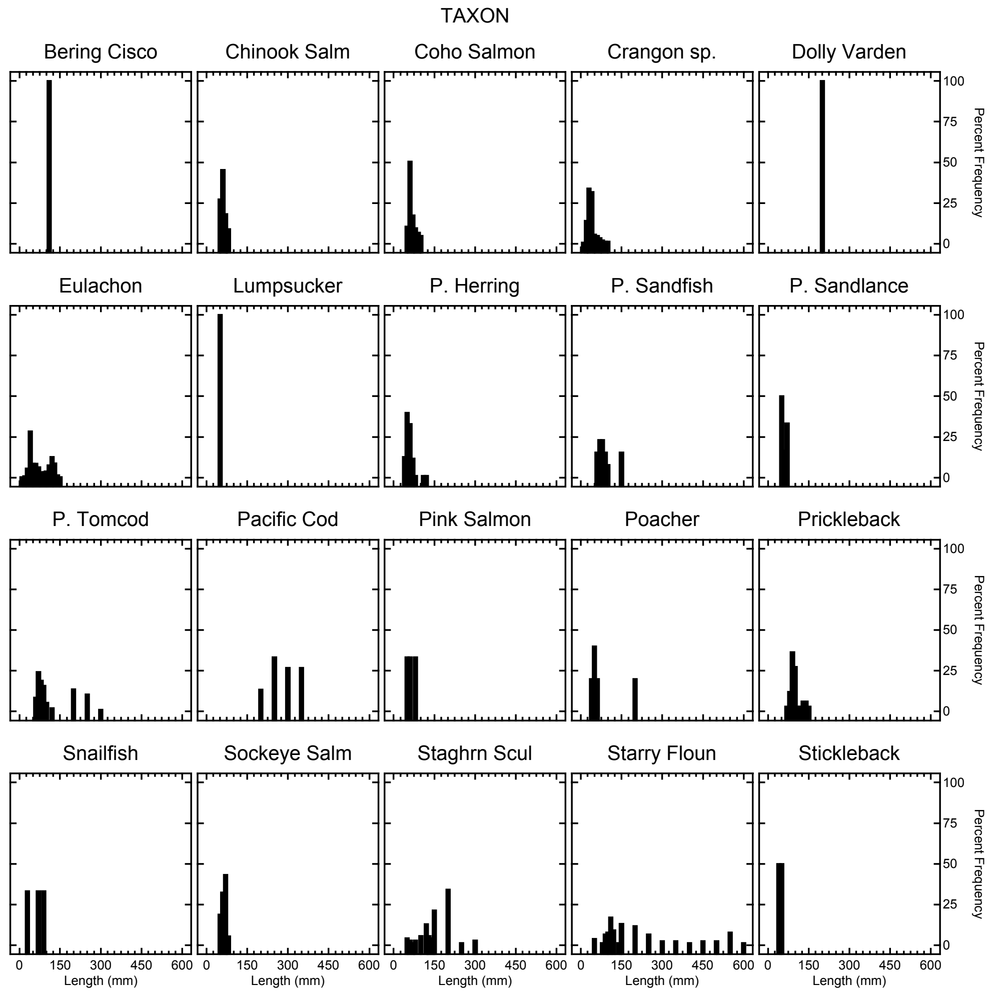


**Figure 4.** Length frequency distributions for 20 taxonomic groups of animals captured during September.

*Objective 2:* Diet composition of fishes and partial food webs

Maturity of fishes was determined for specimens collected for stomach content analysis. All specimens examined in 12 taxonomic groups of fishes were immature (Table 6). Stages of maturity differed significantly among sampling periods for eulachon and starry flounder but not other taxonomic groups. More eulachon were mature in September than June, while more starry flounder were mature in June than September. Mean stomach fullness of eulachon and Pacific tomcod declined significantly from June to September, but differences in mean stomach fullness were not significant for other taxonomic groups (Table 7).

A partial food web for the estuary during April was based primarily upon benthic invertebrate prey, mostly amphipods (Figure 5). The complexity of the partial food web in June increased dramatically. Thirty-three percent of the finfish taxonomic groups in June were benthic invertebrate feeders, while 40% were primarily piscivores, 13% planktivores, and 13% insectivores (Figure 6). Isopods were the dominant invertebrate prey, Trichoptera the dominant insect prey, eulachon the dominant fish prey, and large calanoid copepods (mostly *Eurytemora* spp.) the dominant zooplankton prey. Piscivorous fishes also consumed a significant mass of insects and benthic invertebrates. A fourth class called 'Other Prey' (not shown in the figure) was dominated by fish processor waste (72%). These prey were consumed primarily (96%) by piscivores.

The complexity of the partial food web decreased in September. While the total number of finfish taxonomic groups increased, the number of piscivores declined (Figure 7). Chinook and coho salmon switched from primarily piscivory to insectivory, while Pacific staghorn sculpin and eulachon switched to consuming mostly benthic invertebrates. Pacific staghorn sculpin consumed primarily shrimp, while eulachon consumed primarily *Neomysis* spp. and amphipods. Benthic invertebrate feeders also consumed a significant mass of zooplankton. The 'Other Prey' class was now dominated by vegetation and rocks, which were consumed entirely by benthic invertebrate feeders. Infaunal prey (primarily polychaetes and bivalves) were not important in these partial food webs during any sampling period, comprising less than 3% of the mass of benthic invertebrates consumed.

Coho salmon, chinook salmon, Pacific staghorn sculpin, Pacific tomcod, and starry flounder consumed juvenile salmon, but salmon were not a dominant prey in the diet of these fishes. Juvenile salmon comprised 32% of the diet of coho salmon in June, and 48% and 20% of the diets of chinook and coho salmon in September. Salmon comprised less than 10% of the diets of the other fishes that fed on them. Pacific staghorn sculpin and starry flounder consumed the greatest range of sizes of fish prey (Figure 8). Most predator taxonomic groups consumed fish less than 100 mm in length.

*Objective 3:* Density and species composition of zooplankton

Zooplankton densities in the estuary were low (Table 8). The brackish water genera *Eurytemora* and the epibenthic genera *Harpacticus* occurred during every sampling period. In June, the zooplankton was dominated by species typically found in freshwater. Attempts to collect samples at low tide were generally not successful, because silt clogged the net. However, samples were successfully collected 1.5 hours after low tide on April 11. The species composition and densities of animals collected near high tide on April 9 and near low tide on April 11 were not substantially different (Table 8).

*Objective 4:* Feasibility study examining alongshore fish distribution

During our 12-hour acoustic study along the north shore of the estuary, no targets were seen that appeared to be salmon smolt, but targets that were likely larger fishes were observed. The 6.6$^o$ acoustic beam used in this study fit well within the water column at this location, and the sled-system towed by a 4-wheeler was able to move the transducer up and down the beach with few difficulties as water level changed. However, we concluded that the limited range of the acoustic beam was not sufficient to effectively study the distribution of salmon smolt in the estuary, since large numbers of smolt could have been present beyond the range of our acoustic beam. Further studies were not conducted due to lack of available staff and time.

*Objective 5:* Temperature and salinity distributions and time series

The vertical distributions of water temperature and salinity measured at station two in April were clearly affected by tide stage. A profile measured near high tide on April 8 exhibited little vertical structure, while another measured on April 11 three hours after low tide showed a relatively warm, low salinity layer above 2 m depth (Figure 9). On both dates turbidity was relatively high and increased with depth.

Time series of temperature and salinity measured 2 m above the bottom at station two revealed the highly dynamic nature of the physical environment in the estuary. During all months except April, salinities dropped from greater than 20 ppt to near 0 ppt within 2-3 hours of high tide (Figures 10-13). In April, salinities also changed rapidly, but often remained above 10 ppt even at low tide. At this time, water temperatures at low tide were 1-2$^o$ C warmer than at high tide, indicating that Kenai River was warmer than Cook Inlet. By June, this pattern was reversed, and water temperatures in the estuary were warmer at high tide than low tide.

**Table 6.** Percent frequency of occurrence for fishes in three stages of maturity during three sampling periods.

| | | Stage of Maturity | | | |
|---|---|---|---|---|---|
| Month | Taxonomic Group | Immature | Mature | Spent | n |
| April | Longfin Smelt | 100 | - | - | 3 |
| | Pacific Herring | 100 | - | - | 1 |
| | | | | | |
| June | Arrowtooth Flounder | 100 | - | - | 1 |
| | Big Skate | - | 100 | - | 1 |
| | Eulachon Smelt | 86 | 14 | - | 148 |
| | Pacific Herring | 100 | - | - | 1 |
| | Pacific Staghorn Sculpin | 96 | 4 | - | 56 |
| | Pacific Tomcod | 100 | - | - | 24 |
| | Snake Prickleback | 92 | 8 | - | 64 |
| | Spiny Dogfish | - | 100 | - | 3 |
| | Starry Flounder | 79 | 21 | - | 19 |
| | Threespine Stickleback | 57 | 43 | - | 14 |
| | | | | | |
| Sept. | Bering Cisco | 100 | - | - | 1 |
| | Dolly Varden | 100 | - | - | 1 |
| | Eulachon Smelt | 70 | 30 | - | 88 |
| | Pacific Cod | 100 | - | - | 10 |
| | Pacific Herring | 100 | - | - | 32 |
| | Pacific Sandfish | 100 | - | - | 6 |
| | Pacific Sandlance | 67 | 33 | - | 3 |
| | Pacific Staghorn Sculpin | 100 | - | - | 21 |
| | Pacific Tomcod | 94 | - | 6 | 34 |
| | Sawback Poacher | 100 | - | - | 2 |
| | Silvergray Rockfish | - | 100 | - | 1 |
| | Smooth Lumpsucker | 100 | - | - | 1 |
| | Snailfish | 100 | - | - | 2 |
| | Snake Prickleback | 100 | - | - | 14 |
| | Spiny Dogfish | 64 | 36 | - | 11 |
| | Starry Flounder | 100 | - | - | 30 |
| | Threespine Stickleback | 100 | - | - | 2 |

**Table 7.** Diet composition (% of stomach content weight) and stomach fullness (% of body weight) for several taxonomic groups of finfishes captured during three sampling periods.

| Month | Taxonomic Group | Insects | Zooplankton | Benthic Invertebrate | Fish | Other Prey | Stomach Fullness | n |
|---|---|---|---|---|---|---|---|---|
| April | Coho Salmon | 100.0 | - | - | - | - | 0.9 | 1 |
| | Longfin Smelt | - | - | 100.0 | - | - | 0.1 | 16 |
| | Pacific Cod | - | - | 100.0 | - | - | 7.7 | 1 |
| | Pacific Herring | - | - | 100.0 | - | - | 28.5 | 2 |
| | Pink Salmon | - | - | - | - | - | 0.0 | 1 |
| | Smelt, unidentified | - | - | - | - | - | 0.0 | 3 |
| | | | | - | - | | | |
| June | Arrowtooth Flounder | - | - | 100.0 | - | - | 0.7 | 1 |
| | Big Skate | - | - | 100.0 | - | - | - | 1 |
| | Chinook Salmon | 35.5 | - | 18.2 | 44.6 | 1.4 | 2.6 | 93 |
| | Coho Salmon | 18.9 | | 3.8 | 76.0 | 1.3 | 2.5 | 73 |
| | Dolly Varden | - | - | - | - | - | 0.0 | 1 |
| | Eulachon Smelt | 2.2 | 70.4 | 10.4 | 5.6 | 11.4 | 2.0 | 193 |
| | Flatfish, unidentified | - | - | 100.0 | - | - | 0.4 | 4 |
| | Pacific Cod | - | - | - | - | - | 0.0 | 1 |
| | Pacific Herring | - | - | - | - | - | 0.7 | 1 |
| | Pacific Sandfish | - | - | - | - | - | 0.0 | 1 |
| | Pacific Staghorn Sculpin | 0.2 | - | 8.9 | 77.4 | 13.6 | 6.4 | 105 |
| | Pacific Tomcod | 0.0 | 3.3 | 61.5 | 35.2 | - | 4.1 | 49 |
| | Pink Salmon | 66.7 | - | - | 33.3 | - | 2.2 | 5 |
| | Sand Sole | - | - | 25.0 | 75.0 | - | 2.6 | 3 |
| | Snake Prickleback | 2.7 | 11.6 | 14.0 | 51.4 | 20.3 | 2.6 | 90 |
| | Sockeye Salmon | 58.9 | 3.8 | 2.1 | 32.7 | 2.5 | 3.3 | 90 |
| | Spiny Dogfish | - | - | 100.0 | - | - | 1.3 | 3 |

**Table 7.** continued.

| Month | Taxonomic Group | Insects | Zooplankton | Benthic Invertebrate | Fish | Other Prey | Stomach Fullness | n |
|---|---|---|---|---|---|---|---|---|
| June | Starry Flounder | - | - | 6.6 | 93.4 | - | 2.2 | 60 |
| | Threespine Stickleback | 33.4 | 34.3 | 18.4 | - | 13.8 | 2.7 | 17 |
| | | | | - | - | | | |
| Sept. | Bering Cisco | - | 95.0 | 5.0 | - | - | 0.7 | 1 |
| | Chinook Salmon | 52.4 | - | - | 47.6 | - | 2.6 | 11 |
| | Coho Salmon | 75.7 | - | 4.1 | 20.3 | - | 2.3 | 34 |
| | Dolly Varden | - | - | - | - | - | 0.0 | 1 |
| | Eulachon Smelt | - | 6.1 | 93.9 | - | - | 0.6 | 91 |
| | Pacific Cod | - | - | 49.1 | 50.9 | - | 2.4 | 10 |
| | Pacific Herring | - | 98.0 | 2.0 | - | - | 4.7 | 33 |
| | Pacific Sandfish | - | - | 9.6 | 90.4 | - | 8.6 | 12 |
| | Pacific Sandlance | - | 100.0 | - | - | - | 5.0 | 6 |
| | Pacific Staghorn Sculpin | 0.5 | - | 66.1 | 33.4 | - | 3.7 | 29 |
| | Pacific Tomcod | 0.1 | 3.0 | 78.0 | 18.9 | 0.1 | 2.7 | 41 |
| | Pink Salmon | 100.0 | - | - | - | - | 1.2 | 1 |
| | Sawback Poacher | - | 34.1 | 65.9 | - | - | 11.0 | 3 |
| | Silvergray Rockfish | - | - | - | - | - | 16.4 | 1 |
| | Smooth Lumpsucker | - | - | 100.0 | - | - | 6.1 | 1 |
| | Snailfish, unidentifie | - | - | 40.5 | - | 59.5 | 2.1 | 3 |
| | Snake Prickleback | - | 100.0 | - | - | - | 3.9 | 14 |
| | Sockeye Salmon | 100.0 | - | - | - | - | 1.8 | 18 |
| | Spiny Dogfish | - | - | 20.0 | 80.0 | - | - | 11 |
| | Starry Flounder | - | 0.2 | 23.4 | 76.4 | - | 0.8 | 43 |
| | Threespine Stickleback | - | - | - | 100.0 | - | 0.8 | 2 |

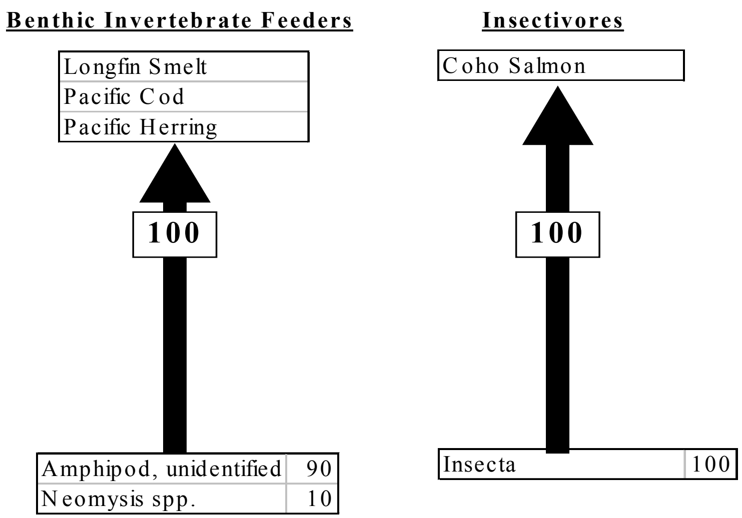


**Figure 5.** Partial food web for aquatic organisms in the Kenai River estuary during April. Percent of total biomass consumed from each prey class is indicated adjacent to each prey taxonomic group. Percent of total biomass consumed from each prey class by each predator class is indicated on arrows.

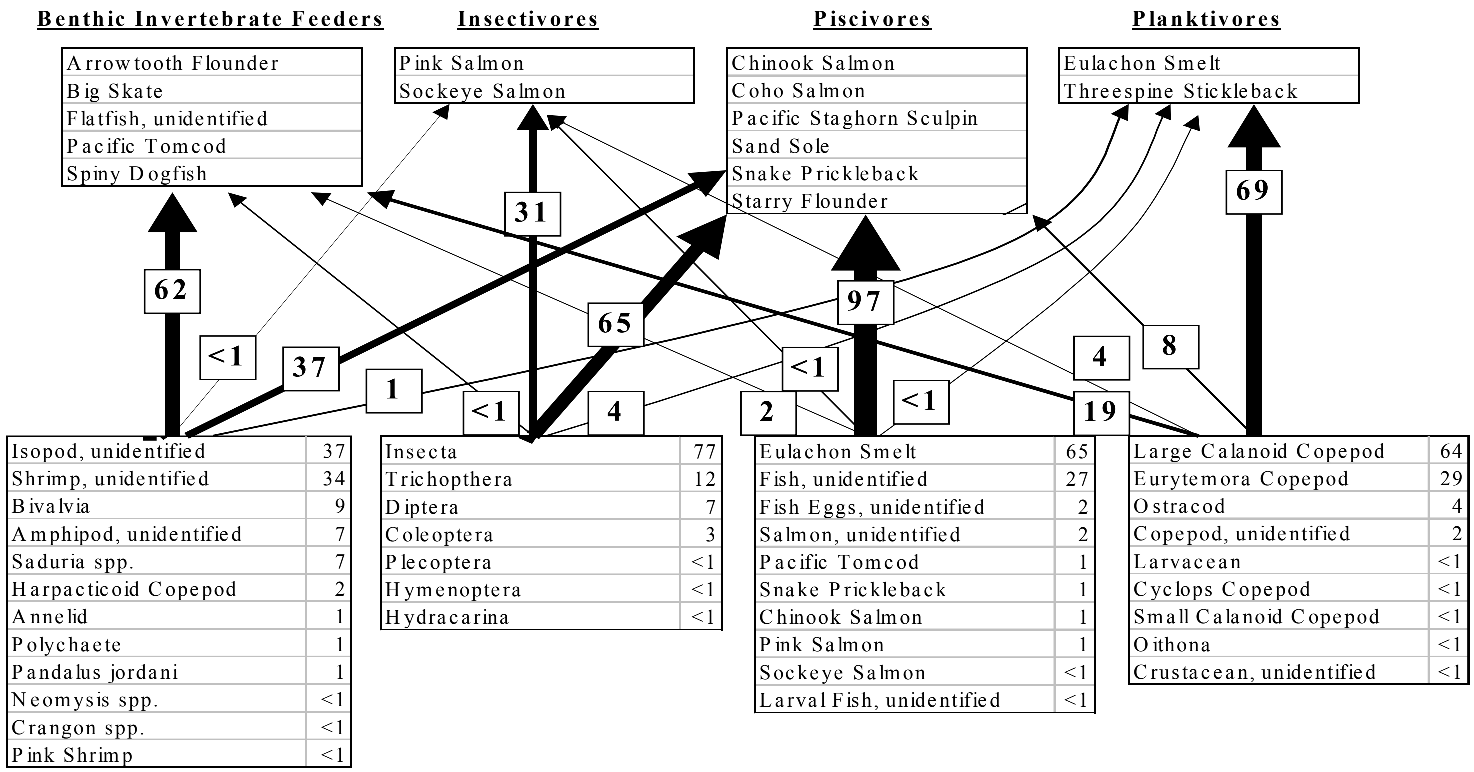


**Figure 6.** Partial food web for aquatic organisms in the Kenai River estuary during June. Percent of total biomass consumed from each prey class is indicated adjacent to each prey taxonomic group. Percent of total biomass consumed from each prey class by each predator class is indicated on arrows.

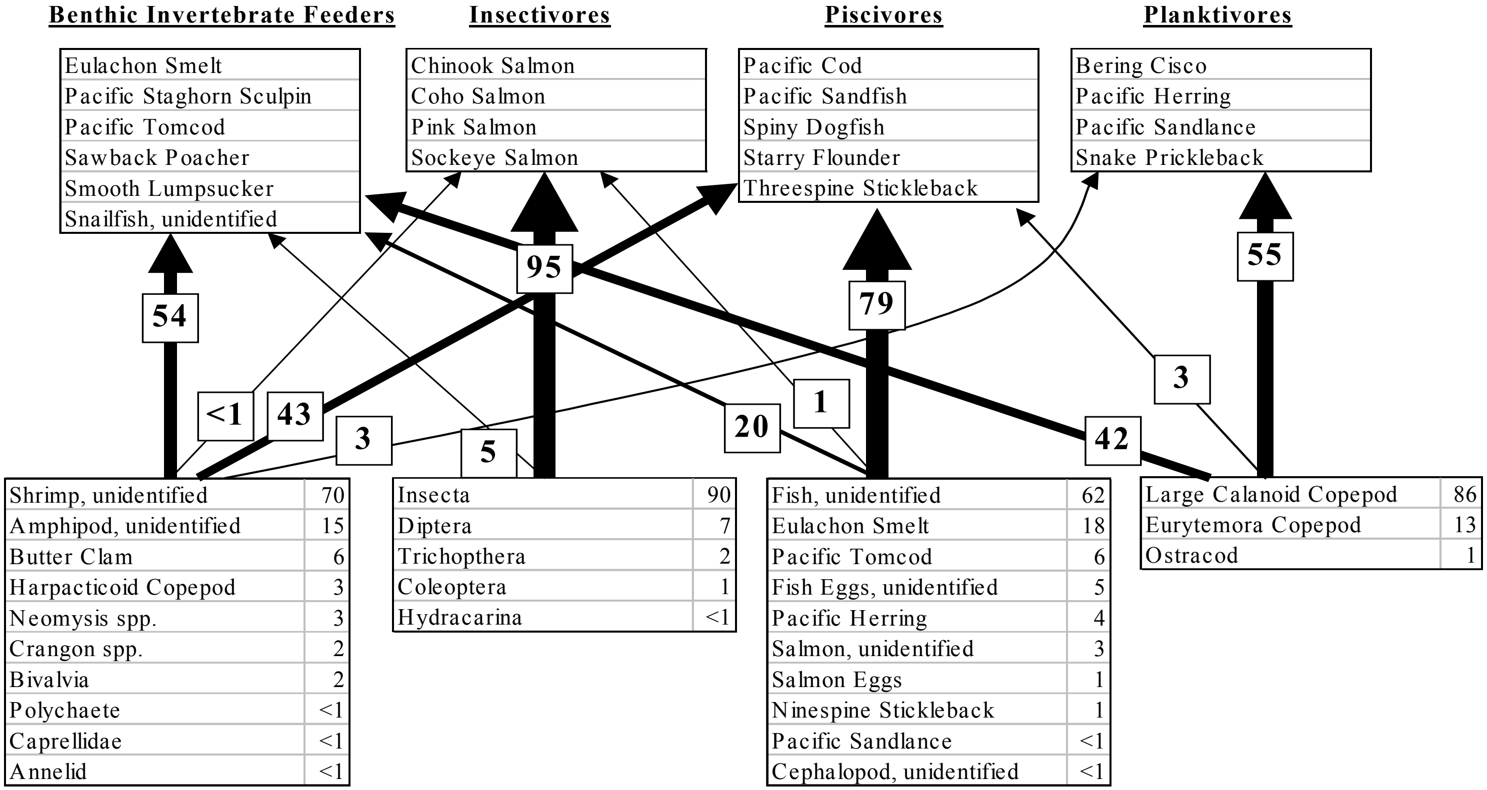


**Figure 7.** Partial food web for aquatic organisms in the Kenai River estuary during September. Percent of total biomass consumed from each prey class is indicated adjacent to each prey taxonomic group. Percent of total biomass consumed from each prey class by each predator class is indicated on arrows.

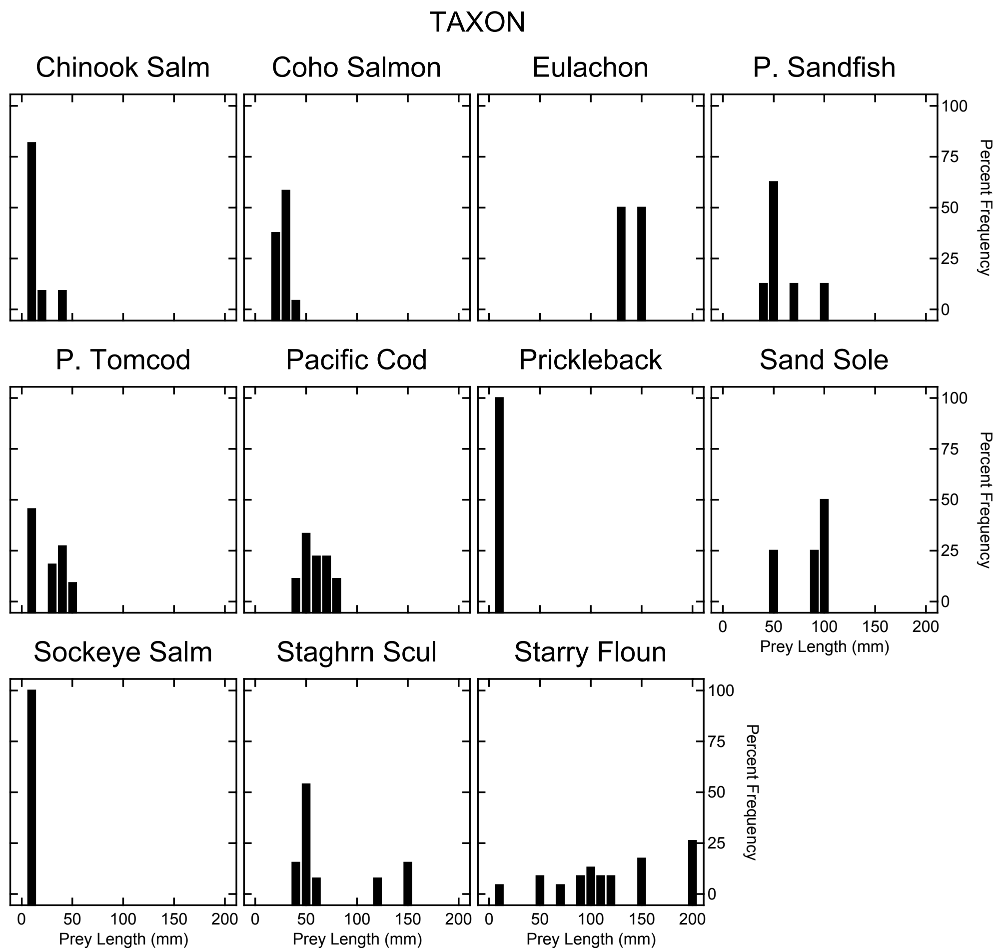


**Figure 8.** Length frequency distributions for prey fish consumed by 11 taxonomic groups of finfishes in the Kenai River estuary.

**Table 8.** Mean density and biomass (wet weight) of zooplankton collected in the Kenai River estuary during three sampling periods.

| | | Density (no./$m^3$) | | | Average | Biomass |
|---|---|---|---|---|---|---|
| Date | Taxonomic Group | Tow 1 | Tow 2 | Mean | Wt (mg) | (mg/$m^3$) |
| April 9 | *Acartia* spp. | 0.62 | 0.37 | 0.50 | 0.046 | 0.023 |
| | Amphipoda | 0.24 | 0.01 | 0.13 | 4.636 | 0.583 |
| | Barnacle nauplii | 3.12 | 2.23 | 2.67 | 0.185 | 0.496 |
| | Cyphonautes larva | 7.80 | 13.35 | 10.58 | 0.019 | 0.200 |
| | *Eurytemora* spp. | 0.21 | 3.21 | 1.71 | 0.080 | 0.137 |
| | *Harpacticus* spp. | 0.10 | 0.00 | 0.05 | 0.292 | 0.015 |
| | *Oithona* spp. | 5.93 | 0.87 | 3.40 | 0.006 | 0.019 |
| | Larval fish | 0.00 | 0.12 | 0.06 | 5.000 | 0.309 |
| | *Neomysis* spp. | 0.00 | 0.04 | 0.02 | 1.993 | 0.037 |
| | *Oncea* spp. | 0.00 | 0.37 | 0.19 | 0.012 | 0.002 |
| | Polycheate | 1.25 | 0.00 | 0.62 | 1.049 | 0.654 |
| | *Pseudocalanus* spp. | 1.25 | 1.61 | 1.43 | 0.086 | 0.123 |
| | shrimp zoea | 0.02 | 0.01 | 0.02 | 0.526 | 0.009 |
| | Total | | | | | 2.607 |
| April 11 | *Acartia* spp. | 0.07 | 0.17 | 0.12 | 0.046 | 0.006 |
| | Amphipoda | 0.01 | 0.07 | 0.04 | 4.636 | 0.194 |
| | Barnacle nauplii | 0.12 | 0.42 | 0.27 | 0.185 | 0.050 |
| | *Cyclops* spp. | 0.18 | 0.09 | 0.14 | 0.013 | 0.002 |
| | Cyphonautes larva | 3.57 | 8.80 | 6.18 | 0.019 | 0.117 |
| | *Eurytemora* spp. | 0.14 | 0.64 | 0.39 | 0.080 | 0.031 |
| | *Harpacticus* spp. | 0.00 | 0.06 | 0.03 | 0.292 | 0.009 |
| | Larval fish | 0.00 | 0.05 | 0.02 | 5.000 | 0.122 |
| | *Oithona* spp. | 1.35 | 0.62 | 0.99 | 0.006 | 0.006 |
| | *Oncea* spp. | 0.00 | 0.01 | 0.01 | 0.012 | 0.000 |
| | *Podon* spp. | 0.00 | 0.04 | 0.02 | 0.137 | 0.003 |
| | Polycheate | 0.02 | 0.09 | 0.05 | 1.049 | 0.056 |
| | *Pseudocalanus* spp. | 0.14 | 0.43 | 0.29 | 0.086 | 0.025 |
| | Total | | | | | 0.618 |

**Table 8.** continued.

| | | Density (no./m$^3$) | | | Average | Biomass |
|---|---|---|---|---|---|---|
| Date | Taxonomic Group | Tow 1 | Tow 2 | Mean | Wt (mg) | (mg/m$^3$) |
| June 20 | Copepod nauplii | 23.08 | 5.99 | 14.53 | 0.014 | 0.209 |
| | *Cyclops* spp. | 301.86 | 309.12 | 305.49 | 0.021 | 6.412 |
| | *Diaptomus* spp. | 15.00 | 18.71 | 16.86 | 0.013 | 0.215 |
| | *Eurytemora* spp. | 0.16 | 0.00 | 0.08 | 0.080 | 0.007 |
| | *Harpacticus* spp. | 3.46 | 3.74 | 3.60 | 0.292 | 1.052 |
| | Larval fish | 0.38 | 0.00 | 0.19 | 5.000 | 0.948 |
| | Total | | | | | 8.843 |
| | | | | | | |
| Sept. 16 | *Acartia* spp. | 18.48 | 20.22 | 19.35 | 0.046 | 0.884 |
| | Amphipoda | 0.17 | 0.00 | 0.09 | 4.636 | 0.398 |
| | Barnacle nauplii | 4.62 | 8.59 | 6.60 | 0.185 | 1.225 |
| | Bivalvia | 6.38 | 4.58 | 5.48 | 0.037 | 0.202 |
| | Cheatognath | 0.13 | 0.19 | 0.16 | 0.603 | 0.096 |
| | Copepod nauplii | 5.72 | 13.16 | 9.44 | 0.014 | 0.136 |
| | *Cyclops* spp. | 0.22 | 0.38 | 0.30 | 0.021 | 0.006 |
| | Cyphonautes larva | 11.66 | 14.31 | 12.98 | 0.019 | 0.245 |
| | *Eurytemora* spp. | 11.88 | 26.71 | 19.29 | 0.080 | 1.544 |
| | *Harpacticus* spp. | 3.30 | 2.48 | 2.89 | 0.292 | 0.844 |
| | *Oithona* spp. | 1.54 | 0.76 | 1.15 | 0.006 | 0.007 |
| | Polycheate | 2.64 | 3.43 | 3.04 | 1.049 | 3.186 |
| | *Pseudocalanus* spp. | 0.88 | 0.38 | 0.63 | 0.086 | 0.054 |
| | Total | | | | | 8.826 |

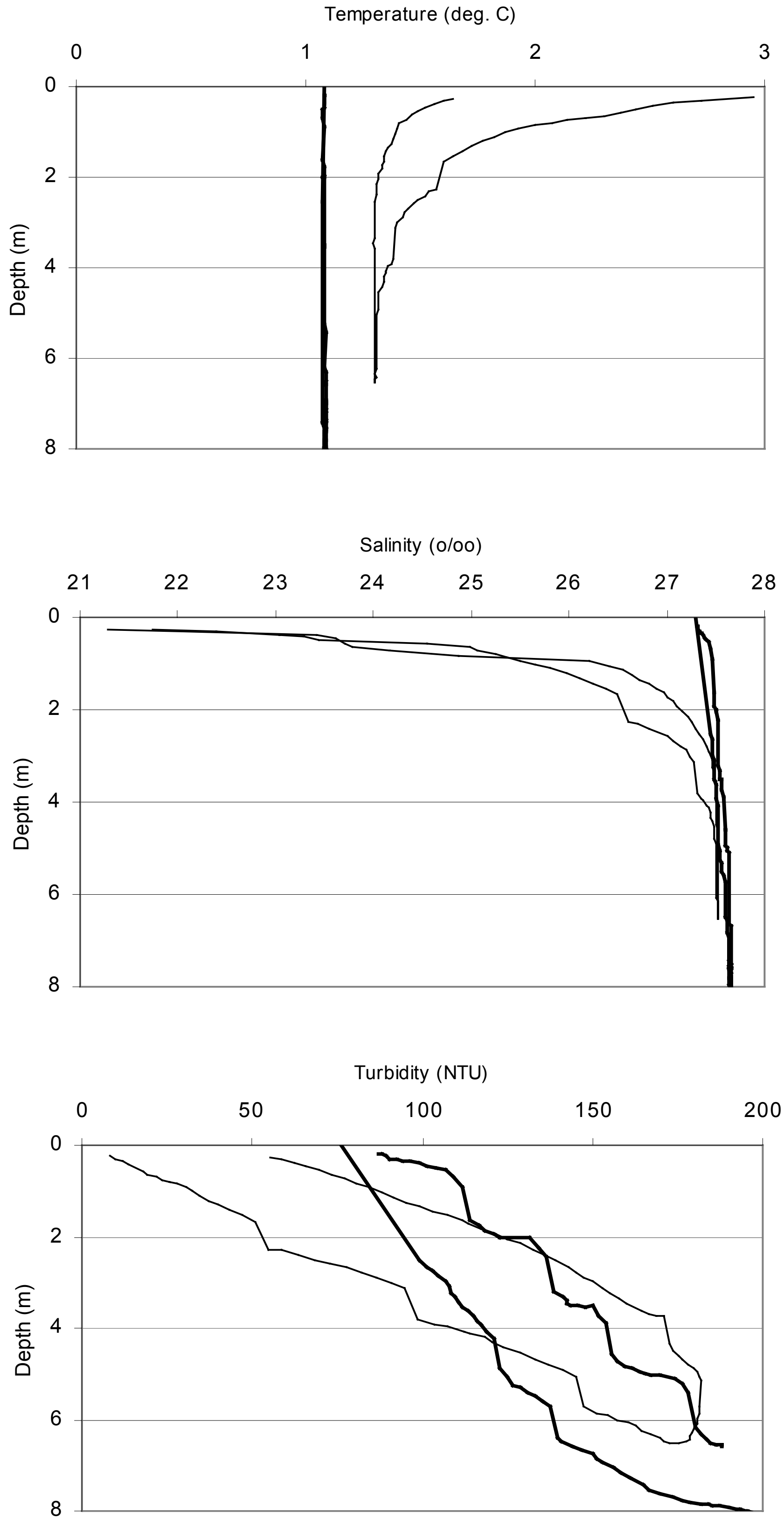


**Figure 9.** Profiles of temperature, salinity, and turbidity measured in mid channel at station two on April 8 (heavy solid line) and April 11 (thin solid line).

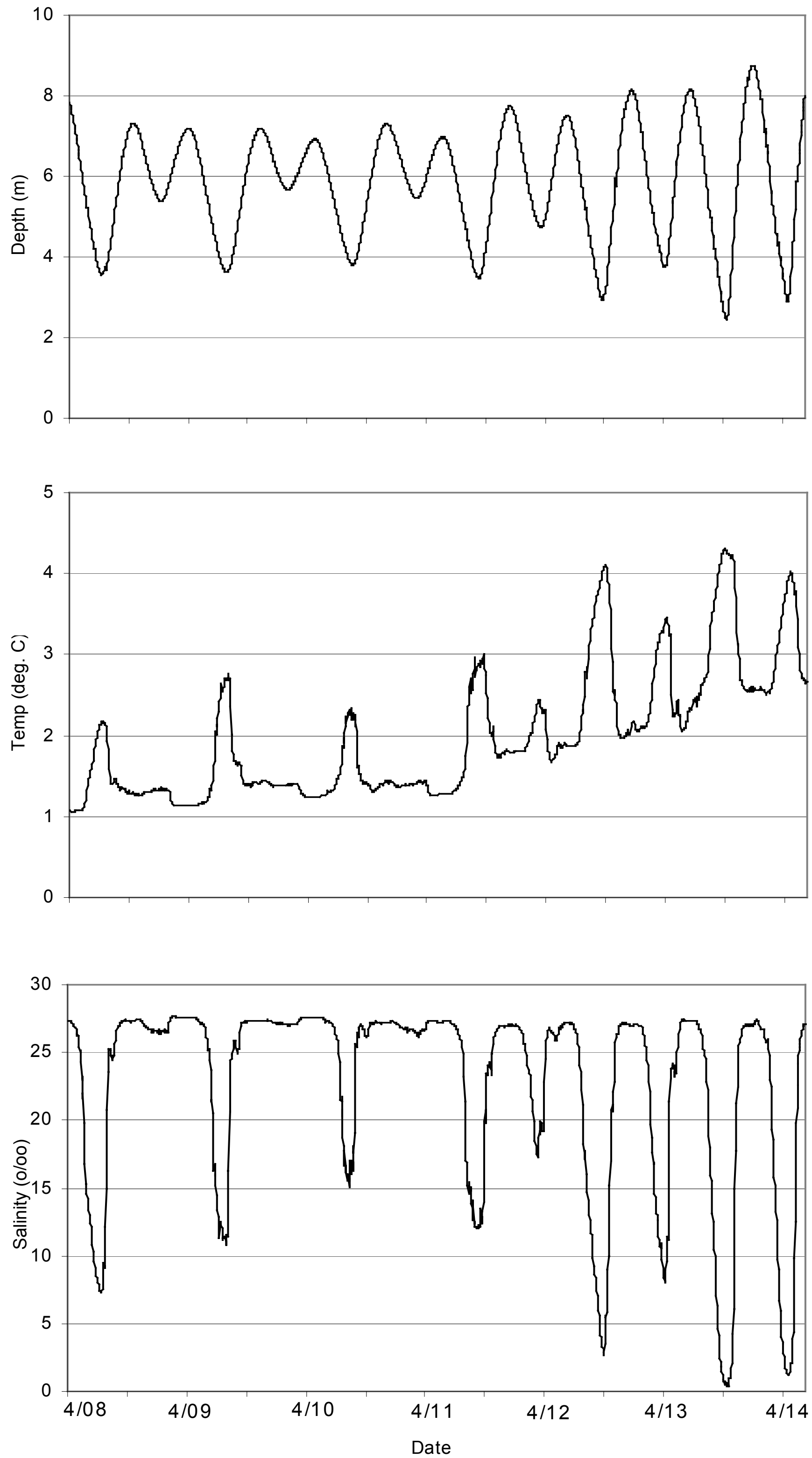


**Figure 10.** Time series of water depth, temperature, and salinity measured 2 m above the bottom in mid channel at station two, April 8-14.

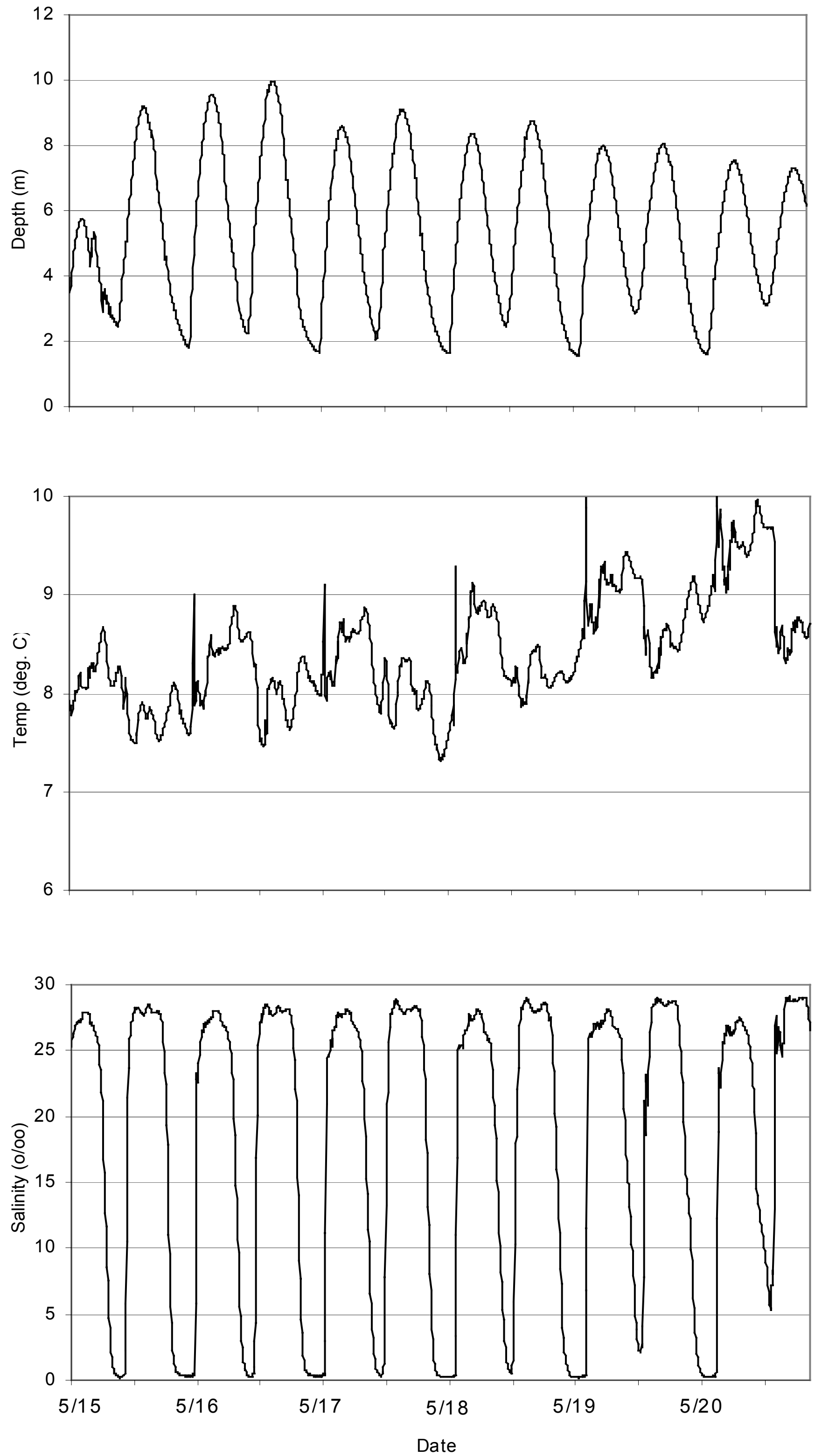


**Figure 11.** Time series of water depth, temperature, and salinity measured 2 m above the bottom in mid channel at station two, May 15-21.

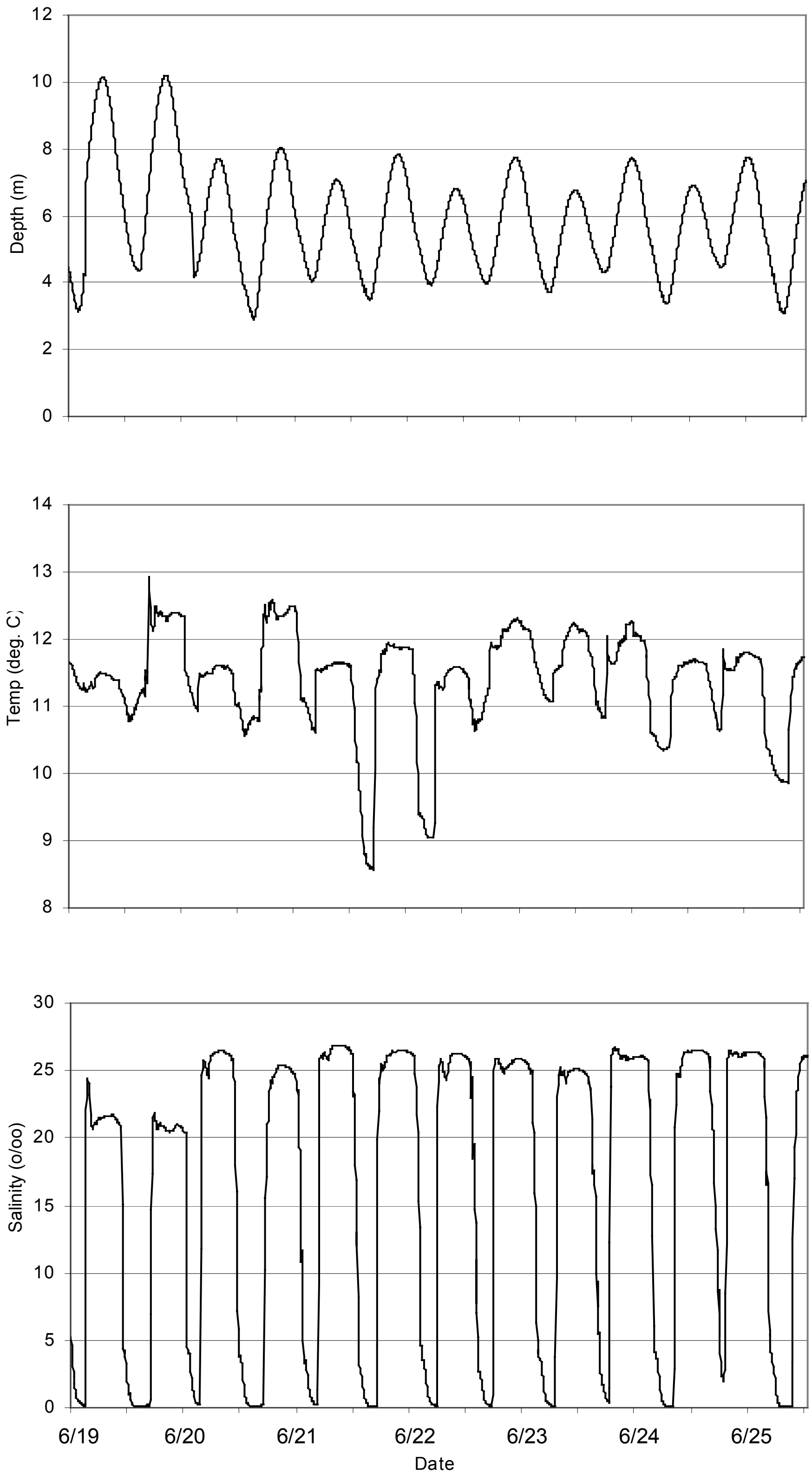


**Figure 12.** Time series of water depth, temperature, and salinity measured 2 m above the bottom in mid channel at station two, June 19-25.

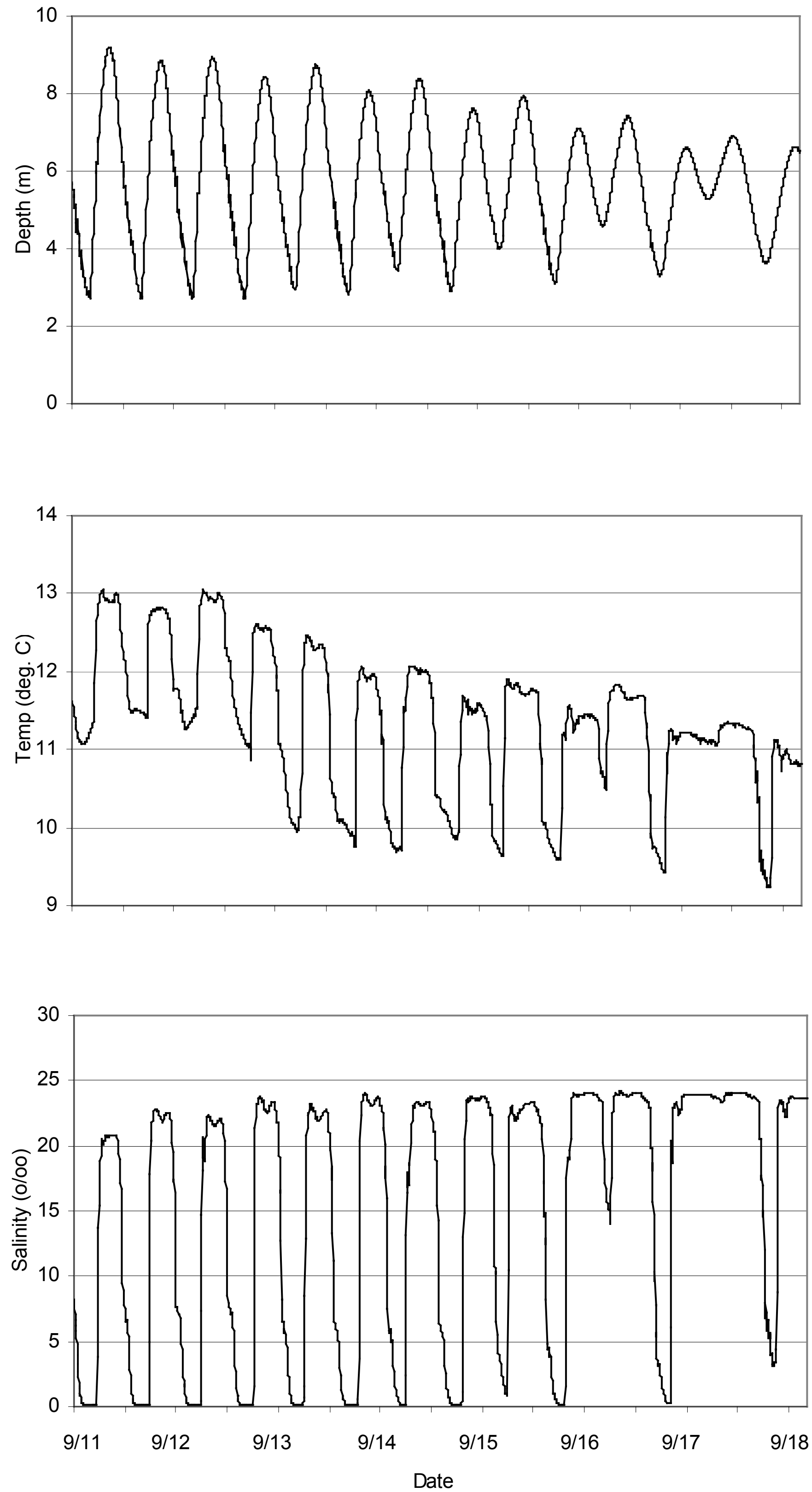


**Figure 13.** Time series of water depth, temperature, and salinity measured 2 m above the bottom in mid channel at station two, September 11-18.

## DISCUSSION

We documented the occurrence of 13 taxonomic groups of animals in the Kenai River estuary that had not previously been reported in the literature (Bendock and Bingham 1988a, 1988b): arrowtooth flounder, big skate, *Crangon* spp., *Gammarus* spp., *Neomysis* spp., *Pandalus jordani*, *Saduria* spp., sand sole, sawback poacher, silvergray rockfish, smooth lumpsucker, snake prickleback, and spiny dogfish (Table 1). Of the 31 taxonomic groups of animals found in the estuary, 19 typically occur in marine habitats, 8 are anadromous, and 4 typically occur in estuaries, but are also found in freshwater or coastal marine habitats (Mecklenburg et al. 2002). The Bering cisco commonly overwinters in salt or brackish water near river mouths (Mecklenburg et al. 2002).

Catch per net set provides a general indication of relative abundance of various taxonomic groups of animals and changes in relative abundance among sampling periods within the habitat sampled by each gear type. The townet and screw trap primarily sampled smaller animals in the water column. But, the catch per net set from these two gears cannot be directly compared, because the volumes of water they sampled differed, and screw trap catchability changed with current speed. The beach seine sampled a broader size range of animals occurring on the bottom and in the water column along shore. Variable-mesh gillnets sampled larger animals occurring from the bottom to near the surface, except when strong tidal currents caused the nets to submerge. Longlines sampled the largest animals occurring near the bottom. Our highest longline catches occurred when the gear was deployed overnight. Our data (Tables 2-5) support the following conclusions regarding the faunal assemblage sampled by these gears: (1) epibenthic invertebrates dominated the fauna sampled in April, (2) eulachon dominated the fauna sampled in the water column in June and September, and (3) six taxonomic groups of finfish were significantly more numerous in our catches in September than in previous sampling periods, while snake prickleback and the invertebrates *Neomysis* spp. and *Saduria* spp were less numerous in September.

Our April data suggest that epibenthic invertebrates may dominate the faunal assemblage in the estuary during winter. Bendock and Bingham (1988a) previously observed 11 species of finfish in the lower 10 km of the Kenai River during winter. We found only 5 of these species and 3 others they did not find. These differences may have resulted in part, because Bendock and Bingham (1988a) initiated sampling in early October, they sampled with minnow traps and substrate samplers in addition to beach seines, and they found about 10% of the juvenile salmon in inter-gravel or inter-rubble substrates, which we did not sample. However, they also did not report catches of invertebrates. The physical conditions we observed in the estuary in April were still winter like with water temperatures initially near 1$^{o}$C at low tide and river discharge very low. Further sampling should be conducted to better describe the faunal assemblage in the estuary during winter.

The species composition of the zooplankton sampled in the estuary on June 20 (Table 8) was very similar to that found in lakes in the Kenai River watershed, but the density of *Cyclops* spp. was an order of magnitude lower than typically observed in Skilak Lake (Edmundson et al. 2003). The dominance of *Cyclops* spp. in these samples was not reflected in the diets of planktivores, which largely consumed *Eurytemora* spp. in June (Figure 6). Although, the zooplankton samples we collected in June were taken near high tide, it is possible that a freshwater layer containing primarily freshwater species persisted. A shallow freshwater layer was evident on April 11 three hours after low tide (Figure 9). In June, when river discharge was greater, a shallow freshwater layer may have persisted even at high tide. Oblique tows may provide a more representative sample of zooplankton in the estuary when the water column is stratified.

Between June and September, eulachon relative abundance increased (Table 5), eulachon switched from feeding primarily on zooplankton to benthic invertebrates (mostly *Neomysis* spp. and amphipods), and their stomach fullness declined (Table 7). Their shift in feeding strategy was not related to a measured decline in zooplankton density (Table 8), but our samples may not have adequately described the zooplankton available in the estuary at that time. The decline in eulachon stomach fullness may have been related to their increase in relative abundance in the estuary and/or a decline in relative abundance of *Neomysis* spp. (Table 5). During this same period, Pacific staghorn sculpin switched from feeding primarily on fish to epibenthic invertebrates (mostly *Crangon* spp.), which were more numerous in seine and gillnet catches in September than June (Table 5). Further sampling should be conducted in the estuary using gears better designed to capture benthic invertebrates. Burrowing invertebrates (e.g. *Crangon* spp.) were likely under represented in our catches.

The Kenai River estuary can be classified as a vertically homogenous estuary in which tidal flow is great relative to river discharge and vertical salinity gradients often disappear (Kennish 2000). A general lack of vertical salinity gradients was evident in our data from the drop in salinity to near 0 ppt 2 m above the bottom at low tide during most sampling periods (Figures 10-13). Our data indicate that the Kenai River estuary supports a detritus food web in winter and a combination of detritus and grazing food webs in summer and fall. The epibenthic invertebrates that appeared to dominate the food web in April are typically suspension-feeding detritivores (Kennish 2000). Autotrophic production at this time of year is probably very low due to low light levels, high turbidity, and cold temperatures. The appearance of finfish that consumed mostly zooplankton, insects and other fishes in June indicates development of a grazing food web but detritivory was still important. The grazing food web was likely supported in large part by allochthonous inputs of organisms from nearby freshwater and marine habitats, because high turbidity in the estuary limited autotrophic production. One exception may be the marginal vascular plants that supported invertebrate grazers. This was evident from the occurrence of vegetation in the stomachs of some benthic invertebrate feeding fishes sampled in September.

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