Kuskokwim River Middle Mile Fiber Technical Feasibility Study
RD-RU-COOP-25-09

Fish and Fish Habitat Analysis

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Acronyms and Abbreviations

ADFG	Alaska Department of Fish and Game
AWC	Anadromous Waters Catalog
BMP	best management practice
EFH	Essential Fish Habitat
FMP	Fishery Management Plan
FOC	fiber optic cable
HDD	horizontal directional drilling
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fisheries Management Council
NTIA	National Telecommunications and Information Administration
Project, the	River Installed Fiber Optic Cable Feasibility Study

Introduction and Background

The Kuskokwim River and many of its tributaries are important habitats for fish and aquatic organisms. The river provides passage to favorable spawning and rearing grounds and is recognized as Essential Fish Habitat (EFH) for Pacific salmon throughout its length. Installation of infrastructure (e.g., bridge pilings, pipes, or cables) into flowing waterbodies may impact normal stream flow and function over time depending on many factors, which in turn can directly or indirectly impact fish habitat or biota over time. These disturbances may result in temporary or long-term impacts depending on the methods and materials used during construction or installation. The Kuskokwim River Middle Mile Fiber Technical Feasibility Study (the Project) seeks to explore the potential impacts to fish and fish habitat from the deployment of a fiber optic cable (FOC) in the flowing waters of the Kuskokwim River between Aniak and McGrath, Alaska using various installation methods. The following analysis is intended to inform planning for installation and operation of a FOC in the context of potential impacts to fish and fish habitat within the Project area, with special consideration given to river hydrological regimes, ice scouring mitigation, fish habitat impacts, environmental processes, and installation method best practices.

FOC installation between two or more remote communities for the purposes of this feasibility study involves the placement of FOC within flowing river waters. In some circumstances, FOC installation may also involve terrestrial routing of the FOC to mitigate areas with particularly high scouring or cable breakage risks. The placement of FOCs within rivers or streams can reduce environmental impacts relative to traditional overland installation methods by using less intrusive cable placement methods. Vessels or barges used to place the FOC in rivers may result in little to no environmental disturbance versus buried or ground-laid FOC installation methods.

Essential Fish Habitat

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 USC 1801 et seq.) is the primary law governing fisheries management in U.S. federal waters. The MSA is intended to foster long-term biological and economic sustainability of U.S. marine fisheries through the prevention of overfishing, the rebuilding of overfished stocks, and increasing long-term economic and social benefits to ensure a safe and sustainable supply of seafood. The MSA extended U.S. jurisdiction from 12 nautical miles to the 200 nautical mile[1] limit of the U.S. Exclusive Economic Zone (EEZ) and established eight regional fisheries management councils to develop Fishery Management Plans (FMPs), which must comply with conservation and management standards to promote sustainable fisheries management. The FMPs also define EFH, which is the aquatic habitat where fish spawn, breed, feed, and grow through various life stages; this habitat includes marine waters, wetlands, coral reefs, seagrasses, and rivers. The FMPs further define habitat areas of particular concern, which are high-priority areas that are rare, particularly sensitive, or critical to overall ecosystem functions.

Essential Fish Habitat

The National Marine Fisheries Service (NMFS) or the National Oceanic and Atmospheric Administration (NOAA) Fisheries personnel lead EFH consultation pursuant to the MSA. The MSA defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” The MSA also defines an adverse effect as:

> *…any impact that reduces the quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. (50 CFR 600.810(a))*

[1] Measured from the mean high tide line.

Only fish that are included in a federal FMP have defined EFH; in Alaska, these fish are identified in the six North Pacific Fisheries Management Council (NPFMC) plans:

- Fishery Management Plan for Fish Resources of the Arctic Management Area (NPFMC 2024a)
- Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (NPFMC 2024b)
- Fishery Management Plan for Groundfish fisheries of the Gulf of Alaska (NPFMC 2024c)
- Fishery Management Plan for the Salmon Fisheries in the EEZ off Alaska (NPFMC 2024d)
- Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs (NPFMC 2024e)
- Fishery Management Plan for the Scallop Fishery off Alaska (NPFMC 2024f)

Appendix A, Table 1 summarizes the fish species covered in Alaska under federal FMPs in the United States and which therefore have EFH protections.

Fish and Aquatic Resources

The Alaska Department of Fish & Game (ADFG) plays a crucial role in assisting NOAA Fisheries in identifying freshwater EFH in Alaska. ADFG's systematic approach to fish sampling in inland freshwaters results in many new streams being nominated for inclusion in the Anadromous Waters Catalog (AWC) each year because of the presence of Pacific salmon and other anadromous fish (e.g., Dolly Varden, whitefish species) (ADFG 2025a). Following review of the AWC, the NPFMC may designate those waters EFH for species that are included in a FMP. The Kuskokwim River and many of its tributaries have been designated EFH through NOAA Fisheries.

Additionally, the State of Alaska has enacted the Anadromous Fish Act (AS 16.05.871-901) which requires permit approval from ADFG for activities impacting "the natural flow or bed" of AWC waters. The Fishway Act (AS 16.05.841) requires that project administrators obtain authorization from the ADFG Habitat section for any activities in or across flowing waters which may create an impediment to efficient passage of any fish, resident of anadromous.

The National Telecommunications and Information Administration (NTIA) has developed a programmatic agreement for EFH consultation (NTIA 2024) that is applicable to NTIA-funded broadband and fiber optic projects. NTIA (2024) has a five-year term and is valid from March 2024 through March 2029, after which, consultation may be reinitiated to extend the current agreement (with or without modification) or to terminate the agreement.

Aquatic Habitat in the Project Area

The Kuskokwim River is a large river in southwest Alaska, which drains nearly 50,000 square miles of watershed and flows for 724 miles from its headwaters to the Bering Sea, making it the second largest river in the state behind the Yukon River (ADFG 2025b). The upper region is marked by the confluence of several large rivers which flow together to form the Kuskokwim River; the north, south, and east forks, along with a host of smaller tributaries combine to form the Kuskokwim River. The upper Kuskokwim River, most of which is upstream of the study area, is bordered by the Alaska Range to the southeast and by the Kuskokwim Mountains to the northwest (). Heavy glacial input results in a relatively turbid river. The middle section, which includes almost all the study area, cuts through the Kuskokwim mountains and is marked by a meandering constrained channel influenced by several large tributaries flowing from those mountains. The lower section of the river spreads over a broad floodplain, is less channelized, and is influenced by a marine delta-type ecosystem. The lower Kuskokwim River section likely has little influence on the middle or upper sections as it relates to this project, though impacts from project activities upstream may influence water chemistry or habitat downstream in the lower section.

The upper portion of the study area for the Project (McGrath) marks a transition from the upper section to the middle section Kuskokwim River. Several large Pacific salmon rivers join the Kuskokwim in this middle section, including the Holitna River near Sleetmute, downstream from which the Kuskokwim River bisects the Kuskokwim Mountains and becomes more channelized (Fernald 1960). It is in this region where the river passes the historic Red Devil mercury mine (Wang 1999). The river in this lower, middle section of the study area (from McGrath to Aniak) moves large volumes of water during summer months (1,623 cubic meters per second) but can be highly variable depending on conditions (Wang 1999). This portion of the river typically freezes up in November and remains frozen until breakup beginning in April or May (Fernald 1960).

As the river flows through the Kuskokwim Mountains, it gathers significant sediment from the weathering of adjacent mercury rich ore deposits as well as other metals (Belkin and Sparck 1993; USGS 1999). Past mining activity in the region (e.g., Red Devil Mine) has likely increased sediment load to the river over time. Water quality studies in the upper portion of the study area indicate higher concentrations of analytes compared to the lower portion of the study area around Aniak. These results are mirrored in sediment concentrations in the riverbed. Overall, the general make-up of the substrate is a mix of silt, gravel, and sand, heavily influenced by the glacial and weathering inputs described above (Wang 1999). There are growing concerns over the mobilization of previously frozen metal analytes contained in permafrost in high latitude rivers, including the Kuskokwim River or its tributaries, resulting in changes to water quality which could be harmful to stream biota (Matz et al. 2017; Skierszkan et al. 2024). Projected increases in mining activity in the region (e.g., Donlin Gold) may result in increased sediment input into the river and additional changes to water quality in the coming years.

As annual average temperatures increase in the high latitude regions, it is anticipated that increases in mobilization of chemical analytes from tundra to area waterbodies (O’Donnell et al. 2024). These changes have the potential to change aquatic habitat temperature, hydrology, geochemical interactions, and ultimately the timing of events which connect habitat to aquatic organismal life history events (e.g., freeze-up and thaw) (Carey et al. 2025). These relatively recent changes to aquatic habitat conditions may not only change habitat conditions in the Kuskokwim River as we know it, but may also significantly alter habitat in ways that create new species dynamics in the region in the near future.

Known Fish Resources in the Project Area

Pacific Salmon

In the Kuskokwim River, including the section in the Project area, all five Pacific salmon (sockeye [*Oncorhynchus nerka*], Chinook [*Oncorhynchus tshawytscha*], Coho [*Oncorhynchus kisutch*], chum [*Oncorhynchus keta*], and pink [*Oncorhynchus gorbuscha*]) are present (Table 1). ADFG manages salmon stocks within the Kuskokwim Management Area and helps determine sustainable fishing yield in cooperation with the Alaska Board of Fisheries for commercial, sport, and subsistence activities, the latter of which is of highest priority (Decker et al. 2025). More than 1,500 households currently subsistence fish on the Kuskokwim River (ADFG 2025b). In addition to the mainstem Kuskokwim, many tributaries are deemed important to Pacific salmon life history and management within the drainage (ADFG 2025a).

Table 1. Pacific salmon species present in the Kuskokwim River and its tributaries in the study area, as well as the approximate timing of important life history traits.

Common Name (Scientific Name)	Peak Adult Return to Kuskokwim River	Peak spawning in tributaries	Fertilized Eggs in Substrate	Peak Fry Emergence	In-River Rearing	Smolt Outmigration	Time at Sea
Chum Salmon (*Oncorhynchus keta)*	Early July	Late summer, early fall	6 to 8 months (August to March)	Early March to early April	N/A	Almost immediately upon hatching and subsequently emerging from gravel as fry	Up to 5 years
Coho Salmon (*Oncorhynchus kisutch*)	Early Fall (September)	September to early November	Early Spring, March and April	May or June	1 to 2 years	Spring following ice-out	18 months to 2 years
Sockeye Salmon (*Oncorhynchus nerka*)	June and July	September to October	Until late winter to early Spring	April or May	1 to 3 years	2 to 3 years at age 5	1 to 4 years
Chinook Salmon (*Oncorhynchus tshawytscha*)	May through July	Mid-June to mid-August	Until late winter, early spring	Late March through April	1 year	Spring following ice-out	1 to 5 years
Pink Salmon (*Oncorhynchus gorbuscha*)	Late June to mid-October	Late summer, early fall	6 to 7 months (August to February)	Late winter, early spring	N/A	Spring following ice-out	18 months

Source: Scientific Technical Committee 2004.
Note: N/A (not applicable)

Salmon harvest in the study area (middle) section of the Kuskokwim River contributes 61% of subsistence food by weight (Decker et al. 2025). However, these fisheries have been impacted severely by steady decreases in salmon runs in recent years (Trainor et al. 2025). These declines have led to reductions in subsistence fishing opportunities for Chinook and chum salmon in particular (Brown et al. 2012a; Runfola et al. 2017). Subsistence harvest of Chinook, Coho, chum, and sockeye salmon have declined from an approximate long-term annual average of 243,000 fish harvested (1990-2011) to 160,000 salmon (2023) (Runfola and Larson 2025).

Other Anadromous/Amphidromous Fish

Other anadromous fish commonly observed in the Kuskokwim River and its tributaries within the Project area include Dolly Varden (*Salvelinus malma*), sheefish (*Stenodus leucichthys*), least cisco (*Coregonus sardinella*), broad whitefish (*Coregonus nasus*), and humpback whitefish (*Coregonus pidschian*) (Table 3). These salmonids are present throughout the study area. Many individuals of each species spend at least a portion of their life history in marine waters during summer months to feed before returning to the Kuskokwim River and its tributaries to spawn and overwinter (Ray et al. 2010; Brown et al. 2012b; Harper et al. 2012; Van Lanen et al. 2015; Stuby 2018). Whitefish are a critically important subsistence species for communities throughout the study area, particularly considering the recent regional declines in Pacific salmon.

Resident Fish

In addition to anadromous Pacific salmon and whitefish, several resident fish species are present throughout the Kuskokwim River and its tributaries (Van Lanen et al. 2015). These include Northern Pike (*Esox lucius*), Arctic grayling (*Thymallus arcticus*), longnose sucker (*Catostomus Catostomus*), and round whitefish (*Prosopium cylindraceum*) (Table 3). There is a dearth of information on sport and subsistence fishing for these species in the Kuskokwim River.

Surprisingly, there are very few studies linking habitat to fish life history on the Kuskokwim River, particularly for non-salmonid fisheries. Most studies describe Pacific salmon spawning locations in the main stem of the river or its tributaries. Only a handful of other studies looking at habitat are available and focus on high-value commercial or subsistence species (Stuby 2018).

Table 2. Anadromous fish species for tributaries to the Kuskokwim River between Aniak and McGrath, Alaska, by 25-kilometer Kuskokwim River segment.

Kuskokwim River - 25 km Segment[a] (No.)	AWC No.	Tributary Name	Fish Species
1	335-20-16600-2400	Aniak River	Chum (spawning), Coho (present), Chinook (present), Inconnu/Sheefish (present), Whitefishes (present)
	335-20-16600-2411	Owhat River	Chum (present), Coho (present), Chinook (present)
2	335-20-16600-2501	Kolmakof River	Chum (spawning), Coho (present), Chinook (present)
	335-20-16600-2530	Victoria Creek	Coho (present)
3	335-20-16600-2540	Holokuk River	Chum (present), Coho (present), Chinook (present), Pink (present), Sockeye (present), Inconnu/Sheefish (present), Whitefishes (present)
	335-20-16600-2559	Sue Creek	Coho (present)

Kuskokwim River - 25 km Segment[a] (No.)	AWC No.	Tributary Name	Fish Species
	335-20-16600-2560	Veahna Creek	Coho (rearing)
4	335-20-16600-2630	Oskawalik River	Chum (present), Coho (present), Chinook (present), Sockeye (present), Inconnu/Sheefish (present), Whitefishes (present)
	335-20-16600-2641	Jungjuk Creek	Coho (rearing)
5	335-20-16600-2669	Village Creek	Coho (rearing)
	335-20-16600-2671	Crooked Creek	Chum (spawning), Coho (spawning), Chinook (spawning), Pink (present), Sockeye (present)
6	335-20-16600-2741	George River	Chum (spawning), Coho (spawning), Chinook (spawning), Pink (spawning), Sockeye (present), Inconnu/Sheefish (present), Whitefishes (present)
	335-20-16600-2740	Downey Creek	Coho (present, rearing), Chinook (rearing)
	335-20-16600-2739	California Creek	Coho (rearing)
	335-20-16600-2765	Unnamed	Chinook (rearing)
7	335-20-16600-2780	Fuller Creek	Coho (present)
	335-20-16600-2790	Red Devil Creek	Coho (rearing), Chinook (rearing)
	335-20-16600-2800	Vreeland Creek	Chum (present), Coho (rearing, spawning), Chinook (present)
8	335-20-16600-2830	Holitna River	Chum (present), Coho (present), Chinook (present), Pink (present), Sockeye (present), Inconnu/Sheefish (present), Whitefishes (present)
9	335-30-16600-2039	Moose Creek	Chum (present), Coho (present), Chinook (present)
	335-30-16600-2041	Unnamed	Coho (present)
10	335-30-16600-2040	Stony River	Chum (present), Coho (present), Chinook (present), Sockeye (present), Humpback Whitefish (present), Inconnu/Sheefish (present), Whitefishes (present)
11	335-30-16600-2070	Swift River	Chum (present), Coho (present), Chinook (present, rearing), Sockeye (present)
	335-30-16600-2080	Tatlawiksuk River	Chum (spawning), Coho (present), Chinook (spawning, rearing), Pink (present), Sockeye (present), Humpback Whitefish (present), Inconnu/Sheefish (present)
12	335-30-16600-2096	Unnamed	Coho (present)
	335-30-16600-2101	Unnamed	Coho (present)
13	335-30-16600-2115	Nunsatuk River	Chum (present), Coho (present), Whitefishes (present)
15	335-30-16600-2170	Selatna River	Chum (present), Coho (present), Chinook (present), Whitefishes (Present)
	335-30-16600-2181	Black River	Coho (present)
17	335-30-16600-2240	Katlitna River	Inconnu/Sheefish (present)

Kuskokwim River - 25 km Segment[a] (No.)	AWC No.	Tributary Name	Fish Species
18	335-30-16600-2255	Takotna River	Chum (present), Coho (present), Chinook (present), Sockeye (present), Inconnu/Sheefish (present), Whitefishes (present)

Source: ADFG 2025
Note: AWC (Anadromous Waters Catalog); km (kilometer); No. (number)
[a] For the purposes of this feasibility study, the Kuskokwim River has been divided into 18 total 25-kilometer-long segments, starting in Aniak, Alaska and ending at McGrath, Alaska.

Overview of Potential Impacts to Fish and Fish Habitat

The typical installation of FOC and associated appurtenances is summarized below.

Installation Timing

FOC construction timing is critical for minimizing direct impacts to fish. This is of particular concern during key life history events which differ in timing by species. For example, each Pacific salmon species has unique seasonal life history events important to the overall population level success of Kuskokwim River salmon (Table 1). These life history events include adult migration and spawning during summer and fall months, in-gravel fertilized egg incubation during fall and winter months, emergence post-hatch in the spring and summer months, the rearing period for juveniles and adults, and smoltification and out-migration to marine waters during spring and summer months. Disturbance of the water column or substrate during these events may result in short term, but significant impacts to the successful outcome of each life history event. Installation activities should take place outside peak migration/spawning season for Pacific salmon. Understanding the timing of life history events and planning installation to avoid peak spawning will result in reduced potential impacts to fish and aquatic species.

Additionally, timing considerations for construction at higher latitudes (e.g., Alaska) must also include high-flow events such as spring breakup, fall rains, winter freeze-up to avoid mishaps during installation. Vessel transit and FOC installation will need to occur during lower flows, with shallower water conditions to ensure not only crew safety but to minimize damage to aquatic habitat. Adherence to these best practices with respect to timing windows will greatly reduce the likelihood of mishaps which could result in spills or other habitat degradation which might be locally harmful to resident or rearing fish populations.

Fish Mortality, Injury, and Behavioral Modification

The installation of submarine cables may cause fish mortality or injury from direct contact (especially during immobile life stages) with the installation equipment (e.g., grapnels, cable plows), or because of the physical alteration/degradation or increased turbidity from installation activity. Installation activity may also result in behavioral modification that affects survival, feeding, migration, and spawning.

If FOC is inadvertently installed in preferred spawning habitat and either directly or indirectly impacts aquatic conditions, it may cause fish to avoid the area. Stream flow dynamics over the FOC may cause avoidance or attraction behavior for fish and their prey (Taormina et al. 2018). However, placement of the FOC in the Kuskokwim River thalweg is likely to help minimize impacts to fish and aquatic organisms and therefore impacts would be short term in duration. It is installation activity itself that may create the biggest risk to fish through temporary impacts to behavior or through direct injury (Limpinsel et al. 2023). For example, the use of water jet pumps which direct high-flow water at the riverbed to create a trench for FOC installation could directly injure fish or otherwise create harmful turbidity conditions. The pumps would also require screen devices to prevent fish impingement or entrainment during water withdrawal. By using an installation process in which the FOC is directly placed on the substrate without water jet usage, project engineers would minimize or prevent such injuries.

Construction activities may also introduce sustained noise from boat traffic or, if required, jet sleds. These activities may result in short term (hours or days) impacts to fish behavior such as habitat avoidance or increased metabolic activity. Anthropogenic noise (e.g., boat motors) can have significant impacts on fish behavior, both short- to long-term, and can even result in mortality due to a reduction in reaction time to predator strikes (Simpson et al. 2015). Again, minimizing the use of water jets may minimize short-term behavior impacts.

Degradation or Loss of Habitat

The pre-lay grapnel run, typically performed prior to placing a FOC, and the burial of the FOC using cable plows or jet sleds can degrade or destroy benthic habitat. Hard-bottomed habitats such as hard-mixed gravels, or vegetated rock area may be particularly susceptible to damage and loss resulting from such installations (Hanson et al. 2005). Cable plows or jet sleds typically result in short-term contact with the riverbed, resulting in temporary increases in localized turbidity. FOC installed by directly surface laying the cable on the riverbed will reduce impacts to habitat (versus riverbed disturbance from plowing or jetting installations).

Increased Turbidity

The increased turbidity from the installation of the FOC runs can impact fish behavior, feeding, overall health, and predator-prey relationships. The effects of turbidity are increased in magnitude in areas with lower water volumes (Gowen 1978). Increased turbidity can result in short-term distress to mortality depending on the severity of the increase.

Resuspension or Redistribution of Contaminants

Of particular concern in the Project area is the presence of formerly mobilized contamination from legacy mining activity. These include mercury and other constituents that are harmful to aquatic organisms. The turbidity resulting from the installation of submarine FOCs can disturb, suspend, and redistribute any contaminants that may be present in the substrate. The redistribution of contaminants can result in an increase in fish mortality (Gowen 1978) and cause adverse effects to EFH (Limpinsel et al. 2023).

Horizontal Directional Drilling

Horizontal directional drilling (HDD) may be employed in select areas of river-run FOC projects to mitigate impacts in discrete areas. For example, in areas with substantial ice scour potential, terrestrial/overland construction may be required to bypass individual river sections. HDD may be employed between the river thalweg and the adjacent terrestrial environment to avoid creating impacts to riverbanks from construction activity. Additionally, overland routing may need to cross streams with fish presence or important fish habitat, and HDD can be used to complete such crossings without directly impacting the streambed or fish.
An inadvertent release of drilling fluids (i.e., drilling mud) can occur during HDD operations. The release of drilling fluids (including bentonite) can adversely affect EFH through increased turbidity and deposition of drilling fluids into spawning gravels and benthic habitat (Betcher et al. 2019).

Post Construction

Frazil ice forms during sub-freezing temperatures when flowing water flows turbulently, preventing a laminar, uniform frozen condition. The ice then forms directly on FOC, causing it to either move along the substrate or even become suspended in the current. In addition to potentially damaging the FOC itself, it may cause significant scouring (Wilt 2013; Barrette 2021). This scouring activity can damage habitat and resuspend sediment. Damaged cable could result in the need for redeployment of construction crews to the Project area, resulting in renewed potential impacts to fish and aquatic resources as described above.

Following construction, river stretches with active sedimentation are expected to result in the FOC becoming slowly buried on the riverbed. The length of time required for complete FOC burial will vary based on river conditions such as sediment deposition rate, which is influenced by river inputs, current, and stream geomorphology. Once naturally buried by sediments, the FOC is unlikely to result in additional impacts to fish or aquatic habitat.

Summary of Potential Impacts

provides a summary of potential impacts to fish and fish habitat from the installation of FOCs and construction of associated supporting infrastructure.

Table 3. Summary of Potential Impacts to Fish and Fish Habitat from the Installation of Fiber Optic Cables and Associated Infrastructure

Installation Method	Description and Potential Impacts	Magnitude of Impacts
Traditional trenching (overland, intertidal)	*Description*: Typical excavations are 3-4 feet wide and 3-5 feet deep; spoils are temporarily sidecast *Potential impacts*: • Wetlands. Wetland impacts include direct physical impacts to wetlands from the use of heavy equipment and excavation and increased sedimentation and siltation from excavation activities and erosion. • Landfall (intertidal zone). Disruption of intertidal habitat along the installation path.	*Uplands and wetlands*: Work is performed in accordance with permit requirements. Impacts are minimized through the implementation of BMPs during construction and post-construction cleanup. *Intertidal*: Work is performed in accordance with permit requirements. Construction activity is conducted between high tides and the trench is refilled to the original grade. Impacts are minimized through the implementation of BMPs.
Vibratory plow	*Description*: Installation trench dimensions for fiber optic cables are a few inches wide and 2-4 feet deep. The trench self-closes immediately behind the vibratory plow blade. *Potential impacts*: Minor sedimentation or siltation.	Impacts are minimized through the implementation of BMPs.
Horizontal directional drilling	*Description*: Typical borehole is less than 6 inches in diameter for fiber optic cables and conduit. *Potential impacts*: Sedimentation and siltation; temporary degradation of fish habitat when drilling is conducted in riverine habitat; and potential for the inadvertent return of drilling fluids to surface waters.	Impacts are minimized through seasonal restrictions to protect sensitive species and habitats, the implementation of BMPs, and performing work in accordance with permit requirements (e.g., Alaska Department of Fish and Game Title 16 fish habitat permit).

Installation Method	Description and Potential Impacts	Magnitude of Impacts
Pre-lay grapnel run, jet sled, cable plow, and scratch plow	*Description*: • Pre-lay grapnel run. A marine vessel tows a large grapnel along the proposed fiber optic cable route to clear debris. • Jet sled, cable plow, scratch plow. The fiber optic cable is trenched using a high-pressure water stream (jet sled) or a plow blade (cable plow). The trench dimensions range from approximately 1 foot wide to 1 foot deep (Jet sled) or up to five feet deep (cable plow). *Potential impacts*: • Potential fish mortality and loss of vertically complex hard bottom habitats such as hard corals and vegetated rock reefs (Hanson et al. 2005). • Increased turbidity in areas of soft-bottomed substrate can cause interruption in species behavior and predator-prey relationships, or harm to gills and organ function (Limpinsel et al. 2023). • Resuspension and redistribution of contaminants contained in substrate sediments.	• Can produce local and transient turbidity and sediment plumes during installation and sediment disruption. • Habitat and species behavior may be impacted, but the area of disturbance is minimal and temporary. No long-term or measurable impacts are anticipated on fish populations. • The small scale of trenching is not anticipated to result in significant turbidity and only minor and temporary resuspension and redistribution of contaminants, if present. • Impacts are minimized through seasonal restrictions on work to protect sensitive species and habitats and the implementation of BMPs.
Surface lay (overland, marine)	*Description*: • Overland (wetlands, lakes, and rivers). The fiber optic cable is laid directly across wetlands, lakes, or rivers (typically on ice or snow during winter months) with sufficient slack to allow self-bury over time. • Marine. Usually in hard bottom areas, or where the water column is sufficiently deep to avoid scouring and wave activity (Limpinsel et al. 2023). *Potential impacts*: Potential damage or loss of sensitive habitat (e.g., corals).	The relatively small diameter of fiber optic cables will not likely prevent normal migratory movement of fish species.
New or replacement utility poles (terrestrial environment)	*Description*: New and replacement utility pole foundations are typically placed to a depth that is 10% of the pole height, plus two feet (average 5-6 feet). Foundations are excavated using an auger, which creates a minimal and localized ground disturbance. *Potential impacts*: Foundation excavation can create run-off sedimentation.	Work is performed in accordance with permit requirements. Impacts are minimized through the implementation of BMPs.

Installation Method	Description and Potential Impacts	Magnitude of Impacts
Ground equipment construction (terrestrial environment)	*Description*: Unless already sited in a previously disturbed area, proposed equipment locations are cleared and graded. This can include the location which generally requires an area of 50 feet by 50 feet up to 100 feet by 100 feet, in addition to any required access roads or utility easements. Access road and utility easements may require water crossings (e.g., culverts). *Potential impacts*: Vegetation clearing and surface grading can result in sedimentation or siltation in wetlands or waters. The impacts vary depending on the scale of site clearing.	Dependent on the scale of development and the proximity to wetlands or waters. Permitting requirements and implementing BMPs minimize impacts.

Notes: BMP (best management practice).

Mitigation Strategies

The mitigation measures below are recommendations intended to prevent or minimize adverse impacts on fish and EFH that may result from the installation of FOCs, and to promote the conservation, enhancement, and proper functioning of EFH (Limpinsel et al. 2023). FOC projects require mitigation strategies and best management practices (BMPs) to reduce sedimentation and turbidity, to reduce riparian zone habitat damage, to reduce the possibility of direct damage to fish and aquatic species or their habitat, and to reduce concerns related to subsistence fishing activities in waterbodies.

Reducing Sediment Inflows and Turbidity

Excavation and other ground-disturbing construction activity can lead to sedimentary runoff reaching fish-bearing waters that leads to turbidity within the water column. As noted above, suspended sediments in fish-bearing waters can lead to changes in water quality that impacts water pH and results in potential impacts to fish health. Additionally, highly turbid conditions can impact the transport of oxygen across gills. As it settles, fine sediment can even impact spawning redds, impacting the ability for oxygen to pass across the egg membrane. Measures to reduce these impacts include:

- Develop and adhere to Stormwater Pollution Prevention Plans to minimize the discharge of stormwater pollutants to waterways. Typical BMPs employed to reduce erosion and associated impacts include:
  - Clearly marking project clearing limits and clearing the minimum amount of vegetation required to complete the task.
  - Preserving natural vegetation in riparian zones by minimizing clearing to provide buffer zones and stabilized areas to help control erosion and protect water quality.
  - Providing a vegetation buffer of undisturbed vegetation no less than 25 feet wide from waterbody edges.
  - Using fiber rolls (straw, flax or similar materials bound into a tight tubular roll) to protect slopes, slow sheet flow, and as perimeter control to prevent sediment from traveling offsite.

  - Using brush barriers as a perimeter sediment control structure made of natural materials such as small tree branches, root mats, stone, or other non-erodible debris left over from site clearing.
  - Implementing seeding or other stabilization methods of disturbed soils as soon as possible to minimize erosion and sedimentary runoff.
- Install erosion control measures along the perimeter of all work areas to prevent the displacement of fill material outside of the authorized work area. Erosion control measures should remain in place until work is completed and the work areas are stabilized.
- Snow and ice clearing operations should not result in the discharge of vegetation, soil, or debris into waterbodies outside of the authorized fill area.

Water Withdrawal Best Practices
Water withdrawals are used to support HDD, dewatering activities, high-pressure jetting for FOC burial, supply for potable water, and more. A primary concern for ADFG is related to water withdrawals resulting in fish becoming entrained, impinged, or entrapped in the water pumping system. ADFG requires water intakes to be screened to avoid or minimize fish impacts, particularly juvenile fish and smaller resident fish. Construction best practices for water withdrawals include:

- Using the minimum amount of water required for any task.
- Water intakes must be screened to avoid injury to fish.
- Typically, screen opening may not exceed 0.25 inches (0.10 inches or less in areas with sensitive fish species or life stages, and water velocity at the screen or water interface may not exceed 0.5 feet per second when the pump is operating.
- Pump intake screens should be checked periodically during operations to ensure the screening has not collapsed, there are no breaks or gaps in the mesh, and the screen has not become blocked by debris.

Fiber Optic Cable Alignments
New access roads or pads, if needed, should be constructed to minimize adverse effects to habitat and migratory fish, such as Pacific salmon. The installation of the FOC is the action with the most potential to disturb fish and aquatic species and their habitat. These potential impacts may include direct harm to fish or spawning habitat. It may also indirectly impact fish through the disturbance of stream substrate, thereby entraining potentially impactful analytes into the water column, impacting pH and gills ability to diffuse oxygen into the blood stream, or creating toxic conditions. Mitigation strategies and BMPs to reduce impacts from FOC installation include:

- To the degree possible, split the deployment into manageable units of construction to minimize the length of the construction season and to assist in future segment deployments (e.g., ground-truthing concept). Begin at the upstream segment.
- Align the cable lengthwise in the river channel, in the thalweg, if possible, to avoid contact with vessels or ice scouring.
- Avoid known subsistence fished areas or complex habitat (e.g., boulder sections, emergent vegetation, areas that commonly collect large woody debris).
- Maintain a safe distance from incoming tributaries, particularly those known to be an anadromous fish bearing streams.
- Prior to laying FOC, conduct necessary terrestrial work after freeze-up to reduce risk of sedimentation to stream and minimize land scarring during subsequent installation during the open water season.

Terrestrial Excavation

In limited cases, particularly at start and end locations, excavation work may be required to establish project infrastructure. Excavation work could lead to sediment input to water, to degradation of surrounding wetlands, or entrainment of formerly trapped analytes to the adjacent river. Mitigation measures and BMPs to reduce impacts from terrestrial excavation include:

- Store and contain excavated material on uplands. If storage in wetlands or waters cannot be avoided, use alternate stockpiles to allow continuation of sheet flow. Store stockpiled materials on construction cloth rather than bare tundra.
- Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation. Restore original marsh elevations. Stockpile topsoil and organic surface material, such as root mats, separately and return it to the surface of the restored site. Use adequate material so that the proper pre-project elevation is attained following the settling and compaction of the material. After backfilling, implement erosion protection measures where needed.
- Where able, stockpile and reuse native vegetation and topsoil removed for project construction for site rehabilitation. Seeding and planting will follow this order of preference:
    - Species native to the site
    - Species native to the area
    - Species native to the state
- Trenches must be constructed or backfilled in such a manner to ensure wetland or other Waters of the U.S. are not drained (intentionally or inadvertently).
- Excess material should be removed to an upland location.

Horizontal Directional Drilling

HDD is often used to support utility installations around sensitive environmental features or human-made infrastructure, and it is frequently employed in FOC construction. In the case of FOC installations, these locations may include the beginning and terminus of each project section. However, there may be instances when there is a need to bypass a section of river due to complex habitat (e.g., boulders, high-velocity flows) or due to the location of an important spawning area for fish. Mitigation strategies and BMPs to reduce impacts from horizontal directional drilling include:

- Use HDD where FOCs would cross anadromous fish streams, salt marshes, vegetated intertidal zones, or steep erodible bluff areas.
- At locations where HDD will be used to cross under an anadromous stream, complete a geotechnical survey to ensure the drilling is conducted at an appropriate depth to prevent an inadvertent release of drilling muds into surface waters.
- Alternatively, install the cable a minimum of 5 to 10 feet below the streambed and use inert drilling muds (e.g., bentonite). Downstream visual monitoring should be employed to monitor for the inadvertent loss of drilling muds.
- Maintain equipment required to clean up an unplanned release of drilling fluids.
- Maintain a riparian buffer between the drill entry and exit pits and minimize disturbances to existing vegetation.
- At HDD sites, a vegetated riparian buffer should be maintained between the drill entry and exit sites and disturbance to existing vegetation should be minimized.
- During HDD operations under anadromous streams, equipment required to clean up an accidental release should be available and ready to deploy at the site.

Permafrost Protections

Permafrost is present throughout much of Alaska and becomes more continuous at northern latitudes, typically starting about the Brooks Range. Permafrost is sensitive to disturbance and once impacted, can lead to permafrost thaw that results in subsidence and/or the development of thermokarst ponds. Once permafrost is impacted and exposed, thawing can develop and spread, and stopping or reversing permafrost thaw is a challenging objective that may not be able to be achieved. For in-river FOC deployment, permafrost is most likely to be encountered at river entry and exit points (e.g., cable landings) and may further be encountered during trenching activities to extend the FOC to communities. To minimize the likely impact to permafrost, the following mitigation measure is recommended:

- When a FOC cable is entering or exiting a river from a terrestrial location, consider using HDD to make the transition. The HDD should be setback from the river the greatest practicable distance (e.g., not requiring substantial vegetation clearing) and at a minimum of 50 feet if possible and extend to the river's thalweg. This construction method removes disturbance of the riverbank where permafrost damage is most likely to occur and ultimately spread and cause erosion.

Timing Restrictions and Windows

Fish are more sensitive to construction-related impacts (e.g., noise, turbidity) at specific life stages (e.g., spawning) and instituting project-specific timing restrictions or windows to complete construction activity that may impact fish or their habitat can mitigate many construction-related impacts. Timing restriction and timing window BMPs include:

- In-river installations should be completed outside of the local fish spawning timelines to avoid disturbing eggs in gravel substrates or disturbing returning adult salmon.
- Conduct construction during the time of year when it will have the least impact on sensitive habitats and species. Specific dates will depend on the location. Consultation with NMFS and ADFG can provide specific work windows.

In-Water Construction

Construction in freshwater or marine environments includes specific considerations to minimize impacts to the environment. The following BMPs are recommended for in-water work:

- Bury submerged cables where possible. Unburied cables or cables buried in areas where scouring or wave activity eventually exposes them run a much greater risk of damage.
- Remove inactive submerged cables unless they are in sensitive areas (e.g., marsh, seagrass). If cables are allowed to remain in place, ensure that they are properly secured to avoid release into the environment and result in unintended impacts.
- Use silt curtains or other barriers to reduce turbidity and sedimentation near the project site whenever possible.
- Locate alignments along routes that minimize damage to marine and estuarine habitat. Avoid laying cable over high-relief bottom habitats.

General Construction Mitigation Measures

The following BMPs are applicable to many construction activities and may be applicable to some FOC construction activities:

- Limit access for equipment to the immediate project area. Tracked vehicles are preferred over wheeled vehicles. Consider using mats and boards to avoid sensitive areas. Caution equipment operators to avoid sensitive areas, and clearly mark sensitive areas to ensure that equipment operators do not traverse them.
- Limit construction equipment to the minimum size necessary to complete the work. Use shallow-draft equipment to minimize effects and to eliminate the necessity for temporary access channels. Use the push-ditch method in which the trench is immediately backfilled to minimize the impact duration when possible.
- Handle and store all fuels and hazardous substances used in the project area in accordance with applicable state and federal regulations. Include both primary and secondary containment areas for all fuel and chemicals.
- Use only licensed, commercial transporters, following U.S. Department of Transportation regulations, for the safe transport of fuels and other products to/from the project area.
- Fuel storage and handling activities for equipment must be sited and conducted so there is no petroleum contamination of the ground, subsurface, or surface waterbodies.
- Handle and store all fuels and hazardous substances used in the project area in accordance with applicable state and federal regulations. Include both primary and secondary containment areas for all fuel and chemicals.
- During construction, spill response equipment and supplies such as sorbent pads shall be available and used immediately to contain and cleanup oil, fuel, hydraulic fluid, antifreeze, or other pollutant spills.
- Construction equipment shall not be operated below the ordinary high-water mark if equipment is leaking fuel, oil, hydraulic fluid, or any other hazardous material. Equipment shall be inspected and recorded in a log daily for leaks. If leaks are found, the equipment shall not be used and pulled from service until the leak is repaired.
- Invasive species: Vehicles brought into the permitted project area from areas should be washed and checked for the absence of plant and animal invasive species, prior to entering the project area. This includes vehicle and equipment bodies, undercarriages, and tires or tracks, as well as equipment trailers and skid-based modules.
- Fill material (including dredge material) must be clean soil, sand, gravel or rock, free from petroleum products and toxic contaminants in toxic amounts.
- All solid waste and foreign debris must be eliminated by removal to an off-site, permitted facility or by burning (if a paper product). Waste, in this paragraph means all discarded matter, including, but not limited to human waste, trash, garbage, litter, oil drums, petroleum, ashes and discarded equipment. Hazardous waste must not be disposed of on-site but instead must be hauled out for disposal to a permitted disposal site.

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Figure 1. Overview of the project study area for a potential fiber optic cable installation in the middle section Kuskokwim River between Aniak and McGrath, Alaska.

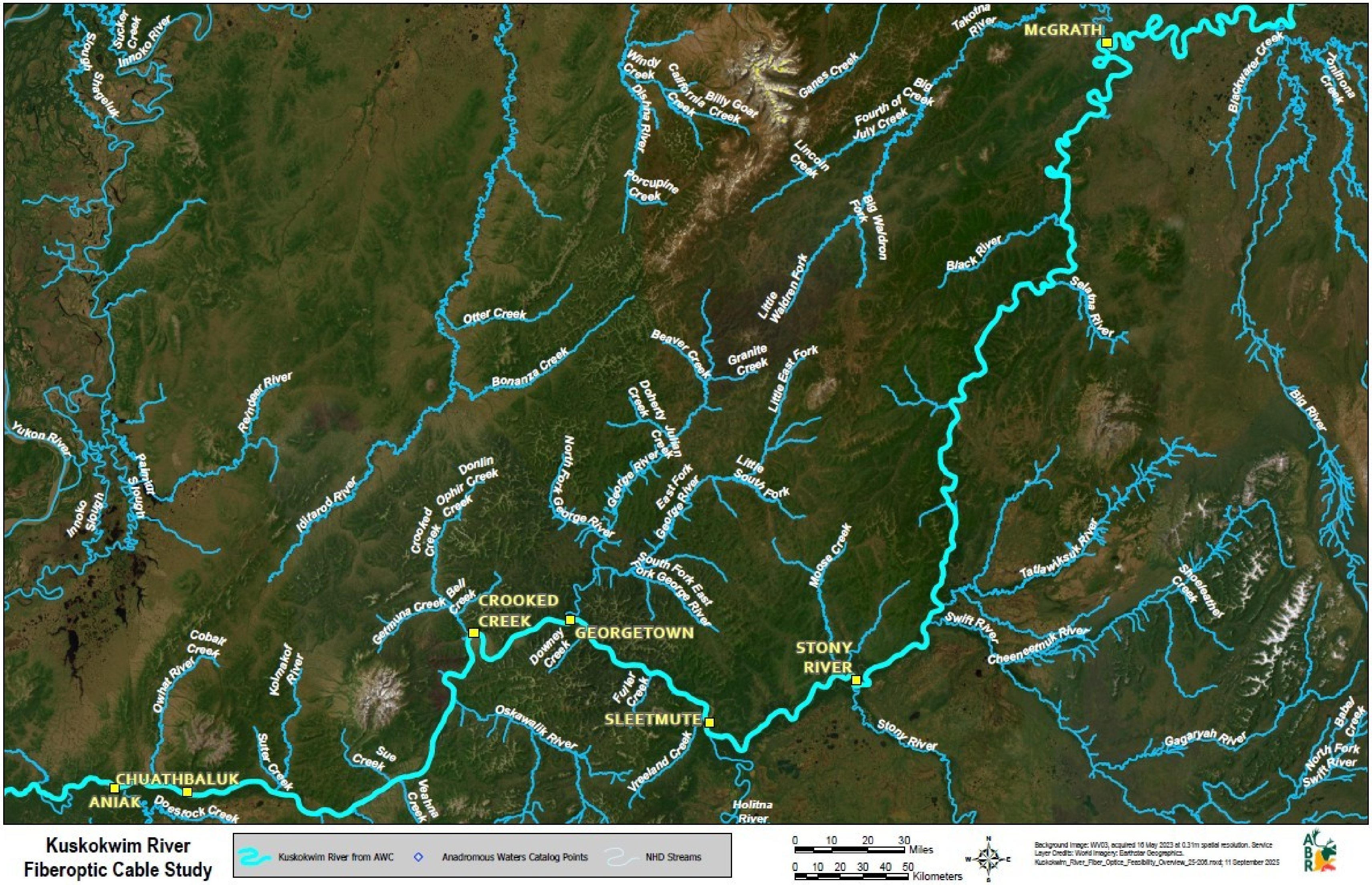

Figure 2. Anadromous tributaries to the Kuskokwim River as determined by the Alaska Department of Fish and Game.

River Installed Middle Mile Fiber Technical Feasibility and Design Basis:
Fish and Fish Habitat Impact Analysis

Appendix A. Fish Species Covered in Alaska Under Federal Fisheries Management Plans

Table A.1. Alaska Fish Species Covered Under Essential Fish Habitat

Common Name	Scientific Name	Fishery Management Plan[a]
Yellowfin sole	*Pleuronectes asper*	Arctic, Gulf of Alaska, Bering Sea-Aleutians Groundfish
Alaska plaice	*Pleuronectes quadrituberculatus*	Arctic, Gulf of Alaska, Bering Sea-Aleutians Groundfish
Flathead sole/Bering flounder	*Hippoglossoides elassodon/ Hippoglossoides robustus*	Arctic
Starry flounder	*Platichthys stellatus*	Arctic, Gulf of Alaska, Bering Sea-Aleutians Groundfish
Capelin	*Mallotus villosus*	Arctic
Rainbow smelt	*Osmerus mordax*	Arctic
Blue king crab	*Paralithodes platypus*	Arctic, Bering Sea- Aleutians Crab
Arrowtooth flounder	*Atheresthes stomias*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Atka mackerel	*Pleurogrammus monopterygius*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Dover sole	*Microstomus pacificus*	Gulf of Alaska, VERIFY if BSAI Ground
Dusky rockfish	*Sebastes variabilis*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Flahead sole	*Hippoglossoides elassodon*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Northern rockfish	*Sebastes polyspinus*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Giant octopus		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Qullback rockfish		Gulf of Alaska
Rosethorn rockfish		Gulf of Alaska
Yelloweye rockfish	*Sebastes ruberrimus*	Gulf of Alaska
Greenstriped rockfish		Gulf of Alaska
Harlequin rockfish		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Pygmy rockfish		Gulf of Alaska
Redbanded rockfish		Gulf of Alaska
Redstripe rockfish		Gulf of Alaska
Shapchin rockfish		Gulf of Alaska
Silvergray rockfish		Gulf of Alaska
Pacific cod	*Gadus macrocephalus*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Pacific Ocean perch	*Sebastes alutus*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Rex sole	*Glyptocephalus zachirus*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Rougheye/Blackspotted rockfish	*Sebastes aleutianus / Sebastes melanostictus*	BSAI Groundfish, GOA Groundfish
Sablefish	*Anoplopoma fimbria*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Butter sole		Gulf of Alaska, Bering Sea-Aleutians Groundfish
English sole		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Northern rock sole	*Lepidopsetta polyxystra*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Pacific sanddab		Gulf of Alaska

Common Name	Scientific Name	Fishery Management Plan[a]
Petrale sole		Gulf of Alaska
Saffron cod	*Eleginus gracilis*	Arctic
Sand sole		Gulf of Alaska
Slender sole		Gulf of Alaska
Southern rock sole	*Lepidopsetta bilineata*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Spiny dogfish		Gulf of Alaska
Shortraker rockfish	*Sebastes borealis*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Alaska skate		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Aleutian skate		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Bering skate		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Big skate		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Longnose skate		Gulf of Alaska
Thornyhead rockfish	*Sebastolobus alascanus*	Gulf of Alaska
Shortspine thornyhead		Gulf of Alaska, Bering Sea-Aleutians Groundfish
Walleye pollock	*Patinopecten caurinus*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Bering flounder		Gulf of Alaska
Greenland turbot	*Reinhardtius hippoglossoides*	Gulf of Alaska, Bering Sea-Aleutians Groundfish
Kamchatka flounder	*Atheresthes evermanni*	Gulf of Alaska
Deepsea sole		Gulf of Alaska
Longhead dab		Gulf of Alaska
Sakhalin sole		Gulf of Alaska
Mud skate		Gulf of Alaska
Whiteblotched skate		Gulf of Alaska
Octopus	**Multiple species*	BSAI Groundfish, GOA Groundfish
Red king crab	*Paralithodes camtschaticus*	Bering Sea-Aleutians Crab
Golden king crab	*Lithodes aequispina*	Bering Sea-Aleutians Crab
Tanner crab	*Chionoecetes bairdi*	Bering Sea-Aleutians Crab
Snow crab	*Chionoecetes opilio*	Bering Sea-Aleutians Crab
Weathervane scallops	*Patinopecten caurinus*	Scallop
Rock scallops	*Crassadoma gigantea*	Scallop
Pink scallops	*Chlamys rubida*	Scallop
Sharks	**Multiple species*	BSAI Groundfish, GOA Groundfish
Skates	**Multiple species*	BSAI Groundfish, GOA Groundfish
Spiny scallops	*Chlamys hastata, C. behringiana, and C. albida*	Scallop
Chinook salmon	*Oncorhynchus tshawytscha*	Salmon
Coho salmon	*Oncorhynchus kisutch*	Salmon
Pink salmon	*Oncorhynchus gorbuscha*	Salmon
Sockeye salmon	*Oncorhynchus nerka*	Salmon
Chum salmon	*Oncorhynchus keta*	Salmon

[a] Sources: Arctic (NPFMC 2024); Gulf of Alaska (NPFMC 2024); Bering Sea-Aleutian Groundfish (NPFMC 2024); Bering Sea-Aleutians Crab (NPFMC 2024); Scallop (NPFMC 2024); Salmon (NPFMC 2024)