Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Cook Inlet Beluga Whale Study
(Study 9.17)

2014 Cook Inlet Beluga Whale Prey
Study Implementation
Technical Memorandum

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

LGL Alaska Research Associates, Inc.

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation or Symbol	Definition
CIBW	Cook Inlet beluga whale
NMFS	National Marine Fisheries Service
MMPA	Marine Mammal Protection Act
GPS	Global Positioning System
m	meters
mm	millimeter
ft	foot
ha	hectare
msec	millisecond
kHz	kilohertz
dB	decibels
~	approximately
>	greater than
<	less than

1. BACKGROUND

As stated in RSP 9.17, the goals of the Cook Inlet Beluga Whale (*Delphinapterus leucas*; CIBW) study are to (1) provide current, fine scale information on CIBW distribution and movements within the Susitna River delta, (2) correlate these data with information on the ecology and habitat parameters of CIBW prey species, including eulachon (*Thaleichthys pacificus*) and Pacific salmon (*Onchorynchus* spp.), and (3) record incidental observations of all marine mammals sighted during beluga whale studies. Three specific objectives were identified:

1. Document CIBWs and other marine mammals in the Susitna River delta, focusing on CIBW distribution and upstream extent;
2. Document CIBW group size, group composition, and behavior within the Susitna River delta; and
3. Develop a model to describe the relationships between river flows, water surface elevation, and CIBW foraging habitats in the Susitna River.

This technical memo summarizes activities conducted in 2014 that tested methods to document CIBW prey and prey habitat in the Susitna River delta. Vessel-based surveys were used as a platform to collect data on beluga prey species as well as data from marine mammal sightings including distribution, behavior, and group composition. Split-beam sonar was used to collect prey data while marine mammal observers collected environmental and marine mammal sighting data. Marine mammal observers also directed vessel activities to remain in compliance with the Marine Mammal Protection Act (MMPA).

2. METHODS

Vessel surveys were carried out using a ~9 m landing craft launched from the Port of Anchorage (Figure 1). Surveys were designed to follow the shoreline between the Little Susitna River and the Beluga River in a “zig-zag” pattern. A sonar technician and two marine mammal observers from LGL participated in each survey, in addition to a skipper. The sonar technician operated and monitored data collected by a split-beam sonar (mounted at ~1 m depth on the port side of the vessel) which recorded information on fish and water depth.

Data collected during each survey included:

1. A continuous trackline from a GPS.
2. The data stream from the split-beam sonar including a continuous log of depth.
3. Environmental conditions every 30 minutes or more frequently if conditions changed (i.e., sightability increased or decreased), and
4. Observations of beluga whales and other marine mammals.

2.1 Split-Beam Sonar Surveys for Beluga Prey

The sonar system used to collect prey data was a BioSonics DT-X® split-beam echo-sounder. The echo-sounder was programmed to transmit at 206 kHz, which is outside the range of beluga whale hearing (Castellote et al. 2014). The data collection threshold for the system was set to -70 dB with a -10 dB power reduction level. The sample rate for the transducer was 12 pings per second. The pulse duration was set to 0.2 msec. Data were geo-referenced with a GPS and the locational information was collected simultaneously with the hydroacoustic sample data. The acoustic system was calibrated using a standard (36 mm diameter) tungsten carbide calibration sphere. The calibration sphere was lowered to about 2 m below the transducer, positioned in the beam, and several thousand pings were recorded to estimate target strength of the sphere. The post-calibration analysis indicated that the target strength was about 1.3 dB lower than the expected target strength for the calibration sphere. As a result, an offset of +1.3 dB was applied to the entire data set.

Acoustic data were processed using Echoview software v5.40. For targets detected 2.5 to 25 m in depth, echo tracking was used to combine individual echoes into fish tracks. The tracks were filtered by off axis angle to include only those tracks within 12 degrees of the center of the beam. The effective beam width then varied by fish depending on the fish size relative to the analysis threshold of -60 dB.

For each transect, fish density values were estimated as follows: each observed fish was weighted by the effective width of the beam at the range of the fish. The weighted fish count was then summed over each transect and divided by the transect length using the formula:

$$D_i = \frac{\sum_j \frac{1}{b_j}}{l_i}$$

where D_i is the fish density (fish/m^2) of transect i, the summation is over all fish j observed in transect i, b_j is the beam diameter (m) at range of fish j, and l_i is the length (m) of transect i. Density estimates were then expressed as fish per hectare.

We assumed Love's (1977) equation for all aspects was representative of the target strength distribution:

TS = 20 log L – 69.23 (all aspects);

where TS = target strength in decibels; and L = fork length in centimeters.

2.2 Visual Surveys for CIBW and other Marine Mammals

Two observers conducted visual scans using unaided eyes and 7x50 binoculars while the vessel conducted the surveys. Observers were primarily responsible for early detection of CIBW in the survey area and then providing guidance to the vessel skipper to operate the vessel in such a way as to avoid disturbance.

Environmental data were collected at the beginning and end of each survey, and once every 30 minutes during the survey, or if conditions affecting visibility changed rapidly. Environmental data were collected using custom-built data entry software ("PSOTracker"). The following data were collected:

- time, location, speed, heading, and leg of survey;
- sea state, visibility, and sun glare; and
- presence of other vessels in the vicinity of the survey area.

Sighting data were collected using a combination of "PSOTracker" and paper datasheets. Information was recorded at the beginning, end, and at five minute intervals during each marine mammal sighting. PSOTracker was used to capture a timestamp and GPS coordinates at the beginning of a sighting and generate a unique Sighting ID. When new information about the sighting needed to be recorded, a new record was created using PSOtracker to record a new timestamp, coordinates, and a unique Record ID. Paper datasheets were used to record the following information for each sighting:

- Sighting ID, Record ID, time and location from PSOTracker;
- Water depth at vessel and vessel heading;
- Species, group size, age/size categories;
- Location, bearing, and distance from vessel;
- Primary and secondary behaviors;
- Apparent reaction to vessel (e.g., none, avoidance, approach, etc.) and behavioral pace; and
- Group formation (e.g., parallel, echelon) and inter-individual distance

3. RESULTS

3.1 Survey Effort

Nine surveys were at least partially completed in 2014 (Table 1). Two surveys were substantially reduced due to weather, one survey was reduced due to CIBW presence in the area, and six surveys were complete. No surveys were attempted from June 3 through June 12 to avoid conflicting with National Marine Fisheries Service (NMFS) aerial surveys of CIBW abundance.

Surveys took place during low tide (n=4) and during high tide (n=5; Table 1). Surveys were designed to follow the shoreline between the Little Susitna River and the Beluga River in a "zig-zag" pattern and get as close as possible to the Susitna River mouth (Figure 2). One of the high tide surveys was modified with the intent to identify, investigate, and characterize deep channels near the river mouth. Water depth in areas surveyed ranged from ~4 ft to ~90 ft. During high tide surveys, average recorded water depth was ~18 ft and the shallowest depth recorded was ~4 ft. During the low tide surveys, the average depth was ~40 ft and the shallowest depth recorded was ~6 ft. Visibility was good for each survey, with occasional glare obstructing the view of observers. Sea states in the survey area ranged from calm (glassy sea with small ripples) to ~5 ft seas, at which point survey efforts were aborted. The final survey was nearly completed but discontinued in response to concerns about CIBW presence in the area.

Two surveys were terminated before completion due to poor quality sonar data caused by weather. Bathymetric data were good quality with minimal noise when collected during low sea states; however, sea states >3 ft and the resulting turbidity and entrained air caused excessive noise in the data. High sea states also create large gaps in the data as the pitch of the vessel can raise the transducer partially out of the water.

3.2 Sonar Surveys for Beluga Prey

The sonar data stream included a continuous log of depth as well as presence of fish targets. Deep channels were detected near the Little Susitna River and the Beluga River, but too few data points were collected to create accurate bathymetry of those areas (Figure 3). Three possible channels or holes were detected in the main body of the Susitna Delta during high tide surveys (Figure 3), but were unable to be investigated extensively due to safety concerns. The eastern channel is likely the deeper and larger of the identified channels. The edge of the flats, surveyed during low tides, is characterized by a drop off and relatively flat plain that gradually increases in depth in relation to distance from the mudflats. No substantial troughs were identified during low tide surveys although gradual fluctuations in depth were detected.

Individual fish were detected during June and July surveys. The highest fish density as averaged across the duration of each survey was on June 2nd, but in general, densities were lower in June than July (Table 2). Fish densities were highest at low tidal stages (Figure 4). No relationship between tidal stage and mean fish length is apparent. Mean fish length was somewhat greater during June surveys (Table 2). Eighty-nine percent of fish detected were <15 cm in length.

While no large fish aggregations were identified, higher densities of fish were consistently detected along the edge of the mudflats, while fewer fish were identified closer to the Susitna River in channels and holes. Deep channel habitats and holes where fish might aggregate were identified on high tide surveys, and one survey on July 21st was dedicated to exploring and characterizing such troughs; however, few fish targets and no aggregations were found in these channels and holes and mean fish density for this investigative survey was quite low (Table 2).

Fish were consistently found in the center of the Susitna Flats and towards the west near Beluga River; few fish were detected near the Little Susitna River (Figure 5). Fish were most reliably detected during low tide within ~1000 m of the exposed Susitna mudflats. This area is characterized by a deep, relatively flat plain sloping towards the inlet (Figure 3). Fish were detected ~5 m from the bottom during low tide surveys and ~1 m from the bottom during high tide surveys (Figure 6). The average bottom depth at the location of fish detections during high tide was ~10 m shallower than the average depth at fish detections during low tide surveys. Fish were detected at an average water depth of 16.3 m during low tide surveys, which was ~2 m deeper than the average depth measured across all of the low tide surveys, which indicates that fish were found more often in the deeper waters of those surveyed (Figure 6).

3.3 Marine Mammal Observations

CIBW, harbor seals, and unidentified seals were observed during surveys and during transit to and from the survey site (Figure 7). Marine mammals were observed on every survey except June 14th, which was aborted early due to weather. CIBWs were initially sighted at an average of >1000 m away and closely monitored throughout the duration of the sighting to maintain compliance with the MMPA. Observers requested multiple course alterations, reductions in speed, and shut down of engines to avoid harassment of whales and seals hauled-out on mudflats. Since the vessel frequently altered course to maintain a safe distance from marine mammals during survey operations, sizes, colors, and behaviors were difficult to discern and group composition and behavioral data are not reliable for distant sightings.

3.3.1 CIBW Sightings

Few CIBW sightings were recorded in June and these were of individual whales or small groups (Figure 8). CIBW were sighted more consistently in July and in larger groups in late July (Figure 8). The greatest number of groups was observed on July 2nd, and the greatest number of individuals was observed on July 22nd. Average group size in late June and early July was ~5 individuals and in late July was ~67 individuals, although there was substantial variability in group size in late July (Figure 9).

No discernable difference in group composition was seen during the season (Figure 10). For sightings in which the stationary boat was approached by whales, which occurred 2 times, groups were generally composed of white whales and large gray whales, with the exception of a sighting on July 16th where one small, dark-gray whale was observed (Figure 10).

The pace of all observed CIBWs was described as sedate or moderate, with the exception of one instance where belugas were observed chasing fish out of the water. The primary behavior of all CIBWs sighted in June was swimming (Figure 11). The primary behavior of CIBWs sighted in July included surface active, milling, travelling, and swimming. More coordinated group behaviors were observed in late July than June or early July. CIBWs sighted in early July exhibited behaviors such as blowing, fluking, and swimming ~80% of the time (Figure 11). In contrast, CIBWs observed in late July exhibited milling (~40%) and feeding or suspected feeding (~20%; Figure 11). There were no observable reactions to the vessel during any of the beluga sightings, including the two instances when whales approached the drifting vessel.

3.3.2 Detailed Accounts of each CIBW Sighting

CIBW were sighted three times in the month of June. Two of these sightings occurred in the survey area and only one of them occurred during a survey (Table 3). The first CIBW sighting (Sighting ID = 12) was observed near the Port of Anchorage on June 23rd and occurred while the vessel was stationary making equipment adjustments. The second sighting (Sighting ID = 18) occurred on June 28th near the eastern edge of the survey area while the vessel was in transit to the start of the survey line. This group of five CIBWs was observed ~500 m to the side of the vessel and heading away from the vessel. Given the distance and directional heading of the whales, the survey vessel did not change course to further avoid the group. The third sighting also occurred on June 28th (Sighting ID = 21). A group of 10 whales was observed ~300 m to the side of the vessel, which was surveying on transect at <5 mph. Again, no change of course was required to avoid the whales. Lighting conditions were poor at the time of the sighting, and observers could not distinguish the color of the whales.

CIBWs were sighted during all four surveys in July. On July 2nd, five sightings of small groups of beluga whales were observed. Two of the groups were observed while the vessel was in transit to the start of the survey (Sighting IDs = 30, 31). The third sighting (Sighting ID = 32) occurred while the vessel was present on a transect line, but stationary while sonar equipment was being adjusted. The last two sightings on July 2nd (Sighting ID = 34, 35) occurred during surveys.

CIBWs were sighted two times on July 16th, including a group of approximately 50 individuals that were initially detected 2,000 m from the vessel as it was surveying (Sighting ID = 38). The vessel altered course and abandoned the survey line when whales were ~400 m away. The vessel then stopped and turned off its engines when belugas approached the vessel to within ~250 m. Several whales approached as close as 10 m from the drifting vessel and appeared to be feeding. One fish jumped out of the water with a whale in pursuit. There was no apparent reaction to the vessel and CIBW behavior was consistent throughout the encounter. After the whales moved >400 m away, the engine was restarted and the survey continued. The second sighting on July 16th (Sighting ID = 39) occurred during transit after the survey was completed. Several belugas were seen ahead of the vessel and the vessel reduced speed, then stopped and turned off the engines when whales were ~250 m from the vessel. Some individuals approached the stopped vessel as close as 3 m, including one cow with a dark gray calf. Observers recorded that whales appeared to be traveling past the vessel. Again, there was no apparent reaction to the vessel and no behavioral changes were observed. The vessel resumed transit when the belugas were >300 m away.

A single, distant sighting of a group of 45 individuals occurred on July 21st (Sighting ID = 40). Due to the distance of the sighting, mostly white whales and a few large gray whales were distinguished within the group.

Two sightings occurred on July 22nd. Whales were initially observed at ~2,500 m with a closest point of approach of ~350 m (Sighting ID = 45). At ~350 m, the vessel altered course and abandoned the survey line to maintain distance from the whales. Severe glare made group composition impossible to determine. The second sighting was brief and distant, and only blows were clearly visible (Sighting ID = 47).

3.3.3 Accounts of Seal Sightings

More sightings of seals occurred in June than July; however, larger groups were seen in July than in June. Twenty six sightings of 34 individual harbor seals and unidentified seals occurred in June and 7 sightings of 134 seals occurred in July (Table 4). It is likely that unidentified seal sightings were harbor seals; however, the sightings were too brief or distant for the observers to identify to species. The most common primary behavior of seals was look, followed by swim. The most common reaction to the presence of the vessel was look, followed by no observable reaction. Two of the seal sightings were of haul-outs on the mud flats during low tide. The majority of the seals observed were described as sedate.

3.4 Marine Mammal Distribution and Prey

In general, on days when fish densities were high, marine mammal sightings were also high; although this relationship appears stronger for CIBW than for seals (Figure 12). The major exception to this trend is that the highest fish density was detected on June 2nd, but no CIBW were observed in the Susitna River delta during that survey. Large groups of CIBW were first detected in the Susitna River Delta on July 16th. Of the three days surveyed when belugas were observed in large groups, two days (July 16th and July 22nd) also had high fish densities. There was also a strong spatial relationship between fish density and CIBW sightings on these days (see Figure 13 and descriptions below). This relationship did not appear to be present on days with low to moderate fish density (Figure 14). It is important to note that data analyses from the split-beam sonar can only describe the fish density along the vessel trackline and fish density at distant CIBW sightings may have been much higher (or lower) than the average density near the survey vessel.

On July 16th, the vessel altered course and shut off engines to avoid harassment of a group of beluga whales traveling southwest along the mudflats (see *Detailed Accounts of each CIBW Sighting* for more information). As belugas approached the drifting vessel (Record ID 2 in Figure 15), fish density below the vessel increased dramatically (Figure 16). Fish density reached the highest recorded value (~2,000 fish/ha) encountered during the 2014 season when whales were <100 m from the vessel (Figure 16). CIBW behavior during this time was recorded as feeding or suspected feeding. Once the whales moved past the vessel (Record ID 4 in Figure 15), fish density had decreased to relatively low levels.

On July 22nd, the vessel altered course several times to maintain safe distance from a group of beluga whales spread out across the survey area to the north of survey activities. Fish densities increased as the vessel followed transect lines that neared the group of belugas and then decreased as the vessel altered course and moved away from belugas (Figure 17). Primary behavior for the group of belugas was “milling.”

Harbor seal sightings also occurred in areas of highest fish density. The survey on June 2nd had the highest density of fish and the largest number of harbor seal sightings. Harbor seal sightings occurred in the areas of highest fish density in the survey (Figure 18).

4. LITERATURE CITED

Castellote, M., T.A. Mooney, L. Quakenbush, R. Hobbs, C. Goertz, E. Gaglione. 2014. Baseline hearing abilities and varibability in wild beluga whales (*Delphinapterus leucas*). Journal of Experimental Biology. (217) 1682-1691.

Love, R. H. 1977. Target strength of an individual fish at any aspect. Journal of the Acoustical Society of America 62:1397-1403.

5. TABLES

Table 1. CIBW prey surveys in the Susitna River Delta in 2014.

Date	Tide at Start	Tide at End	Tidal Stage	Duration (h)	Fish Detected	Belugas Observed
June 02 2014	+27.4	+6.6	Low	4.8	Yes	No
June 14 2014	+32.8	+32.2	High	1.0	No	No
June 23 2014	+23.4	+25.9	High	1.8	Yes	Yes
June 28 2014	+28.8	+24.2	High	2.8	Yes	Yes
June 29 2014	+26.6	+28.8	High	2.0	Yes	No
July 02 2014	+13.5	+4.9	Low	2.8	Yes	Yes
July16 2014	+10.8	+0.1	Low	2.8	Yes	Yes
July 21 2014	+22.8	+19.9	High	3.8	Yes	Yes
July 22 2014	+11.0	+4.1	Low	2.9	Yes	Yes

Table 2. Mean fish density (number of fish per hectare) and standard error, count of fish detected, and mean fish length (cm) by survey.

Date	Tidal Stage	Mean Density*	Standard Error	Count	Mean Fish Length (cm)
June 01 2014	N/A	N/A	N/A	N/A	N/A
June 02 2014	Low	85.0	6.9	451	9.9
June 14 2014	High	0.0	0.0	N/A	N/A
June 23 2014	High	2.6	2.6	1	3.0
June 28 2014	High	28.2	6.7	32	9.3
June 29 2014	High	2.4	1.4	3	8.3
July 02 2014	Low	40.8	5.5	107	5.6
July16 2014	Low	48.9	13.5	139	7.5
July 21 2014	High	4.7	2.6	6	4.5
July 22 2014	Low	53.8	6.9	187	6.6

* number of fish per hectare

Table 3. CIBWs observed both during surveys and during transits to the survey area in 2014.

Sighting ID	Sighting Date	Sighting Time	During Survey	Total Number of Individuals	Initial Sighting Distance (m)	Closest Point of Approach (m)
12	6/23/2014	14:45	N	1	300	300
18	6/28/2014	06:44	N	5	500	500
21	6/28/2014	09:40	Y	10	300	300
30	7/2/2014	14:32	N	4	1000	750
31	7/2/2014	14:42	N	6	1500	1500
32	7/2/2014	14:55	N	3	400	400
34	7/2/2014	16:08	Y	7	1000	1000
35	7/2/2014	16:11	Y	4	700	700
38	7/16/2014	15:41	Y	50	2000	10
39	7/16/2014	18:00	N	75	400	3
40	7/21/2014	15:30	Y	45	3000	1000
45	7/22/2014	08:41	Y	150	2500	300
47	7/22/2014	09:52	Y	15	1000	750

Table 4. Seals observed during surveys and during transits to the survey area in June, 2014.

Species	Total Number of Sightings	Total Number of Individuals
Harbor Seal	28	162
Unidentified Seal	5	6

6. FIGURES

Figure 1. Landing craft used for surveys. The mounted transducer is on the port side of the vessel forward of the wheelhouse.

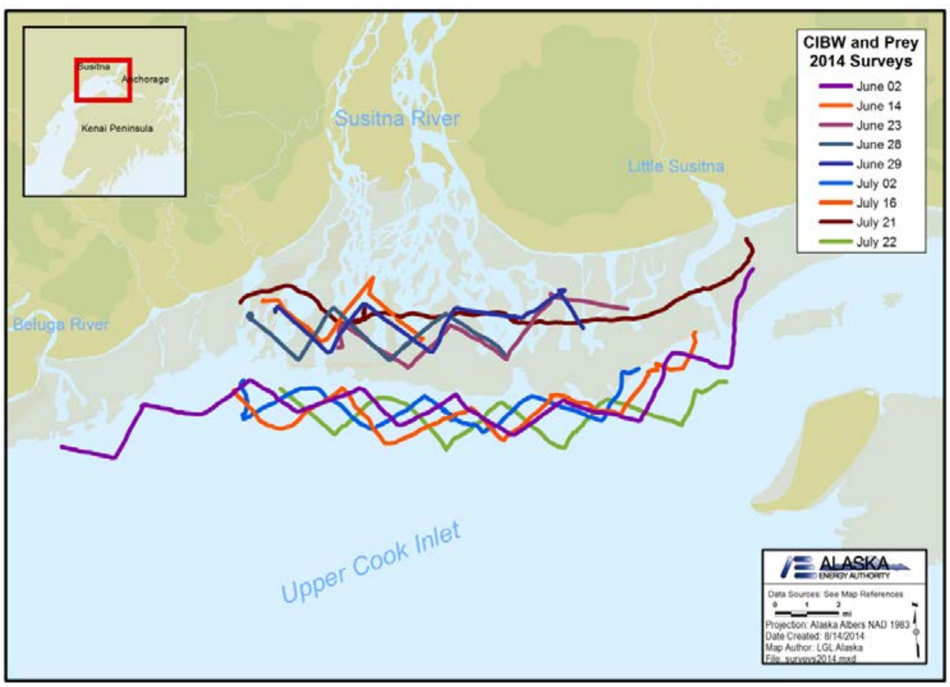

Figure 2. CIBW prey surveys in the Susitna River Delta in 2014. Five of the surveys occurred during high tide (lines closer to the mouth of the Susitna River), and four occurred during low tides (longer lines further from the river mouth).

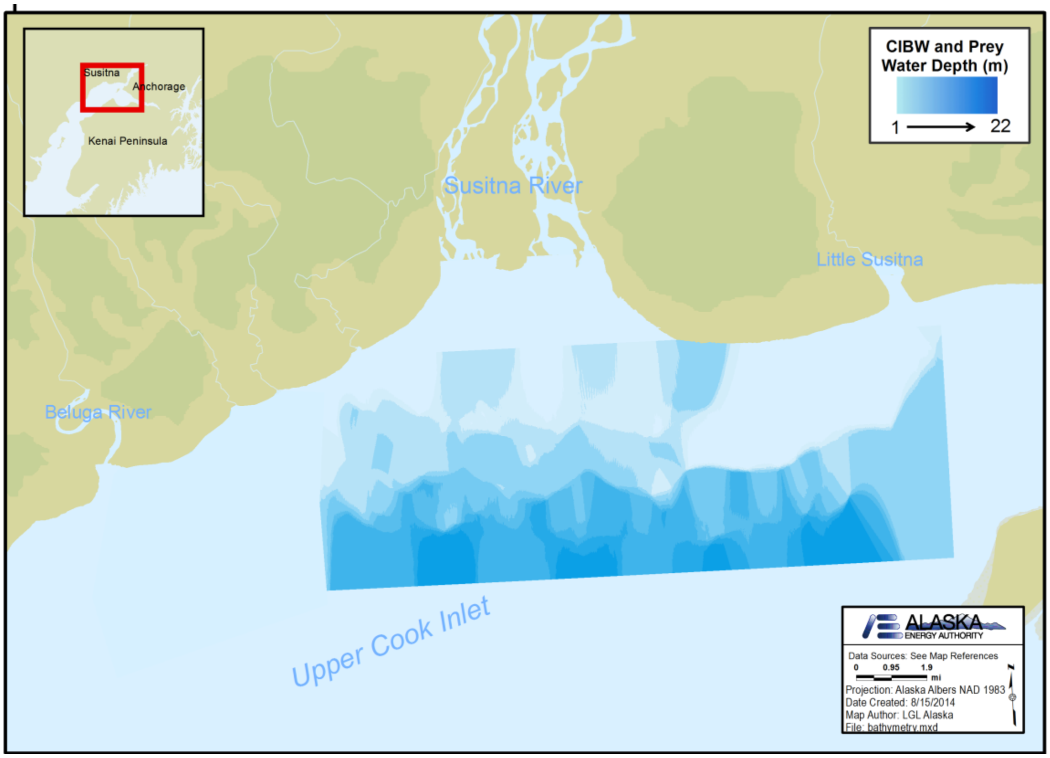

Figure 3. Water depth in meters corrected for MLLW in the Susitna River Delta in 2014. Depth between data points was interpolated using the kriging formula in ArcGIS 10.2. Depths near the Little Susitna River and at the southern portion of the survey area were calculated using few data points and should be interpreted with caution.

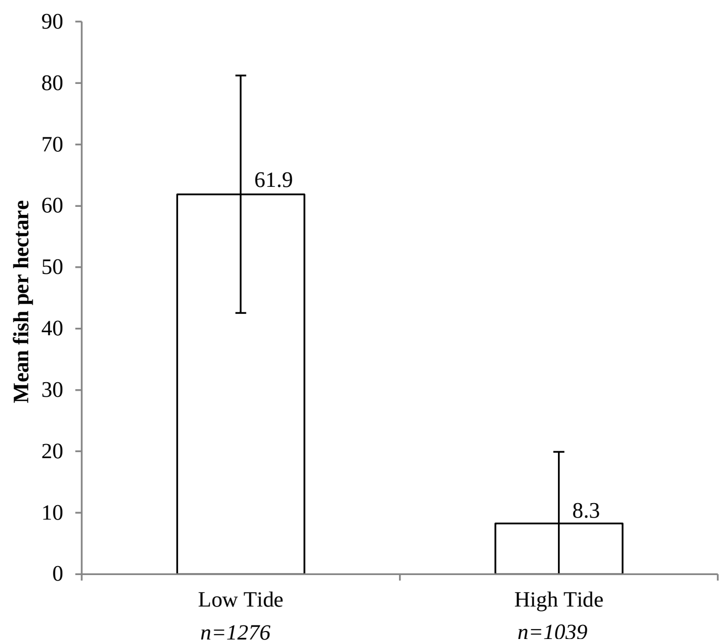

Figure 4. Fish densities at low and high tidal stages

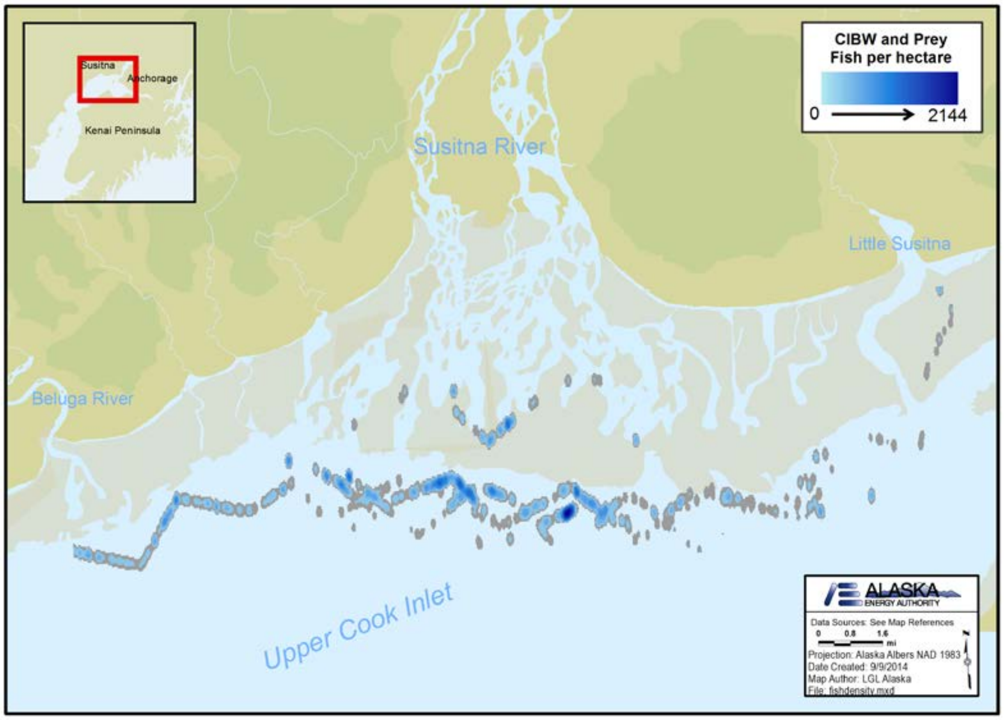

Figure 5. Density of prey (fish per hectare) for all surveys in the Susitna River Delta in 2014. Highest densities of fish were detected near the edge of the exposed mudflats during low tide.

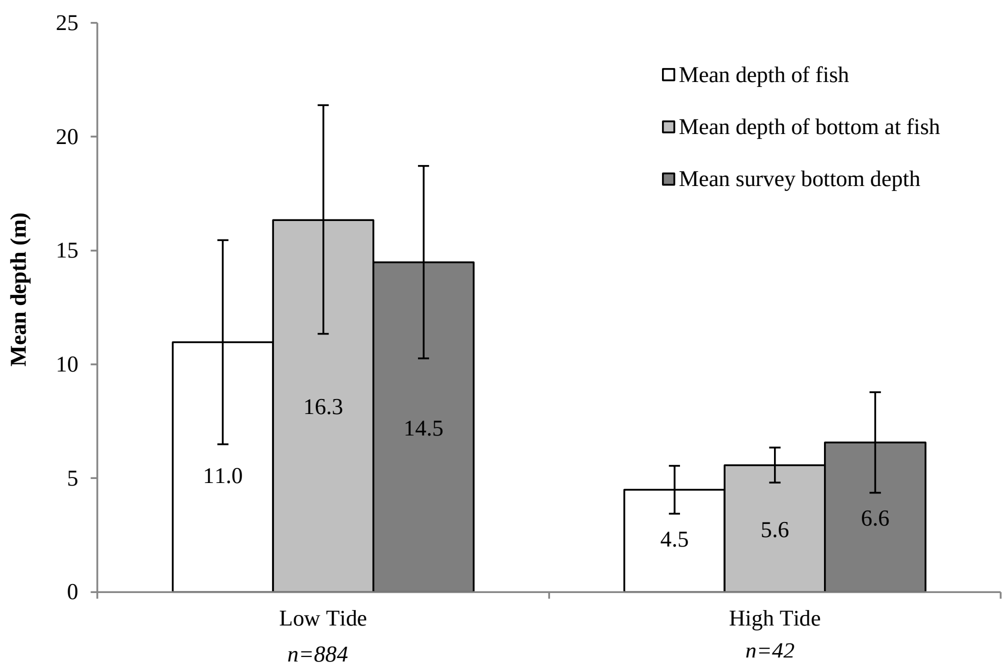

Figure 6. Mean water depth (m) of fish, mean depth of water at the time of fish detection, and mean depth of water of each survey by tidal stage.

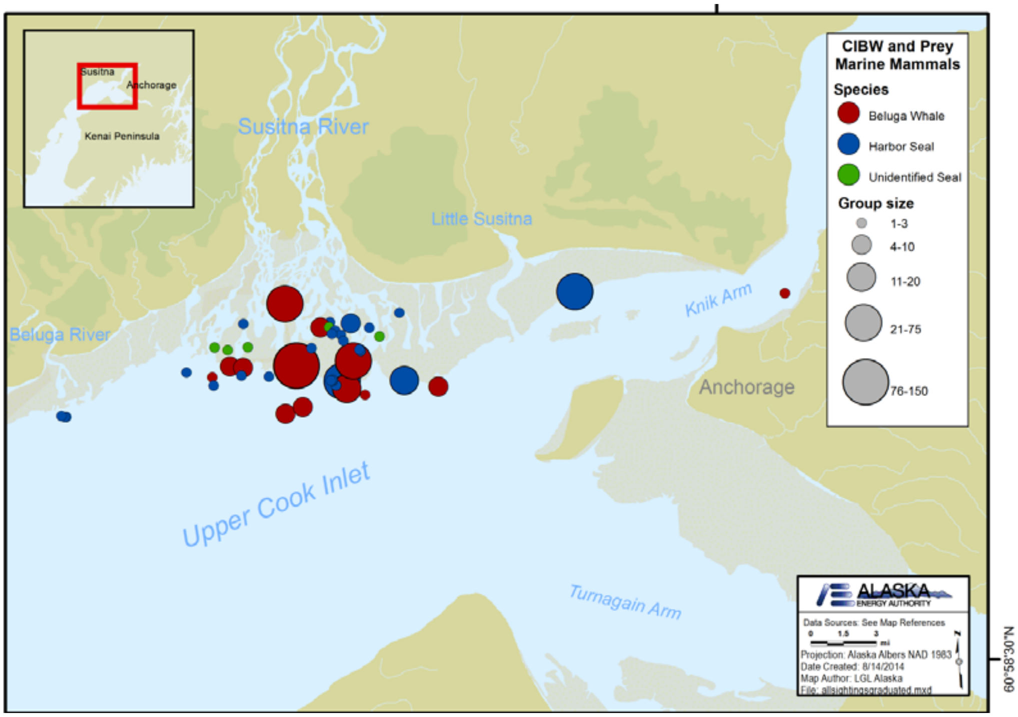

Figure 7. Marine mammals observed during surveys and transits to the survey area in 2014. Observation locations depicted were corrected for distance and location relative to the vessel during post-season data processing using ArcGIS 10.2.

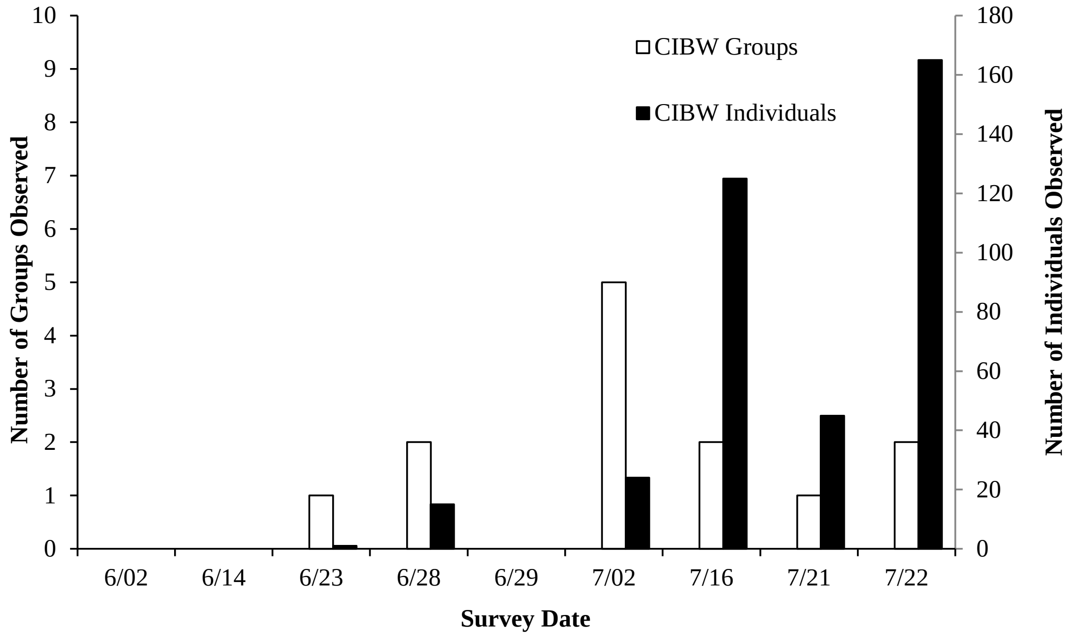

Figure 8. Number of CIBW groups and number of CIBW individuals observed during surveys and transits to the survey area in 2014.

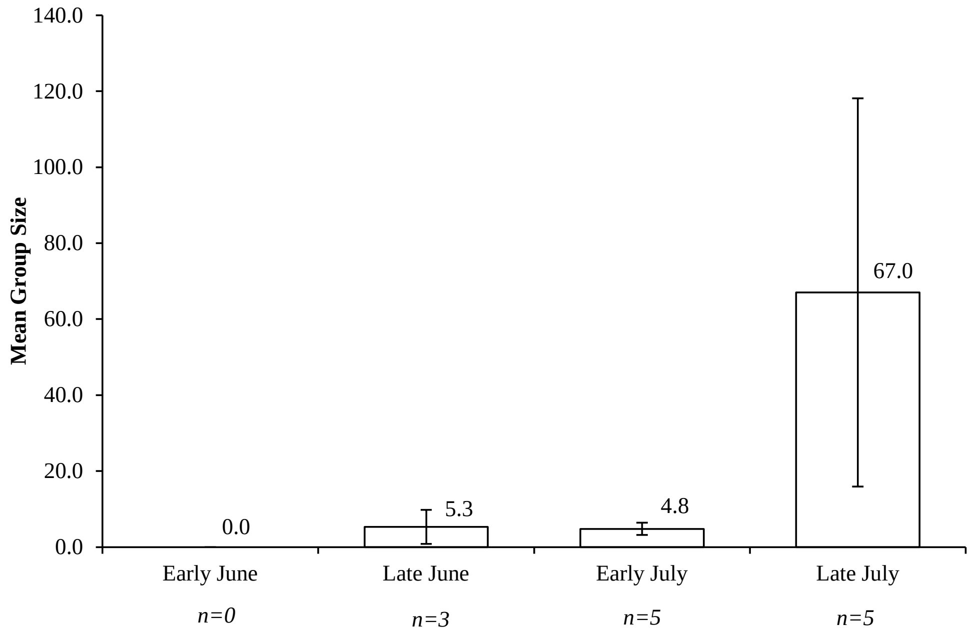

Figure 9. Mean number of individuals per group of CIBWs in the Susitna River Delta in June, 2014.

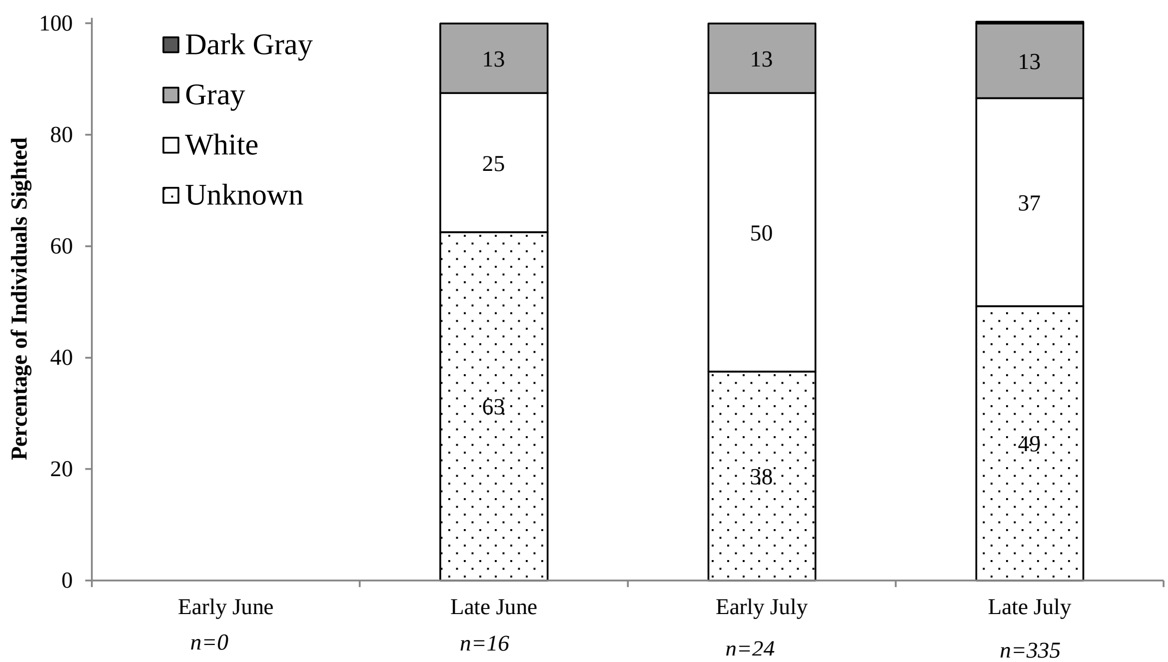

Figure 10. Color composition of CIBW groups observed in the Susitna River Delta in June, 2014. Due to the effort of the vessel to maintain distance from CIBW groups, group composition data are not reliable for distant sightings. See Detailed Accounts of each CIBW Sighting for more information.

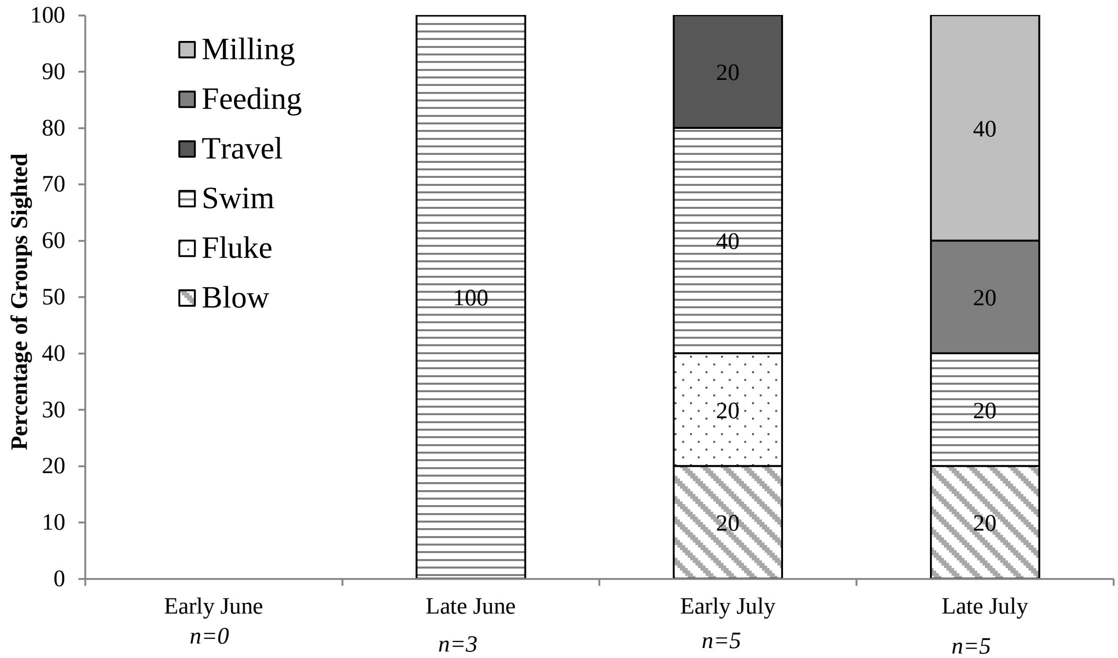

Figure 11. Behavioral composition of CIBW groups observed in the Susitna River Delta in June, 2014. Due to the effort of the vessel to maintain safe distance from CIBW groups, behavioral data are not reliable for distant sightings. See Detailed Accounts of each CIBW Sighting for more information.

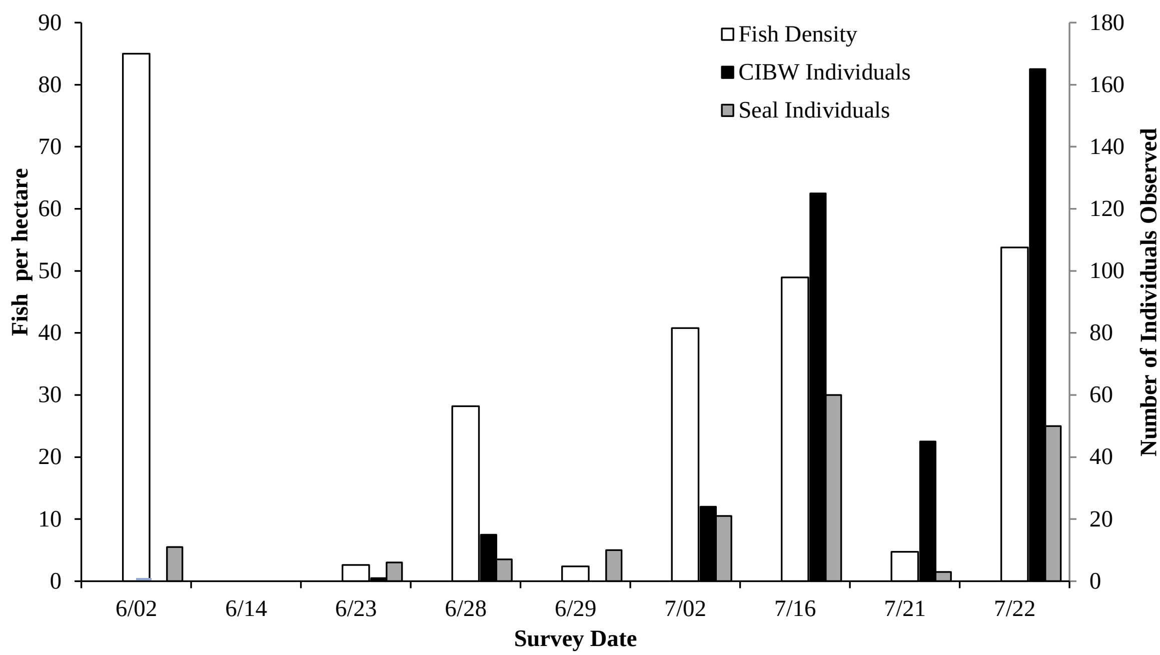

Figure 12. Fish density detected, number of CIBW individuals, and number of harbor seal and unidentified seal individuals observed in the Susitna River Delta in 2014.

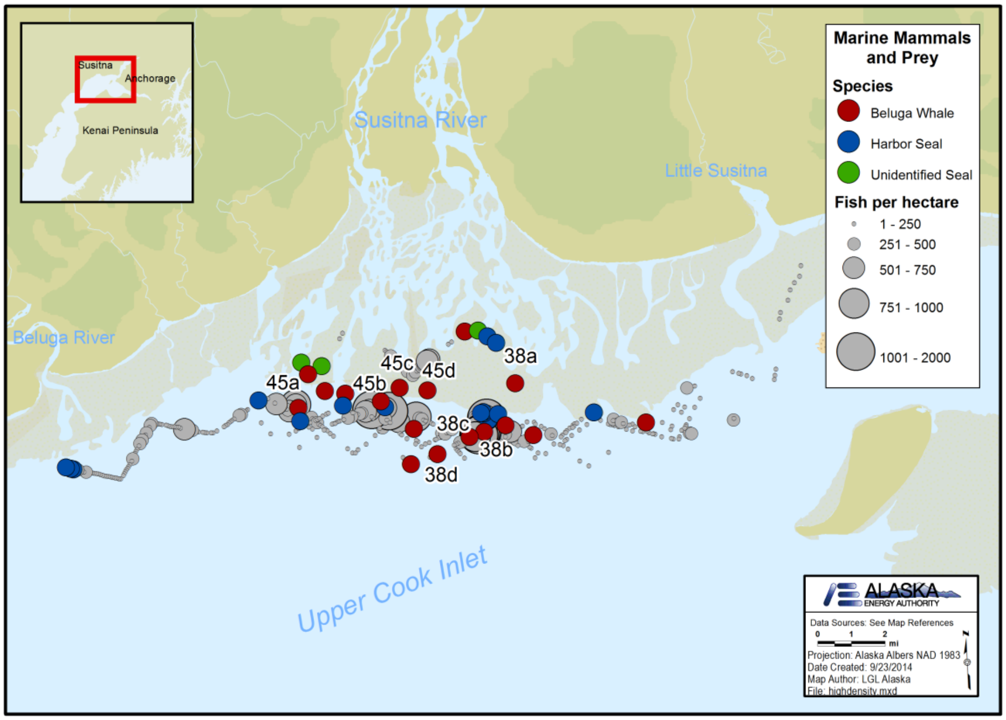

Figure 13. CIBW, harbor seal, and unidentified seal sightings on days with high fish density (June 02, June 28, July 02, July 16, and July 22). Labels indicate the location of multiple records of the same Sighting ID.

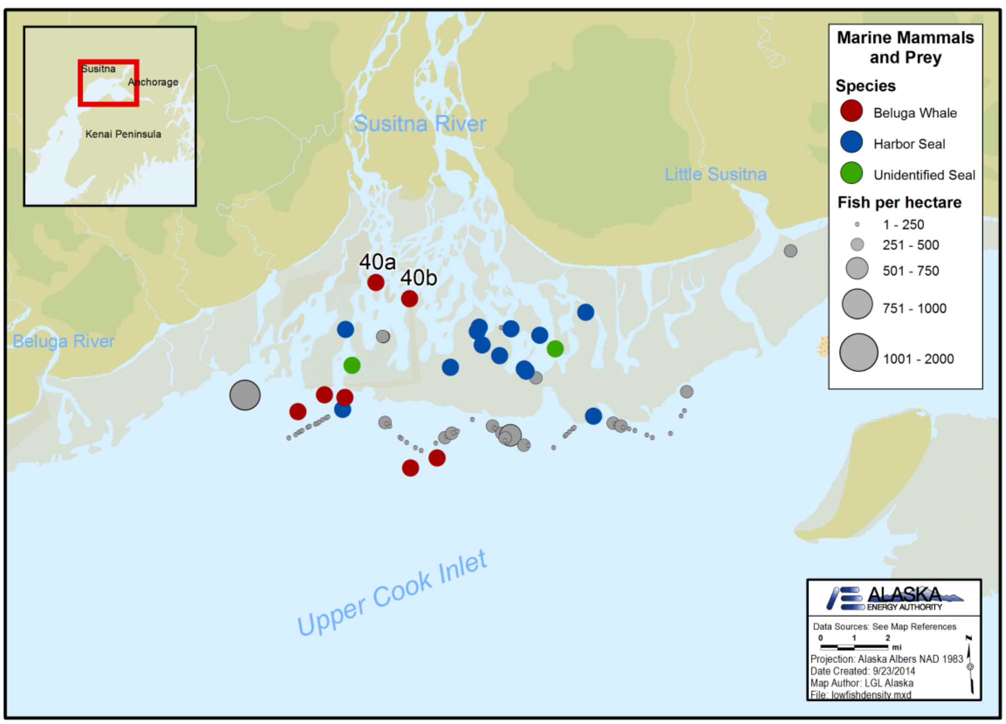

Figure 14. CIBW, harbor seal, and unidentified seal sightings on days with low fish density (June 14, June 23, June 29, and July 21). Labels indicate the location of multiple records of the same Sighting ID.

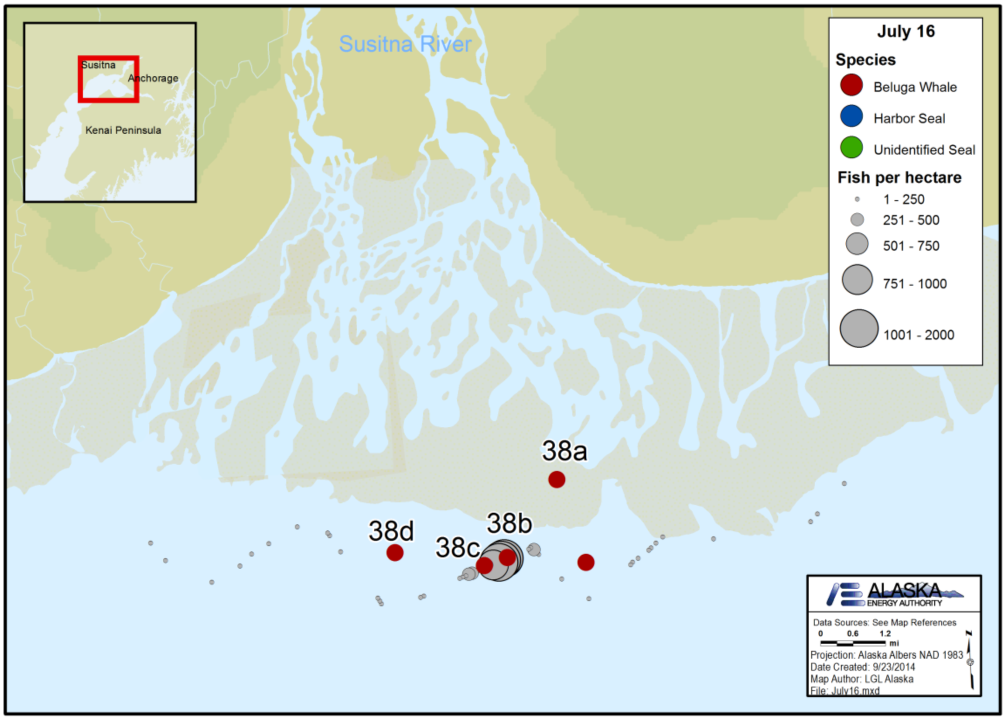

Figure 15. CIBW sightings and fish density on July 16, 2014. Labels indicate the location of multiple records of the same Sighting ID.

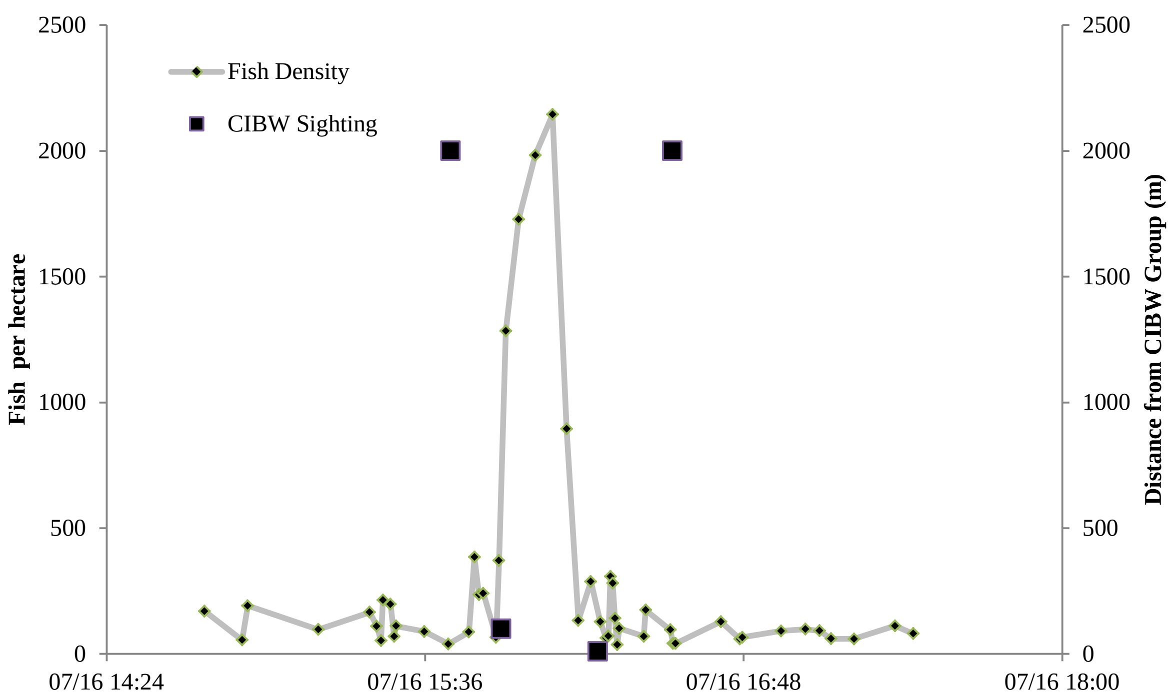

Figure 16. Fish density and distance of vessel from CIBWs for Sighting ID 38. As fish density increased, distance from CIBWs decreased. Vessel engines were off and vessel was drifting when closest whales were ~250 m away.

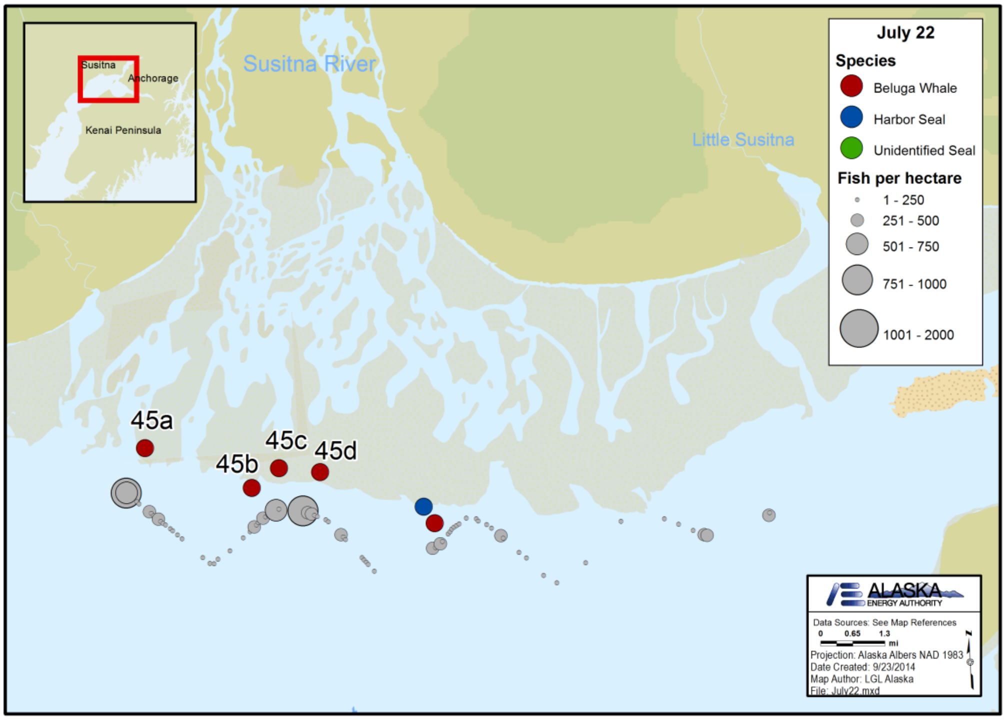

Figure 17. CIBW sightings, harbor seal sightings, and fish density on July 22, 2014. Labels indicate the location of multiple records of the same Sighting ID.

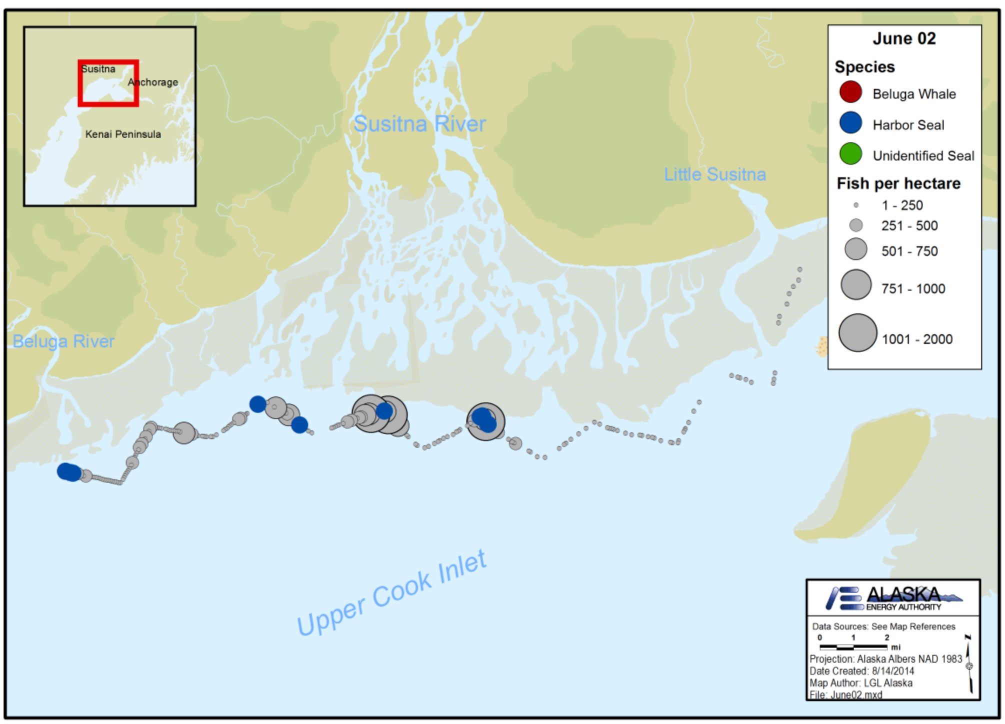

Figure 18. Harbor seal sightings and fish density on June 02, 2014.