Corps Discussion of Turbidity Memo

Memorandum

Discussion of Turbidity, Change in Substrate, and Contaminants

Date:	May 5, 2023
Project Name:	Port of Alaska Modernization Program
To:	Mike Holley (HDR)
Thru:	
From:	Suzann Speckman (HDR), Mallory Allgeier (HDR)

Several agencies expressed three primary concerns regarding potential effects of disposing fill material from North Extension Stabilization (NES1) deconstruction into Knik Arm: settling of sediment into Cook Inlet beluga whale (*Delphinapterus leucas*) designated Critical Habitat, changes in substrate composition attracting benthic organisms, and additional contaminant loading within the water column.

1. Turbidity

Cook Inlet is a large estuary that at its southern terminus feeds into the Gulf of Alaska. Upper Cook Inlet, defined as the portion of the Inlet north of the East and West Forelands, is a shallow basin with depths of approximately 19.8 meters (65 feet; USACE 2023). At its northern reaches, Upper Cook Inlet divides into two branches: Knik Arm and Turnagain Arm. Knik Arm flows from the northeast and has an average depth of 15.2 meters (50 feet) for half of its length before it shoals into a tidal flat. The navigation harbor at the POA is a dredged basin in the natural tidal flat. Turnagain Arm is primarily a large tidal flat cut by many tidal channels. It flows from the southeast and shoals within its first ten miles (USACE 2023).

Tides in Cook Inlet are semidiurnal, with two unequal high and low tides per tidal day (tidal day = 24 hours, 50 minutes). Due to Knik Arm's predominantly shallow depths and narrow widths, tides near Anchorage are greater than those in the main body of Cook Inlet. The tides at the Port of Alaska (Port) have a mean range of about 8 meters (26 feet), and the maximum water level has been measured at more than 12.5 meters (41 feet) at the Anchorage station (NOAA 2023). Maximum current speeds in Knik Arm, observed during spring ebb tide, exceed 7 knots (3.7 meters per second [12 feet per second]) and are typically about 4.8 to 6.8 knots (2.5 to 3.5 meters per second [8.2 to 11.5 feet per second]). Tides result in strong currents in alternating directions through Knik Arm and a well-mixed water column.

The large quantities of glacially-derived sediments that enter Upper Cook Inlet from rivers are a natural phenomenon (Sharma and Burrell 1970). Sediment loads in Upper Cook Inlet can be high; river discharges introduce considerable amounts of sediment into the system (Sharma and Burrell 1970, Ebersole and Raad 2004). About 70 percent of the freshwater discharged into Cook Inlet comes from three glacier-fed rivers: the Susitna, Matanuska, and Knik rivers (Gatto 1976). Two of these rivers, the Matanuska and Knik, enter Knik Arm, where the Port is located, and discharge approximately 20 million tons of sediment annually. Rivers entering Turnagain Arm discharge approximately 3 million tons of sediment (Gatto 1976). Suspended sediment concentrations in Upper Cook Inlet can be higher than 1,700 milligrams of sediment per liter near Anchorage (Wright et al. 1973). Natural sedimentation processes act to continuously infill the dredged basin at the Port each spring and summer.

Several studies have attempted to measure the recovery time for a marine system to return to baseline suspended sediment concentration levels after dredging and disposal occurred. Palanques et al. (2022) conducted a study along the Barcelona Continental Shelf that showed the effects of persistent disposal (10 to 19 disposal events per day for 54 days) on the benthic environment and water quality. The disposal site was located 4 kilometers (approximately 2.5 miles) offshore, had a depth of 48.8 to 70.1 meters (160 to 230 feet), and was generally not considered to be a highly dispersive environment with a current speed of approximately 10 centimeters per second (3.9 inches per second). Palanques et al. (2022) found the sediment disposal acutely affected the natural ambient water turbidity. Suspended sediment concentration levels ranged from 0.4 to 22.7 milligrams per liter and had a mean of 1.3 milligrams per liter before dumping was initiated. Suspended sediment concentration levels peaked during disposal at 203 milligrams per liter, the upper range capability of the sensor used. The time to recover to baseline suspended sediment levels was 110 to 130 minutes; however, due to the frequency of disposal, the ambient suspended sediment concentration levels were not achieved until the end of the day after the last dump occurred. A tidally-driven disposal site off the coast of Belgium with current speeds of 30 to 80 centimeters per second (11.8 to 31.5 inches per second) saw sediment level recovery times of 35 minutes (van Parijs et al 2002, Lanckneus et al. 2001). A sand disposal area near the Strait of Gibraltar had current speeds up to 63 centimeters per second (24.8 inches per second), and a sediment level recovery time of approximately 9 minutes (Roman-Sierra et al. 2011).

The tide speeds and ranges in Knik Arm are far more extreme than in the previously noted studies, and the Coriolis forces at this northern latitude further enhance mixing and turbulence (Sharma and Burrell 1970). Additionally, the tides reverse the direction of flow twice per day. These high-energy forces result in a well-mixed water column, and are anticipated to disperse and dilute water-suspended sediments quickly into background levels.

HDR conducted an assessment of the offshore sediment disposal of the NES1 fill material (McPherson et al. 2023). The model determined that sediment particles finer than approximately 0.3 millimeters are expected to settle into the disposal area within approximately 15 minutes of release. Gravel is expected to travel a maximum of 61 to 305 meters (200 to 1,000 feet), and medium and coarse sand will travel 76 to 1,219 meters (250 to 4,000 feet) from the disposal point. Fine sand and smaller grains of sediment smaller than approximately 0.2 millimeters are anticipated to remain in the water column long enough to be washed out of the disposal area in all scenarios when the current flows in high tide, mid tide, and low tide discharges. Fines of 0.2 millimeters and smaller may be carried over 2.13 kilometers (7,000 feet) in all scenarios before settling to the seafloor. Depending on tidal current and depth, fines may travel more than 22.5 kilometers (14 miles) before settling (McPherson et al. 2023).

The duration that discharged sediment will be suspended in the water column can be calculated based on settling velocity and depth. Assuming the same mean seafloor elevation outside the disposal area and within (25 meters [82 feet]) and time-varying tidal elevation, sediment 0.2 millimeters and finer will remain suspended for 18 minutes to 4.7 hours after disposal (McPherson et al. 2023). Sediment is, in theory, suspended longest at low tide because as the sediment settles, the water gets deeper with the incoming tide. McPherson et al. (2023) details the results and is included with this discussion memo.

Turbidity is a dominant structuring force for biological communities in the Cook Inlet estuarine system (Speckman et al. 2005). Turbidity strongly influences chlorophyll α levels, which can be greatly reduced in highly turbid areas (Larrance and Chester 1979, Speckman et al. 2005). The trend of diminishing chlorophyll α levels in the direction of high turbidity is common in estuaries, where the suspended sediments increase light attenuation.

However, turbid areas in Cook Inlet can also be biologically productive for species that are adapted to these environments. Speckman et al. (2005) found that several zooplankton species had peak abundance in highly turbid areas although their overall densities were low. Longfin smelt and juvenile salmon can feed on zooplankton and were found exclusively or nearly so in turbid, warm, low-salinity waters (Speckman et al. 2005). These and additional species are known to occur in Knik Arm (Moulton 1997, Houghton et al. 2005) and to be consumed by beluga whales (Houghton et al. 2005; Rodrigues et al. 2006, 2007; Quakenbush et al. 2015).

Feeding by piscivores (fish-eating fish) is substantially more sensitive to elevated turbidity than feeding by planktivores (plankton-eating fish; De Robertis et al. 2003). De Robertis et al. (2003) found that at a turbidity level of 10 nephelometric turbidity units (NTU; approximately 34.216 milligrams per liter), a piscivorous predator was unable to capture its prey, whereas feeding by two planktivores was unaffected. Elevated turbidity may be advantageous for planktivorous fish because they are less vulnerable to predatory fishes (De Robertis et al. 2003, Gregory and Levings 1998) without having to give up feeding opportunities. High average turbidity levels can create refugia for longfin smelt, juvenile salmon, and other species by reducing predation. Availability of turbid estuarine habitats that provide protection from predators may be especially important for young salmon, which utilize estuaries as they adapt to marine conditions (Linley 2001, Simenstad et al. 1982).

Many marine mammals, including beluga whales, have evolved sophisticated sonar systems to sense the world around them. As such, they are well adapted to inhabit turbid environments (Au et al. 2000), and in some cases, may even benefit from turbidity. “Brown zones” located at the terminus of tidewater glaciers are turbid environments that are important foraging areas for many species due to the upwelling of nutrients. Off the coast of Svalbard, brown zones are important foraging hotspots for marine mammals (Lydersen et al. 2014) such as ringed seals (Freitas et al. 2008) and beluga whales (Lydersen et al. 2001).

Pinnipeds, such as harbor seals, are not equipped with sonar systems, and increased turbidity has been shown to affect their hunting ability (Weiffen at al. 2006); however, studies on foraging behaviors of three blind harbor seals (Newby et al. 1970) and one blind grey seal (McConnell et al. 1999) reported healthy individuals and indicated no difference in foraging behavior despite their lack of vision. Although harbor seals occur near the Port, numbers are low—typically a single animal in 93.7 percent of the sightings—with a sighting rate of approximately 0.3 harbor seals per hour (Port of Alaska 2022). This contrasts with the sighting rates of beluga whales recorded each year passing by the Port (61N 2021, 2022a, 2022b, 2022c), which can be as high as two or more beluga whales per hour, depending on the methodology (Port of Alaska 2022). The Port is unaware of existing literature or studies demonstrating that cetaceans are negatively affected by turbidity (Todd et al. 2014).

The disposal of material from the NES1 deconstruction project is anticipated to be intermittent, with a period of hours or days between barge disposal events and no disposal at nighttime. Turbidity levels from suspended sediments are anticipated to return to background levels in durations of 18 minutes to 4.7 hours, depending on tides. Impacts on zooplankton, fish, and marine mammals, including Cook Inlet beluga whales, are anticipated to be brief, intermittent, and minor, if impacts occur at all. Beluga whales and other species that inhabit Upper Cook Inlet and Knik Arm are adapted to an environment that is highly variable and experiences high turbidity levels. Negative impacts on marine species, including beluga whales, from turbidity associated with disposal of dredged materials are not anticipated.

2. Change in Substrate

Dredging and disposal activities are known to alter benthic communities. While many studies show that benthic communities recover within several months to several years after the related activity ceases (Bolam and Rees 2003, Borja et al. 2009, Schratzberger et al. 2004), other studies show conflicting results (Boon and van Dalfsen 2022). The extreme tidal currents, turbulence, and heavy silt content of Upper Cook Inlet supports a relatively limited habitat for benthic organisms and other intertidal species, such as clams and mussels (Fall 1981, USACE 2017), that are typically found along Alaska’s coastlines. Tiny crustaceans and bottom-dwelling polychaete worms predominantly make up the sparse number of marine invertebrates documented in Upper Cook Inlet (USACE 2017). Because of the unfavorable habitat conditions, it is unlikely that new benthic organisms would colonize at the disposal site. Nearby populations of invertebrates that could seed new areas are lacking in Upper Cook Inlet. If benthic organisms were to colonize the disposal site due to alterations to the substrate, it would likely not occur until after all activity ceases at the disposal site. The disposal site is active all ice-free months, so it is improbable that a new species would colonize the disposal site rapidly during winter only to be negatively affected the following year by disposal.

3. Contaminants

It is possible but unlikely that the disposal of fill into Knik Arm could release pollutants into the water column. The possible mechanisms for release could be the re-suspension of contaminants caused by disturbance in the existing marine sediments in the Offshore Disposal Site or from the disposal of contaminated fill.

The major streams in the Port vicinity that flow into Knik Arm all pass through highly urbanized watersheds and were formerly identified as Clean Water Act Section 303(d) impaired water bodies, but are now classified as Category 4a water bodies (ADEC 2018). Contaminants from these and other sources could have been deposited in the Disposal Site.

The risk of contaminated fill being dumped at the Disposal Site will be mitigated by testing the fill material prior to disposal. Fill material is tested for contaminants (e.g., trace metals, per- and polyfluorinated alkyl substances [PFAS]) and must measure below a regulatory threshold prior to being disposed in water or on land (USACE 2021).

The effects of contaminants on fish health are poorly understood; however, it is known that fish can accumulate high concentrations of contaminants and transmit them to higher trophic levels. Various studies have attempted to establish a baseline of contaminant concentrations (Reiner et al. 2011, Hoguet et al. 2013, Burek-Huntington et al. 2022) and histopathologic assessments for the endangered Cook Inlet beluga whale population (Burek-Huntington et al. 2022). These studies examined blubber and liver samples collected from beluga whales harvested from 1989 to 2005 for several contaminants, including persistent organic pollutants (POPs; e.g., polychlorinated biphenyls [PCB], dichlorodiphenyltrichloroethane [DDT], chlordanes, hexachlorocyclohexane [HCH], chlorobenzenes, and alpha-hexabromocyclododecane [α-HBCD]), perfluorinated compounds (PFCs), PFAS, and total mercury.

The Cook Inlet beluga whale population has lower levels of POPs and heavy metals than other subarctic populations, such as the St. Lawrence Estuary beluga whales (Becker et al. 2000, Martineau et al. 2003). However, a significant increase in polybrominated diphenyl ethers (PBDEs) and α-HBCD was observed in Cook Inlet beluga whales from 1995 to 2005 (Reiner et al. 2011, Hoguet et al. 2013, Burek-Huntington et al. 2022) as well as a positive relationship between body length and concentrations of mercury, mirex, and perfluorotetradecanoic acid (PFTA) (Hoguet et al. 2013, Burek-Huntington et al. 2022). Despite these findings, there is currently no evidence of direct effects of contaminants on Cook Inlet beluga whale health (Burek-Huntington et al. 2022). Many of the contaminants listed are associated with decreased immune systems, increased infections, and potential reduction in reproductive rates in other beluga whale populations, including the St. Lawrence Estuary, the Canadian Arctic, Svalbard, and the Arctic Ocean populations (URS 2010). Due to the potential harm from contaminants, pollution is listed as a potential threat of low concern in the *Cook Inlet Beluga Recovery Plan* (NMFS 2022).

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