2.0 COMPOSITION AND QUANTITIES FOR MATERIALS DISCHARGED

Oil and gas exploration, development, and production facility operations can produce a wide range of waste materials related to the drilling and extraction processes, maintenance of equipment, and personnel housing. The proposed NPDES general permit for Cook Inlet authorizes discharges from the following waste streams:

- Drilling Fluids and Drill Cuttings
- Deck Drainage
- Sanitary Wastes
- Domestic Wastes
- Desalination Unit Wastes
- Blowout Preventer Fluid
- Boiler Blowdown
- Fire Control System Test Water
- Non-Contact Cooling Water
- Uncontaminated Ballast Water
- Bilge Water
- Excess Cement Slurry
- Mud, Cuttings, Cement at Seafloor
- Completion Fluids
- Workover Fluids
- Test Fluids
- Storm Water Runoff from Onshore Facilities

Waterflooding discharges, produced water discharges, and well treatment fluids (other than test fluids) would also be authorized for existing upper Cook Inlet development and production operations.

2.1 DRILLING FLUIDS AND DRILL CUTTINGS

Drilling fluids (also known as drilling muds or muds) are suspensions of solids and dissolved materials in a water or oil base that are used in rotary drilling operations. The rotary drill bit is rotated by a hollow drill stem made of pipe, through which the drilling fluid is circulated. Drilling fluids are formulated for each well to meet specific physical and chemical requirements. Geographic location, well depth, rock type, geologic formation, and other conditions affect the fluid composition required. The number and nature of fluid components varies by well, and several products may be used at any time to create the necessary properties (Avanti 1991). The basic functions of a drilling fluid include

- Transport drill cuttings to the surface
- Suspend drill cuttings in the annulus when circulation is stopped
- Control subsurface pressure
- Cool and lubricate the bit and drill string
- Support the walls of the wellbore
- Help suspend the weight of the drill string and casing
- Deliver hydraulic energy upon the formation beneath the bit
- Provide a suitable medium for running wireline logs (USEPA 1985a)

Five basic components for approximately 90 percent by weight of the materials that compose drilling fluids are barite, clay, lignosulfonate, lignite, and caustic soda (Avanti 1991). Stock barite, which is added to drilling fluids, contains cadmium and mercury. Barite is the main source of heavy metals in drilling fluid discharges.

Drilling fluids can be water-based or oil-based. In water-based fluids, water is the suspending medium for solids and is the continuous phase, whether or not oil is present. Water-based drilling fluids are composed of approximately 50 to 90 percent water by volume, with additives comprising the rest. Water-based fluids may contain diesel oil in greater than trace amounts. The diesel oil up to 4 percent, is added to reduce torque and drag. In a stuck pipe situation, a *pill* (diesel oil or oil-based drill fluid) is pumped down the drill string and "spotted" in the annulus area. The pill may or may not be separated out of the bulk fluid system. If the pill is removed, a small amount of diesel remains with the fluid system (Avanti 1991).

Nonaqueous drilling fluid is drilling fluid that has water-immiscible fluid as its continuous phase and as the suspending medium for solids. Types of these fluids include oil-based fluid, enhanced mineral oil-based fluid, and synthetic-based fluid (Avanti 1991). Oil- and mineral oil-based fluids are well suited for high temperature conditions found in deep wells because oil has a higher boiling point than water and pore-clogging problems that sometimes occur with use of water-based fluids can be avoided. Oil-based fluids are generally more costly and are more toxic to marine organisms than water-based fluids. EPA estimated that about 15 percent of wells drilled deeper than 3,000 meters (approximately 10,000 feet) used some oil-based fluids (USEPA 1993b). Because the industry trend is toward deeper wells, oil-based fluids might become more prominent. However, oil-based fluid cuttings cannot be discharged, so increased use of oil-based fluids might not occur. The oil and gas industry has developed several new oleaginous (oil-like) base materials since about 1990 for use in high performance synthetic-based drilling fluids. Some synthetic materials used in these fluids are vegetable esters, poly alpha olefins, internal olefins, linear alpha olefins, synthetic paraffins, ethers, and linear alkylbenzenes. These synthetic-based fluids were developed to provide the performance characteristics of traditional oil-based fluids and to have the potential for lower environmental impact and greater worker safety through lower toxicity, elimination of polynuclear aromatic hydrocarbons (PAHs), faster biodegradability, lower bioaccumulation potential, and in some cases, decreased drilling waste volume (61 FR 66086, December 16, 1996) (USEPA 2000).

Drill cuttings are the waste rock particles that are brought up from the well bore during exploratory drilling operations. During typical operations, a mixture of cuttings and drilling fluids returns to the surface between the drill pipe and the bore hole. At the surface, the cuttings and fluid are separated, and the cuttings are either saved for analysis or disposed of by discharge into adjacent waters. The main source of pollutants in drill cuttings are associated with the drilling fluids that adhere to the rock particles (Tetra Tech 2005a).

The discharge of drilling fluids is authorized only at exploratory facilities and at existing production and development facilities. The discharge of nonaqueous-based drilling fluids is prohibited at all facilities except for situations where such fluids adhere to drill cuttings at facilities in the territorial seas (the first 3 miles measured from the coastline or boundary between coastal and offshore waters) and federal waters (contiguous zone or ocean). After use, synthetic-based fluids are brought to shore and refurbished so they can be reused. Also, using synthetic-based fluids during drilling allows operators to drill slimmer wells and cause less erosion of the well during drilling than drilling using water-based fluids. Therefore, the volume of drill cuttings discharged is reduced when using synthetic-based fluids in comparison to using water-based fluids (Tetra Tech 2005a).

Federal guidelines for the discharge of drilling fluids and cuttings in offshore and coastal waters establish limits that are required throughout Cook Inlet (Tetra Tech 2005a). On the basis of those guidelines, the limits and prohibitions for the proposed NPDES general permit include:

- No discharge of free oil
- No discharge of diesel oil
- A minimum toxicity limit of 3 percent by volume
- Cadmium and mercury in stock barite, which is added to drilling fluids, are limited to 3 mg/kg and 1 mg/kg, respectively
- No discharge of nonaqueous-based drilling fluids in Territorial Seas and federal waters, except those that adhere to drill cuttings
- The toxicity of suspended particulate phase of drilling fluids is limited to 30,000 parts per million (ppm)

Free oil in drilling fluids discharges is to be measured using the static sheen test method. Toxicity is measured with a 96-hour LC_{50} on the suspended particulate phase using the *Leptachoirus plumniosus* species. Cadmium and mercury are measured using EPA Methods 245.5 or 7471 on the stock barite prior to adding it to drilling fluids. These best available pollution control technology economically achievable (BAT) and new source performance standards (NSPS) based limits apply to drilling fluids discharges throughout the proposed general permit's area of coverage. Drilling fluids that adhere to drill cuttings and are discharged are limited for sediment toxicity (4-day), formation oil contamination as measured by either a reverse-phase extraction test or gas chromatography/mass spectrometry (GC/MS), and base fluids that are retained on discharged drill cuttings (Tetra Tech 2005a).

The discharge rate of drilling fluids and cuttings during well drilling operations is variable. The volume of rock cuttings produced from drilling is primarily a function of the depth of the well and the diameter of the bore hole (Tetra Tech 2005b). It has been estimated that between 0.2 barrels and 2.0 barrels (8.4 to 84.0 gallons) of total drilling waste are produced for each vertical foot drilled (USEPA 1987). During exploratory-drilling operations, bulk drilling fluid, usually about 100–200 barrels at a time, is discharged several times during the drilling of a well, when the composition of the drilling fluid has to be changed substantially, or when the volume exceeds the capacity of the fluid tanks. Washed drill cuttings and a small volume of drilling fluid solids are continuously discharged during drilling operations; the discharge rate varies from about 25 to 250 barrels per day (MMS 2003). Volumes of drill fluids discharged from platforms in the Proposed NPDES general permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 3,444 to 10,000 gallons per day (gpd). Common routes for these discharges are ocean discharge and underground injection. During the drilling of production and service wells from a platform, on an average, dry-weight basis, an estimated 70 tonnes of drilling fluid components and 500 tonnes of cuttings per well will need to be disposed of (MMS 2003).

The proposed NPDES general permit requires that the following effluent limitations be met for depth-dependent discharges of water-based fluids and cuttings:

- No discharge at 0 to 5 meters
- 500 barrels (bbl)/hour (79 cubic meters) at > 5 to 20 meters
- 750 bbl/hour (119 cubic meters) at > 20 to 40 meters
- 1,000 bbl/hour (159 cubic meters) at > 40 meters

The permitted drill cutting and drilling fluid discharges from the oil and gas platforms in the Cook Inlet NPDES general permit area of coverage are expected to meet the effluent limitations requirements listed in Table 1 of the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70.

2.2 DECK DRAINAGE

Deck drainage refers to any waste resulting from platform washing, deck washing, spillage, rainwater, and runoff from curbs, gutters and drains, including drip pans and wash areas (Tetra Tech 2005b). This could also include pollutants, such as detergents used in platform and equipment washing, oil, grease, and drilling fluids spilled during normal operations (SAIC 2001). Oil concentrations in deck drainage are estimated at 24 to 450 mg/L (USEPA 1996). Contaminated deck drainage will be treated through an oil-water separator prior to discharge as described in the proposed NPDES general permit.

Federal guidelines for NSPS, BAT, and best conventional pollution control technologies (BCT) for the offshore and coastal subcategories of the oil and gas extraction point source category require no discharge of free oil (Tetra Tech 2005a). The deck drainage discharged from the oil and gas platforms in the Cook Inlet NPDES general permit area of coverage is expected to meet the effluent limitations requirements listed in Table 2 of the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70.

Deck drainage discharges are not continuous and vary significantly in volume. At the times of platform washdowns, the discharges are of relatively low volume and are anticipated. During rainfall events, very large volumes of deck drainage may be discharged in a very short period of time (Tetra Tech 2005b). Volumes of deck drainage discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 109 to 6,300 gpd with a discharge route of ocean discharge. One platform (Monopod Platform) discharges 15,000 gpd of deck drainage to the Trading Bay Treatment Facility for treatment. The average flow of deck drainage for the Osprey Platform is 108,000 gpd (NCG 2001), depending on precipitation (SAIC 2001).

2.3 SANITARY WASTES

Sanitary waste is human body waste discharged from toilets and urinals. The pollutants associated with this discharge include suspended solids, 5-day biochemical oxygen demand (BOD_5), fecal coliform, and residual chlorine (SAIC 2001). The volume of domestic waste discharged has been estimated to range from 50 to 100 gallons per person per day (USEPA 1993a). Discharge of domestic waste from an Alaskan offshore oil rig is usually less than 6,000 gallons per day according to discharge monitoring reports (Tetra Tech 2005b). Volumes of treated sanitary waste discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 1,500 gpd to 2,740,000 gpd.

The offshore and coastal subcategory ELGs for NSPS and BCT require residual chlorine to be maintained as close to 1 mg/L as possible for facilities continuously manned by 10 or more persons. The ELGs also require no discharge of floating solids for offshore facilities continuously manned by nine or fewer persons or intermittently manned by any number of persons.

The expired general permit specified a maximum Total Residual Chlorine limit of 19 mg/L and a minimum requirement of 1 mg/L. The proposed general permit will specify a maximum Total Residual Chlorine limit of 2 mg/L and maintain the existing minimum requirement of 1 mg/L for facilities located in territorial seas. The proposed general permit will specify a maximum Total Residual Chlorine limit of 13.5 mg/l and a minimum of 1mg/l only for facilities in coastal waters.

The expired general permit also included water quality based limits for biochemical oxygen demand (BOD), and total suspended solids (TSS). The proposed general permit would maintain the existing effluent limitations for these parameters in coastal waters and Territorial Seas.

The sanitary waste discharged from the oil and gas platforms in the Cook Inlet NPDES general permit area of coverage is expected to meet the effluent limitations requirements listed in Table 3 of the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70. In cases where sanitary and domestic wastes are mixed prior to discharge, the discharge limitations for domestic wastes also apply to the mixed waste stream. Common routes for these discharges are ocean discharge and underground injection.

2.4 DOMESTIC WASTES

Domestic waste (gray water) refers to materials discharged from sinks, showers, laundries, safety showers, eyewash stations, and galleys. Gray water can include kitchen solids, detergents, cleansers, oil and grease (SAIC 2001). Volumes of domestic waste discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 200 to 1,300,000 gpd (Tetra Tech 2004).

Federal guidelines for NPSP, BAT, and BCT for the offshore and coastal subcategories of oil and gas extraction point sources require no discharge of floating solids or foam. This limit is contained in the existing NPDES general permit and will be included without modification in the proposed NPDES general permit (Tetra Tech 2005a).

The domestic waste discharged from the oil and gas platforms in the Cook Inlet proposed NPDES general permit area of coverage is expected to meet the effluent limitations requirements listed in Table 4 of the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70. In cases where sanitary and domestic wastes are mixed prior to discharge, the discharge limitations for sanitary wastes also apply to the mixed waste stream. Common routes for these discharges are ocean discharge and underground injection.

2.5 MISCELLANEOUS DISCHARGES

The miscellaneous discharges (desalination unit wastes; blowout preventer fluid; boiler blowdown; fire control system test water; noncontact cooling water; uncontaminated ballast water; bilge water; excess cement slurry; mud, cuttings, cement at the seafloor; and waterflooding) from the oil and gas platforms in the Cook Inlet proposed NPDES general permit area of coverage are expected to meet the effluent limitations requirements listed in Table 5 of the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70.

The proposed NPDES general permit contains a visual sheen monitoring requirement for miscellaneous discharges that has been modified slightly from the existing NPDES general permit. The requirements of treating uncontaminated ballast water and bilge water with an oil-water separator before discharge and no free oil discharges in the existing NPDES general permit have been carried forward in the proposed NPDES general permit.

2.5.1 Desalination Unit Wastes

Desalination wastewater is the residual high-concentration brine discharged from distillation or reverse osmosis units used for producing potable water and high-quality process water offshore. It has a chemical composition and ratio of major ions similar to sea water, but with high concentrations (Avanti 1991). Additives discharged with desalination wastes include cleanser, water purifier, and acidifier/scale remover (Tetra Tech 2005b). Volumes of desalination unit wastes discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 55 to 110,000 gpd. Common routes for these discharges are ocean or surface water discharge and underground injection.

2.5.2 Blowout Preventer Fluid

A vegetable or mineral oil solution or antifreeze (polyaliphatic glycol) is used as a hydraulic fluid in blowout preventer stacks while drilling a well. The blowout preventer may be located on the seafloor and is designed to contain pressures in the well that cannot be maintained by the drilling fluid. Small quantities of blowout preventer fluid are discharged periodically to the seafloor during testing of the blowout preventer device (Avanti 1991). The volume of blowout preventer fluid discharge (Tetra Tech 2005b) has been estimated to range from 67 to 314 bbl per day (USEPA 1993a). Discharge volumes of 100 gpd have been reported for some platforms in the permit coverage area in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004). A common route for this discharge is ocean discharge.

2.5.3 Boiler Blowdown

Boiler blowdown is the discharge of water and minerals drained from boiler drums to minimize solids buildup in the boiler (SAIC 2001). Volumes of boiler blowdown discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 42 to 100 gpd. Common routes for these discharges are ocean or surface water discharge.

2.5.4 Fire Control System Test Water

Fire control system test water is sea water that is released during the training of personnel in fire protection and the testing and maintenance of fire protection equipment on the platform (SAIC 2001). Test water may be treated with a biocide. This discharge is intermittent (Tetra Tech 2005b). Volumes of fire control system test water discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for*

New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska (Tetra Tech 2004) range from 100 to 30,000 gpd. To meet effluent limitations for these discharges, several facilities listed in this table treat contaminated fire control system test water with an oil-water separator prior to discharge to ocean or surface water.

2.5.5 Noncontact Cooling Water

Noncontact cooling water is sea water that is used for noncontact , once-through cooling of various pieces of machinery on a platform (SAIC 2001). Noncontact cooling water is not significantly different in composition than ambient sea water, except for an elevated temperature (estimated at 62º to 84ºF) (USEPA 1996). Discharge of noncontact cooling water from an Alaskan offshore oil rig is approximately 210,000 gpd according to discharge monitoring reports (Tetra Tech 2005b). Volumes of noncontact cooling water discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 100 to > 600,000 gpd. Common routes for these discharges are surface water discharge and underground injection.

2.5.6 Uncontaminated Ballast Water

Ballast and storage displacement water are used to stabilize structures while drilling from the surface of the water. Two types of ballast water are found in offshore producing areas (tanker and platform ballast). Tanker ballast water is not covered under an NPDES permit. Platform ballast (stabilization) water is taken on from the waters adjacent to the platform and may be contaminated with stored crude oil and oily platform slop water. Some floating storage platforms use permanent ballast tanks that become contaminated with oil only in emergency situations when excess ballast must be taken on. Oily water can be treated through an oil-water separator prior to discharge (Avanti 1991). No ballast water discharge volumes from platforms in the permit coverage area were reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004).

2.5.7 Bilge Water

Bilge water, which seeps into all floating vessels, is a minor waste for floating platforms. This sea water becomes contaminated with oil, grease, and solids such as rust where it collects at low points in vessels (Avanti 1991). The proposed NPDES general permit requires that all facilities process all bilge water through an oil-water separator prior to discharge. No bilge water discharge volumes from platforms in the permit coverage area were reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004).

2.5.8 Excess Cement Slurry

To protect a well from being penetrated by aquifers, it is necessary to install a casing in the bore hole. The casing is installed in stages of successively smaller diameters as the drilling progresses. The casings are cemented in place after each installation. The amount of cement used for each well depends on the well depth and the volume of the annular space. Additives are used to compensate for site-specific temperature and salt water conditions (Avanti 1991).

Excess cement slurry will result from equipment washdown after cementing operations (SAIC 2001). The pH may be as high as 12, with temperatures up to 80ºF and oil and grease up to 50 ppm (Amundsen 2000). Discharge volumes of 100 and 2,100 gpd have been reported for some platforms in the permit coverage area in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004). The common route for this discharge is surface water.

2.5.9 Mud, Cuttings, and Cement at the Seafloor

Mud, cuttings, and cement at the seafloor are the materials discharged at the surface of the ocean floor in the early phases of drilling operations, before the well casing is set, and during well abandonment and plugging as described in the proposed NPDES general permit. Discharge volumes of 3,444 gpd have been reported for some platforms in the permit coverage area in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004).

2.5.10 Waterflooding Discharges

Waterflooding discharges are associated with the treatment of sea water or treated produced water prior to its injection into a hydrocarbon-bearing formation to improve the flow of hydrocarbons from production wells. Water must be treated before injection to ensure it is free of constituents (i.e., solids, bacteria, and oxygen) which could potentially contaminate the oil reservoir and, in the case of sulfur-reducing bacteria, could lead to increased concentrations of hydrogen sulfide in the extracted oil (Tetra Tech 2005a; USEPA 2000).

Discharge volumes of 50 to 1,530,000 gpd have been reported for existing platforms in the permit coverage area in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004). Waterflooding discharge routes are surface water, ocean water, and underground injection.

2.6 PRODUCED WATER AND PRODUCED SAND

The term *produced water* refers to the water brought up from oil-bearing subsurface geologic formations during extraction of oil and gas; it can include formation water, injection water, and any chemicals (e.g., scale inhibitors, emulsion breakers, biocides, corrosion inhibitors) added to the well bore, or added during the oil and water separation process. The term *produced sand* refers to slurried particles that are the accumulated formation sands and scale particles generated during oil and gas production (USEPA 1996). It also includes de-sander discharge from the produced water waste stream and blowdown of the water phase from the produced water treating system (Tetra Tech 2005a).

All the existing development and production facilities in Cook Inlet are in coastal waters in the area north of a line extending across Cook Inlet at the southern edge of Kalgin Island. Federal guidelines for the coastal subcategory of oil and gas extraction point source category allow produced waters to be discharged to Cook Inlet coastal waters, provided that these discharges meet a monthly average oil and grease limit of 29 mg/L and a daily maximum oil and grease limit of 42 mg/L. These limits are carried forward from the existing NPDES general permit to the proposed NPDES general permit, without modification (Tetra Tech 2005a).

Produced waters will not be authorized for discharge in either coastal or offshore waters for new sources. Federal regulations define the term *new source* for the oil and gas extraction point source category (61 FR 66125, December 16, 1996). A *new source* with regard to produced waters is a development or production facility, or onshore treatment facility, that was constructed after issuance of New Source Performance Standards (Tetra Tech 2005a).

The proposed NPDES general permit includes a new produced water sheen monitoring requirement that was not part of the existing NPDES general permit, where operators of existing facilities will observe the receiving water down-current of the produced water discharge once per day to see if there is a visible sheen. The prohibition of produced sand discharges on the basis of NSPS, BAT, and BCT established by the Offshore Subcategory Effluent Limitations Guidelines have been carried forward from the existing NPDES general permit into the proposed NPDES general permit without modification (Tetra Tech 2005a).

Volumes of produced water and produced sand discharged from *existing* platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) range from 7,000 to 5,598,600 gpd. Common routes for these *existing* discharges are ocean discharge and underground injection. Over the life of a field, the volume of formation waters produced (MMS 2003) may be equal to 20–150 percent of the oil-output volume (Collins et al. 1983). As oil is pumped from a field, the ratio of water to oil being produced increases. In Cook Inlet in 1970, several years after production began, the oil fields were producing between 0.02–0.1 percent water. In 1990, these fields were producing between 0.4–5.2 percent water (MMS 2003). In 2001, these fields were producing between 0.3–6.2 percent water (AOGCC 2002).

Gas production can also coproduce water. From the 1960s to the end of 2001, approximately 1,518 billion cubic feet of gas and 0.12 million cubic meters of water were produced principally from offshore gas fields in upper Cook Inlet (AOGCC 2002). In

2001, these individual gas fields were producing 0–0.5 cubic meters of water per million cubic feet of gas (MMS 2003).

There have been significant changes in both the volume and number of produced water discharges in Cook Inlet since the existing NPDES general permit was issued. Platforms Baker and Dillon no longer discharge produced water. Due to maturing production in the producing fields, however, the volume discharged from the Trading Bay Facility has significantly increased since the existing NPDES general permit was issued. A comparison of the present discharge rates and those at the time the existing NPDES general permit was issued are shown in Table 1.

Table 1. Comparison of Produced Water Discharge Rates

Facility	Previous discharge rate (gpd)	Current discharge rate (gpd)
	Onshore facilities	
Granite Point	96,986	7,000
Trading Bay	2,742,660	5,598,600
East Foreland	200,459	167,040
	Platforms	
Tyonek A	1,811	31,066
Bruce	6,467	11,500
Baker	42,042	0
Dillon	126,103	0
Anna	44,874	51,000

Source: Proposed NPDES General Permit Fact Sheet

The produced water and produced sand discharged from the existing oil and gas platforms in the Cook Inlet NPDES general permit area of coverage are expected to meet the appropriate effluent limitations requirements listed in the tables in Section II.G.1 of the proposed NPDES general permit. *No new development nor production facilities are authorized to discharge produced water under the proposed NPDES general permit.* The Trading Bay Production Facility is required to install a diffuser within 2 years of the effective date of the permit. In situations where the platforms are not able to treat produced water and a bypass may occur, the Anna and Bruce platforms may route their produced water discharge to the East Foreland Production Facility for treatment and discharge. Trading Bay is authorized to discharge treated ground water extracted as part of the produced water waste stream pursuant to State Compliance Order #91-23-01-053-02. Water collected as a result of spill cleanup can be treated as produced water and discharged with the produced water waste stream as described in the proposed NPDES general permit.

2.7 COMPLETION, WORKOVER, WELL TREATMENT, AND TEST FLUIDS

Federal guidelines for NSPS and BAT (40 CFR 435.15) for the offshore category of oil and gas extraction point sources require monthly average oil and grease limits of 29 mg/L and a daily maximum oil and grease limit of 42 mg/L for completion, workover, well treatment, and test fluids. A limit of no free oil discharge is also required for these discharge categories. These limits for produced water are contained in the existing NPDES general permit and are included without modification in the proposed NPDES general permit.

Completion, workover, well treatment, and test fluids from the oil and gas platforms in the Cook Inlet NPDES general permit area of coverage are expected to meet the effluent limitations requirements listed in Table 8 of the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70. Volumes of these fluids discharged from platforms in the permit coverage area reported in Table 2 of the *Area-Wide EA for New Sources Covered Under the NPDES General Permit for Cook Inlet, Alaska* (Tetra Tech 2004) are 8,400 gpd total per platform. Routes for these discharges are ocean discharge and underground injection.

2.7.1 Completion Fluids

Completion fluids are salt solutions, weighted brines, polymers, and various additives used to prevent damage to the well bore during operations that prepare the drilled well for hydrocarbon production. These fluids move into the formation and return to the surface as a slug with the produced water. Completion fluids are used to plug the face of the producing formation while drilling or completion operations are conducted in hydrocarbon-bearing formations. They prevent fluids and solids from passing into the producing formation, thereby preventing reduced productivity of the formation or damaging the oil or gas. The composition of the completion fluid is site-specific depending on the nature of the producing formation (Avanti 1991).

2.7.2 Workover Fluids

Workover fluids are salt solutions, weighted brines, polymers, and other specialty additives used in a producing well to allow safe repair and maintenance or abandonment procedures. Packer fluids, low solids fluids between the packer, production string, and well casing are considered to be workover fluids (Avanti 2001).

2.7.3 Well Treatment Fluids

Well treatment fluids are used to restore or improve productivity by chemically or physically altering hydrocarbon-bearing strata after a well has been drilled (40 CFR Part 435.11). These fluids are similar to drilling fluid and may contain a range of chemicals and naturally occurring materials (e.g., trace metals) (USEPA 2000).

2.7.4 Test Fluids

Test fluids are the discharge that would occur should hydrocarbons be found during exploratory drilling and are tested for formation pressure and content. It consists of drilling fluids sent downhole during testing along with water from the formation as described in the proposed NPDES general permit. Test fluid discharge may consist of formation water, vegetable or mineral oil, natural gas, formation sands, any added acids or chemicals, or any combination thereof (USEPA 1985b). Test fluids are generally stored and treated with acid to remove oil before being discharged. The addition of strong acidic solutions downhole could cause substantial leaching of heavy metals from the formation and residual drilling fluid (Tetra Tech 2005b).

2.8 CHEMICALLY TREATED SEA WATER DISCHARGES

More than 20 biocides are used to treat sea water and fresh water in offshore oil and gas operations. These chemicals include aldehydes, formaldehyde compounds, amine salts, and other compounds. The toxicity of these compounds to marine organisms (as measured with a 96-hour LC_{50} test) can range from 0.4 mg/L to > 1,000 mg/L. Compounds commonly used in scale inhibitors are amine phosphate ester and phosphonate compounds. Scale inhibitors are generally less toxic to marine life than biocides with 96-hour LC_{50} values ranging from 1,676 to > 10,000 mg/L. Corrosion inhibitors are generally more toxic to marine life than scale inhibitors with 96-hour LC_{50} values ranging from 1.98 to 1,050 mg/L (Tetra Tech 2005a).

The discharge of specific biocides, scale inhibitors, and corrosion inhibitors is currently not covered in the proposed NPDES general permit for several reasons, including the following:

- Because of the large number of chemical additives used, it would be very difficult to develop technology-based limits for each additive.

- If the permit did limit specific chemicals, it could potentially impede the development and use of new and potentially more beneficial treatment chemicals that would not be specifically listed in the permit and for which discharge would not be authorized.

- Field conditions for each producing well can change and require different treatment during the period of permit coverage.

Concentrations of treatment chemicals in discharges of sea water or fresh water will be limited to the most stringent of the following EPA requirements:

- The maximum concentrations and any other conditions specified in the EPA product registration labeling if the chemical additive is an EPA-registered product

- The maximum manufacturer's recommended concentration when one exists

- A maximum of 500 mg/L

The Proposed Permit contains BCT limits prohibiting the discharge of free oil for chemically-treated seawater and freshwater discharges

2.9 STORMWATER RUNOFF FROM ONSHORE FACILITIES

Activities that take place at onshore facilities, such as material handling and storage, equipment maintenance and cleaning, or other operational activities are often exposed to stormwater. The runoff from these activities may discharge pollutants into nearby waterbodies, degrading water quality. Operators of onshore facilities are required under the proposed NPDES general permit to develop and implement stormwater pollution prevention plans (SWPPPs). The SWPPPs must include best management practices (BMPs) to monitor and maintain operations to prevent contamination of stormwater.

2.10 DISCHARGES FROM COOK INLET OIL AND GAS PRODUCTION FACILITIES

Table 2 shows the discharges from oil and gas production facilities in Cook Inlet, as presented in the *Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199 Final Environmental Impact Statement* (MMS 2003). Table 3 shows the estimates of exploration well drilling discharges, additives, and usage rates in Alaska OCS waters.

2.11 SUMMARY

According to estimates provided in the *Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199 Final Environmental Impact Statement* (MMS 2003), an average of 11 wells are drilled per year in Cook Inlet (see Table 5 in Section 5.3 of this ODCE), which generate a total of approximately 3,690 tons of drilling fluids and 5,590 tons of drill cuttings for disposal. This would result in the discharge of approximately 930 tons of suspended sediments. Also, approximately 7.36 million cubic meters of produced waters would be discharged per year in Cook Inlet. Discharges from exploration, development, and production activities are expected to meet the appropriate effluent limitations requirements listed in the proposed NPDES general permit and the appropriate Alaska Water Quality Standards in 18 AAC 70.

Discharges to Cook Inlet from exploration, development, and production facilities will include drilling fluids and drill cuttings; deck drainage; sanitary wastes; domestic wastes; sanitary wastes; domestic wastes; desalination unit wastes; blowout preventer fluid; boiler blowdown; fire control system test water; noncontact cooling water; uncontaminated ballast water; bilge water; excess cement slurry; mud, cuttings, cement at seafloor; waterflooding discharges; produced water and produced sand; completion fluids; workover fluids; well treatment fluids; test fluids; and stormwater runoff from onshore facilities.

The discharge of drilling fluids and drill cuttings is authorized only at exploratory facilities and existing facilities. Also, the discharge of nonaqueous based drilling fluids is prohibited except for situations where such fluids adhere to drill cuttings at facilities located in the territorial seas and federal waters. Operators are limited to drilling discharges from no more than five wells at a single drilling site as described in the proposed NPDES general permit.

The discharge of produced water is not authorized from new sources and new exploratory facilities under the proposed NPDES general permit. Produced water discharges from several existing facilities (Trading Bay, Tyonek A, Bruce, Anna) have increased since the existing NPDES general permit had been issued while others have decreased (Granite Point, East Foreland) or stopped discharging completely (Baker, Dillon) as shown in Table 1 in Section 2.6 of this ODCE. Because Trading Bay is discharging a large amount of produced water in comparison to other existing platforms, it will be required under the proposed NPDES general permit to install a diffuser to reduce pollutant concentrations in its produced water discharge.

Deck drainage contaminated with oil and grease and all bilge water must be processed through an oil-water separator prior to discharge. Discharge of sanitary wastes will result in the discharge of suspended solids, BOD_5, fecal coliform, and residual chlorine; however, concentrations are expected to be in accordance with appropriate water quality standards for the state of Alaska and effluent limitations provided in the proposed NPDES general permit. The other discharges (domestic waste; desalination unit waste; blowout preventer fluid; mud, cuttings, and cement at seafloor; completion, workover, well treatment, and test fluids; boiler blowdown; fire control test water; and excess cement slurry) are low in volume or intermittent and contain minimal concentrations of contaminants (see Table 3). Noncontact cooling water represents a relatively high-volume discharge, but it is expected that pollutant concentrations in this discharge (primarily oil and grease) are low. Operators of onshore facilities are required to develop and implement SWPPPs, which must include BMPs to monitor and maintain operations to prevent contamination of stormwater.

Table 2. Oil and Gas Production Facilities in the Cook Inlet Region

Facility name	Operator	Facility type	Latitude/ longitude	Distance to shore (km/st.mi)[d]	Water Depth (meters MLLW)	Number of oil service wells	Number of gas wells	Oil production (bpd)	Gas production (1,000xCFD)	Fluid and cuttings (Bbl/well)	Produced water (bbl/day)		Produced water discharge location
											Peak	Avg.	
Anna	Unocal	Production Platform	60°51'37"N 151°18'46"W	4.0/2.5	23	20 oil, 8 injection	0	2,700	210	15,000	2000	1500	Platform
Baker	Unocal	Production Platform	60°49'45"N 151°29'01"W	12.1/7.5	31	11 oil, 4 service	1	1,000	280	26,000	55	30	Platform
Bruce	Unocal	Production Platform	60°59'46"N 150°17'52"W	2.4/1.5	19	11 oil, 8 injection	0	600	370	15,000	700	1600	Platform
Dillon[a]	Unocal	Production Platform	60°44'08"N 151°31'45"W	6.0/3.7	28	10 oil, 3 service	0	400	150	27,000	3000	2650	Platform
NCIU Tyonek "A"	Phillips	Production Platform	61°04'36"N 151°56'54"W	8.9/5.5	21	0	12	0	165,000	NA	185	170	Platform
SWEPI "A"	Shell Western	Production Platform	60°47'45"N 151°29'44"W	9.5/5.9	30	16	1	3,100	1,000	NA	2700	1700	E. Foreland Facility
SWEPI "C"	Shell Western	Production Platform	60°45'50"N 151°30'08"W	7.1/4.4	21	15	0	3,000	1,000	11,600	2000	1000	E. Foreland Facility
Granite Point	Unocal	Production Platform	60°57'30"N 151°19'53"W	5.8/3.6	23	11 oil, 6 water injection	0	2,600	1,000	26,500	1000	300	Granite Pt. Facility
Spark[b]	Marathon	Production Platform	60°55'42"N 151°31'50"W	2.9/1.8	18	4 with 1 shut-in	0	300	NA	NA	5000	3900	Granite Pt. Facility
Spurr[c]	Marathon	Production Platform	60°55'10"N 151°33'26"W	2.6/1.6	20	5, with 1 shut-in	1 shut-in	300	NA	NA	500	200	Granite Pt. Facility
Grayling	Unocal	Production Platform	60°50'13"N 151°36'47"W	5.8/3.6	41	24 oil, 10 service, 1 abandoned	2	6,800	9,200	20,000	39000	37000	Trading Bay Facility
Dolly Varden	Unocal	Production Platform	60°48'28"N 151°37'58"W	6.4/4.0	34	24	1, with 1 shut-in	6,700	Platform use only	13,500	33800	31300	Trading Bay Facility
King Salmon	Unocal	Production Platform	60°51'54"N 151°36'18"W	3.9/2.4	24 (MSL)	19	1	5,000	6,000	15,000	42000	40300	Trading Bay Facility
Monopod	Unocal	Production Platform	60°53'49"N 151°34'44"W	2.4/1.5	19	29 oil, 2 service	0	2,800	2,500	5,800	6,000	4800	Trading Bay Facility
Steelhead	Unocal	Production Platform	60°40'54"N 151°36'08"W	7.1/4.4	56	3	11	2,000	165,000	13,500	1000	800	Trading Bay Facility
Osprey	Forest Oil	Production Platform	60°41'46"N 151°40'10"W	2.9/1.8	14	In development	In development	In development	In development	In development[g]	In dev.	In dev.	To be reinjected
Granite Point[c]	Unocal	Onshore Separation	60°01'14"N 151°25'14"W	3.1/1.9[e]	14[f]	NA	NA	NA	NA	NA	5200	4400	Spark Platform
Trading Bay	Unocal	Onshore Separation	60°49'05"N 151°46'59"W	3.1/1.9[e]	11[f]	NA	NA	NA	NA	NA	1.2E5	1.15E5	Outfall
East Forelands	Shell Western	Onshore Separation	60°44'09"N 151°21'13"W	0.24/0.15[e]	11[f]	NA	NA	NA	NA	NA	5000	3100	Outfall

Source: MMS (2003).

a Shut down June 1992 (MMS 2003); b Shut down January 1992 (MMS 2003); c Shut down May 1992 (MMS 2003); d Distance from nearest shore measured from low water mark in kilometers/statute miles; e Distance of discharge point from shore; f Water depth at location of discharge outfall; g Fluids and cuttings to be injected into underlying formation.

Table 3. Estimates of Exploration—Well Drilling Discharges, Additives, and Usage Rates in Alaska OCS Waters

Discharge category	Discharge rates (cubic meters per day)	Type of compound used	Usage rates (liters per month)
Drill cuttings and washwater	760-830	---	---
Deck drainage	4-95	All purpose or general cleaners (biodegradable surfactants or aromatic hydrocarbon mixtures) Water purifiers	Range: 8–1,500 General: 57–550 < 11
Sanitary wastes Domestic wastes Desalination wastes	11–23 15–26 14–76	--- --- Cleaners	--- --- Up to 1,100
		Water Purifiers Acidifier/Scale Removers	< 8 < 7 kilograms per month
Blowout-preventer fluid	0.2–0.4	---	---
Boiler blowdown	0.4–0.8	Corrosion Inhibitors	6–11
Fire control system test water	400 cubic meters–12 times a month	Oxygen Scavengers Biocides	6–11 40
		Antifoam Additives Biocides	8 15–910
Noncontact cooling water	4,900–1,300	Water Purifiers	< 8
		Oxygen Scavengers	1.4 kilograms per month
Uncontaminated ballast water	8–300	Surfactants ---	100–200 ---
Uncontaminated bilge water	30	---	---
Excess cement slurry	21–210 cubic meters–4 times total	---	---
Muds, cuttings, Cements at seafloor	400–660 cubic meters	---	---

Source: MMS, 2003

3.0 TRANSPORT, PERSISTENCE, AND FATE OF MATERIALS DISCHARGED

3.1 TRANSPORT AND PERSISTENCE

Factors influencing the transport and persistence of discharged pollutants include oceanographic characteristics of the receiving water, meteorologic conditions, characteristics of the discharge, discharge rate, and method of disposal.

The quality of the Cook Inlet aquatic environment is determined by water's physical and chemical characteristics. Naturally occurring and contaminant substances enter Cook Inlet waters and are diluted and dispersed by the currents associated with the tides, estuarine circulation, wind-driven waves and currents, and Coriolis force. Based on standard salt balance calculations, 90 percent of waterborne contaminants would be flushed from the inlet in 10 months (Kinney et al. 1969, 1970). Because tidal turbulence is the major mixing factor in Cook Inlet rather than seasonally varying fresh water input, this flushing rate is relatively seasonally invariant. However, some of the persistent contaminants may accumulate in (1) the food chain and exceed toxic thresholds, particularly in predators near the top of the food chain, or (2) the seafloor sediments (MMS 2003).

Within a distance of between 100 and 200 meters from the discharge point, the turbidity caused by suspended particulate matter in the discharged fluids and cuttings is expected to be diluted to levels that are within the range associated with the variability of naturally occurring suspended-particulate matter concentrations (MMS 2003). Brandsma (1999) determined that the high suspended solids discharge of drilling fluids in Cook Inlet would be reduced more than two orders of magnitude within 100 meters under the least turbulent conditions and three orders of magnitude under more turbulent conditions (SAIC 2001). In general, the amounts of additives in the other discharges are expected to be relatively small (from 4 to 400 or 800 liters per month) and diluted with sea water several hundred to several thousand times before being discharged into the receiving waters (MMS 2003).

The nonvolatile hydrocarbons (oil and grease) in the produced waters from an existing oil production platform would be diluted a thousand times within several hundred meters if discharged. At a 1,000:1 dilution, the concentrations of nonvolatile hydrocarbons would reduce from 29 parts per million to 29 parts per billion (a concentration less than several of the facility-specific incremental water quality-based limits presented in the proposed NPDES general permit) within several hundred meters of the platform. The concentrations of total aromatic hydrocarbons might range from 8 to 13 parts per million close to the platform and 8–13 parts per billion, which is also less than several of the facility-specific incremental water quality-based limits presented in the proposed NPDES general permit. At some point within this several-hundred-meter distance, acute and chronic criteria would be exceeded. In territorial seas and federal waters, mixing zones are limited to a 100-meter radius (MMS 2003). This limitation does not apply to state waters, where mixing zones might be expanded using platform discharge rates and pollutant concentrations reported by the operators. Proposed and previous mixing zone lengths for produced water discharges are provided in the proposed NPDES general permit fact sheet. State water quality standards do require that acute aquatic life criteria are met at a boundary of a smaller zone of initial dilution, established within the mixing zone (18 AAC 70.255). Some existing operators wishing to discharge produced waters in Cook Inlet would have difficulty in meeting federal water quality criteria at the edge of the mixing zone: reinjection of produced waters is a more viable option for those operators (MMS 2003).

Detailed oceanographic data on the environment of Cook Inlet are provided in the *Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199 Final Environmental Impact Statement* (MMS 2003). Oceanographic and meteorologic conditions in Cook Inlet are briefly described in the following sections. Characteristics of the discharge, including composition and discharge rate, were described in Section 2. Aqueous-based drilling fluids and drill cuttings and nonaqueous-based drilling fluids that adhere to drill cuttings will be discharged below the surface; no discharge will occur in water depths less than 5 meters. Discharges of produced water from new sources and new exploratory facilities are not authorized under the proposed NPDES general permit.

3.1.1 Oceanography

Cook Inlet is a tidal estuary approximately 290 kilometers (180 miles) long and 97 kilometers (60 miles) wide at its mouth, with a general northeast-southwest orientation. It is divided naturally into the upper and lower inlet by the East and West Forelands, where the inlet is approximately 16 kilometers (10 miles) wide (SAIC 2001).

The upper Cook Inlet is typically about 27 to 30 kilometers (17 to 19 miles) wide and has relatively shallow water depths. Water depths are close to 30 to 61 meters (100-200 feet) (below MLLW) but can exceed 152 meters (500 feet) in deeper channels closer to the Forelands (SAIC 2001).

Tides in Cook Inlet are classified as mixed, having strong diurnal and semi-diurnal components, and are characterized by two unequal high and low tides occurring over a period of approximately one day, with the mean range increasing northward (MMS 1995). Currents in the upper Cook Inlet are predominantly tidally driven. Current speeds are primarily a function of the tidal range, and their directions typically parallel the bathymetric contours. Near the mouths of major rivers, such as the Susitna River, currents may locally influence both the current speed and direction by the large volume of fresh water inflow (SAIC 2001).

The lower portion of Cook Inlet is influenced by the Alaskan Stream and by a parallel current in the western Gulf of Alaska called the Kenai Current or the Alaska Coastal Current (MMS 2003). The Alaska Coastal Current flows along the inner shelf in the western Gulf of Alaska and enters Cook Inlet and Shelikof Strait (Shumacher and Reed 1980; Royer 1981a, 1981b). The current is narrow (less than 30 kilometers) and high-speed (20–175 centimeters per second) with flow that is driven by fresh water discharge and inner-shelf winds (MMS 2003). Peak velocities of 175 centimeters/second occur in September through October (Johnson et al. 1988). The Alaska Coastal Current transport volume ranges from 0.1-1.2 million cubic meters per second and varies seasonally in response to fresh water runoff fluctuations, regional winds, and atmospheric pressure gradients (Luick et al. 1987; Royer 1981a, 1981b, 1982; Reed et al. 1987; Schumacher and Reed 1980, 1986; Schumacher et al. 1989). Oxygen isotope measurements in late summer show that glacial meltwater may provide much of the total fresh water runoff into the Alaska Coastal Current (Kipphut 1990).

Strong tidal currents also produce pronounced and persistent tidal rips at various locations in the inlet. It is believed that these features occur primarily at locations of relatively abrupt bathymetric changes. Tidal rips can be marked by surface debris and steep waves. They can also be hazardous to small boat traffic, however, tidal rips would not typically be a significant problem for platform, pipeline, or rig boat operations. It also has been hypothesized that the tidal rips are important habitat to marine species (SAIC 2001).

A general circulation pattern is also present throughout the inlet. Limited circulation information for the upper inlet suggests that there may be a net southwesterly flow along the western side of the inlet, primarily as a result of fresh water inflows near the head of the inlet (Susitna River and from the Knik and Turnagain Arms). Below the Forelands, oceanic waters most commonly flow up the eastern side and turbid and fresher waters flow southward along the western side (SAIC 2001).

Waves in upper and central Cook Inlet are fetch and depth limited, and wave heights are usually less than 3 meters (10 feet). In storms, waves in the upper inlet (Beluga area) can reach 4.5 meters (15 feet) (USCOE 1993) with wave periods estimated up to 6 to 8 seconds (SAIC 2001).

Ice is present in Cook Inlet for up to 5 months each year, but can vary greatly from year to year. On average, ice will be present in the inlet from late November through early April. Three forms of ice normally occur in the inlet: sea ice, beach ice, and river ice. Sea ice is the predominant type and is formed by freezing of the inlet water from the surface downward. Because of the strong tidal currents, ice does not occur as a continuous sheet but as ice pans. Pans can form up to 1 meter (3 feet) thick and be 305 meters (1,000 feet) or greater across (SAIC 2001). They can also form pressure ridges reportedly up to 5.5 meters (18 feet) high (Gatto 1976). Sea ice generally forms in October or November, gradually increasing from October to February from the West Foreland to Cape Douglas, and melts in March to April (Brower el al. 1988). The primary factor for sea ice formation in upper Cook Inlet is air temperature, and for lower Cook Inlet it is the Alaska Coastal Current temperature and inflow rate (Poole and Hufford 1982).

Beach ice, or stamukhi, forms on tidal flats as sea water contacts cold tidal muds. The thickness of beach ice is limited only by the range of the tides and has been noted to reach 9 meters (30 feet) in thickness. During cold periods, beach ice normally remains on the beach; however, during warm weather in combination with high tides, it can melt free and enter the inlet. Blocks of beach ice that enter the inlet are normally relatively small (less than several tens of feet across) and have relatively low strengths (SAIC 2001).

River ice can also occur in Cook Inlet. It is a fresh water ice that is similar to sea ice except that it is relatively harder. It is often discharged into the inlet during spring breakup (SAIC 2001).

3.1.2 Meteorology

The climate of the central Cook Inlet area is characterized as transitional between maritime and continental regimes. Regional topography and waterbodies heavily influence area climate. The Kenai Mountains to the south and east act as a barrier to warm, moist air from the Gulf of Alaska. The Alaska Range to the north provides a barrier to the cold winter air masses that dominate the Alaska Interior. Cook Inlet waters tend to moderate temperatures in the area. Occasionally, short periods of extreme cold and/or high winds occur when strong pressure gradients force cold air southward from the interior (SAIC 2001).

In the lower Cook Inlet region, the climate is transitional from a maritime to a continental climate. Generally, lower Cook Inlet is a maritime climate, wetter and warmer than the upper Cook Inlet region, which exhibits some continental climatic features—that is, the upper Cook Inlet region is drier and cooler than the lower (MMS 2003).

Overland and Heister (1980) define six Gulf of Alaska weather types that influence the lower Cook Inlet. The Aleutian low-pressure center occurs most often. The Aleutian Low, a semipermanent low-pressure system over the Pacific Ocean, has a strong effect on the climate in the area. As this low-pressure area moves and changes in intensity, it brings storms with wind, rain, and snow (Wilson and Overland 1986). The other weather types are the low-pressure center over central Alaska; the stagnating low off of Queen Charlotte Islands; and the Pacific Anticyclone, also known as the East Pacific High (Overland and Hiester 1980). Generally, winter is characterized by an inland high-pressure cell with frequent storm progressions from the west along the Aleutian chain. During summer, a low-pressure cell is over the inland area, with fewer storms (MMS 2003). Spring and fall are characterized by a transition between these generalized patterns (Macklin 1979).

Precipitation decreases from south to north along the inlet. Kodiak is the wettest, and Anchorage is drier (MMS 2003). Cook Inlet precipitation (SAIC 2001) averages less than 20 percent of that measured on the Gulf of Alaska side of the Kenai Mountains (NCG 2001). Homer, Kenai, and Anchorage all have substantially less precipitation than Kodiak due to the sheltering or *rain shadow* effect of the Kenai Mountains. Homer averages about 65 centimeters of precipitation annually, and Anchorage averages about 40 centimeters. The wettest months are September and October, with the relatively dry conditions in April through July. In the northern inlet, precipitation usually falls as snow from October to April and as rain the rest of the months. Farther south in the inlet, a greater percentage of the precipitation falls as rain (MMS 2003).

Winds in the area are strongly influence by mountains surrounding the Cook Inlet Basin. During the months of September through April, prevailing winds are typically from the north or northwest. During May through August, winds prevail from the south. Mean speeds range from 5 knots in December to 7 knots in May (Brower et al. 1988). Site-specific, short-term data confirm the general trends described above. For example, winds measured at the West Foreland in 1999 and 2000 indicate that during September through April, prevailing winds are from the north-northeast and northeast. During June and July, winds prevail from the south-southwest and southwest. May and September are transition periods for these patterns (HCG 2000a, 2000b, 2000c, 2000d). Extreme winds are commonly out of the northeast or south (SAIC 2001).

3.2 SUMMARY

Overall, Cook Inlet is a high-energy environment. Fast tidal currents and tremendous mixing produce rapid dispersion of soluble and particulate pollutants. If facility operators comply with proposed NPDES general permit requirements, it is expected that discharges from oil and gas exploration, development, and production facilities would not have a measurable effect on the overall quality of Cook Inlet water.

4.0 COMPOSITION OF BIOLOGICAL COMMUNITIES

4.1 PLANKTON

Planktonic communities typically consist of both phytoplankton and zooplankton. During summer months, lower Cook Inlet is among the most productive high-latitude shelf areas in the world (MMS 1996). However, marine productivity in northern Cook Inlet is limited by severe turbidity and extreme tidal variations. The silt-laden waters that enter Upper Cook Inlet load the inlet with sediment and retard its primary (phytoplankton) productivity (Kinney et al. 1970). Larrance et al. (1977) found that lower Cook Inlet marine productivity decreased in a northerly direction. At a station immediately south of the Forelands, the euphotic zone (the upper limit of effective light penetration for photosynthesis) was extremely shallow, ranging from 1 to 3 meters (3 to 10 feet) (SAIC 2002). The suspended material limits light penetration and probably causes reduced surface nitrate utilization in the spring (Sambrotto and Lorenzen 1987).

Zooplankton are used as food for fish, shellfish, marine birds, and some marine mammals. Zooplankton feed on phytoplankton, and their growth cycles respond to phytoplankton production. In the lower inlet, zooplankton populations vary seasonally with biomass reaching a low in the early spring and a peak in late spring and summer. Zooplankton is abundant in the lower Cook Inlet but occurs at much reduced levels in the upper inlet (SAIC 2002).

Impacts on the plankton communities that form the base of the marine food web may result in impacts on higher trophic organisms (SAIC 2002).

4.2 BENTHIC INVERTEBRATES

In addition to high turbidity, Cook Inlet is characterized by extreme tidal fluctuations of up to 12.2 meters (40 feet) (NOAA 1999) that produce strong currents in excess of 8 knots (Tarbox and Thorne 1996). The amount of protected benthic habitat is likely reduced by the periodic scouring or substrate movement caused by Cook Inlet currents that bottleneck at the Forelands, near the Osprey Platform (SAIC 2002).

Mollusks, polychates, and bryozoans dominate the infauna of seafloor habitats in Cook Inlet. Feder et al. (1981) found over 370 invertebrate taxa in samples from lower Cook Inlet. Substrates consisting of shell debris generally have the most diverse communities and are dominated by mollusks and bryozoans (Feder and Jewett 1987). Muddy-bottom substrates are occupied by mollusks and polychaetes, while sandy-bottom substrates are dominated by mollusks. Nearshore infauna, where sediments are fine and sedimentation rates are high, consists mostly of mobile deposit-feeding organisms that are widely distributed through the area. Infaunal organisms are important trophic links for crabs, flatfishes, and other organisms common in the waters of Cook Inlet (SAIC 2002).

Epifauna are dominated by crustaceans, mollusks, and echinoderms (SAIC 2002). The percentage of sessile organisms in Cook Inlet is relatively low inshore and increases towards the continental shelf (Hood and Zimmerman 1987). Rocky-bottom areas consist of lush kelp beds with low epifaunal diversity; moderate kelp beds with well-developed sedentary and predator/scavenger invertebrates; and little or no kelp with moderately developed predator/scavenger communities and a well-developed sedentary invertebrate community (Feder and Jewett 1987).

4.3 FISH

Few studies of marine fish in upper Cook Inlet have been published. The fish of central and lower Cook Inlet have been better studied, due in part to the numerous commercial fisheries in the area. Because of low phytoplankton productivity and the severe tidal currents, it is thought that upper Cook Inlet does not provide a plentiful primary food source or much safe habitat for fish (SAIC 2002). However, recent studies of beluga utilization of Cook Inlet may warrant further investigation of Cook Inlet forage fish (NMFS 2000a).

4.3.1 Anadromous Fish

Anadromous fish migrate through northern Cook Inlet towards spawning habitat in rivers and streams, and juveniles travel through Cook Inlet toward marine feeding areas. The Susitna River drainage is a primary source of these anadromous fish in upper Cook Inlet (SAIC 2002).

4.3.1.1 Salmon

All five Pacific salmon species: pink salmon (*Oncorhynchus gorbuscha*); chum salmon (*O. keta*); sockeye salmon (*O. nerka*); coho salmon (*O. kisutch*); and Chinook or king salmon (*O. tshawytscha*) are found in Cook Inlet. Run timing and migration routes for all five salmon species overlap (SAIC 2002). In upper Cook Inlet, adult salmon inhabit marine and estuarine waters from early May to early November (ADFG 1986). Salmon transit much of Cook Inlet, as smolt leaving natal (home) fresh water drainages and again later as returning adult spawners. Juvenile salmonids from Prince William Sound following ocean currents also may enter Cook Inlet. Salmon in Cook Inlet provide a high value to the commercial fishing industry (MMS 2003).

Pink salmon is typically the smallest salmon species in Cook Inlet, averaging between 3 and 5 pounds. Pink salmon enter their spawning streams between late June and October and typically spawn within a few miles of the shore, often within the intertidal zone. The eggs are buried in the gravel of stream bottoms and hatch in the water. In spring, the young emerge from the gravel and migrate downstream to salt water. Pink salmon stay close to the shore during their first summer, feeding on small organisms such as plankton, insects, and young fish. At about one year of age, pink salmon move offshore to ocean feeding grounds where their food consists mainly of plankton, fish, and squid. Return migration to fresh water takes place during the second summer with few exceptions

(SAIC 2002). The even-year pink salmon return is typically stronger than the odd-year return in Cook Inlet (ADFG 1986).

Chum salmon grow to an average weight of between 7 and 18 pounds. Chum salmon remain nearshore during the summer where their diet consists of small insects and plankton. In the fall, they start moving offshore where they feed on plankton. They return to fresh water in the fall and spawn late in the year. Most chum salmon spawn in areas similar to those used by pink salmon, but sometimes travel great distances up large rivers (e.g., up to 3,218 kilometers (2,000 miles) up the Yukon River). Chum salmon usually return to streams to spawn after 3 to 5 years at sea (SAIC 2002).

Sockeye salmon spawn in stream systems with lakes; fry may reside up to 3 years in fresh water lakes before migrating to sea. Most sockeye spend two to three winters in the North Pacific Ocean before returning to natal streams to spawn and die (SAIC 2002). Sockeye salmon is the most important commercial salmon species in Cook Inlet (ADFG 1999).

Coho salmon return to spawn in natal stream gravels from July to November, usually the last of the five salmon species. Fry emerge in May or June and live in ponds, lakes, and stream pools, feeding on drifting insects (SAIC 2002). Coho salmon may reside in-stream up to three winters before migrating to sea where they typically remain for two winters before returning to spawn (ADFG 1986).

Chinook salmon are the first of the five species to return each season. They reach the Susitna River in approximately mid-May (ADFG 1986). Soon after hatching, most juvenile chinook salmon migrate to sea, but some remain for a year in fresh water. Most chinook salmon return to natal streams to spawn in their fourth or fifth year (SAIC 2002). The Susitna River supports the largest chinook salmon run in upper Cook Inlet which includes systems below the Forelands to the latitude of N 59º46′12″, near Anchor Point (ADFG 1986).

4.3.1.2 Other Anadromous Fish

Steelhead trout (*O. mykiss irideus*) is a rainbow trout that has spent a part of its life in the sea. These fish are unevenly distributed throughout Cook Inlet. Spawning begins in about mid-April and generally continues throughout May and early June. Steelhead trout usually spawn more than once. Eggs are deposited in gravel during the spring and develop into alevins or sac fry. By midsummer, they emerge from the gravel and seek refuge along stream margins and protected areas. Usually, juveniles remain in the parent stream for about 3 years before they enter saltwater (MMS 2003).

Cutthroat trout (*O. clarkii*) are the most common trout species in the region. Resident fish live in a wide variety of environments from small headwater tributaries and bog ponds to large lakes and rivers. Sea-run fish are usually found in river or stream systems with accessible lakes. It is unknown why some fish migrate to sea while others remain in fresh water. Adults spawn in small, isolated headwater streams from late April to early

June, and young cutthroat trout emerge from the gravel in July. Sea-run cutthroat rear for 3 to 4 years in fresh water and then migrate to sea during May for a few days to more than 100 days before returning to their home stream (MMS 2003).

Bering cisco (*Coregonis laurettae*) have been reported in the Susitna River drainage (Barrett et al. 1985). Bering cisco enter river systems in the late summer. In 1982, spawning peaked mid-October in the Susitna River (SAIC 2002). Egg incubation occurs over winter and larvae move into northern Cook Inlet after ice-out in the spring from late April to May (Morrow 1980).

Dolly Varden Char (*Salvelinus malma*) that inhabit Cook Inlet can be anadromous or reside in fresh water. Non-resident Dolly Varden cycle seasonally between fresh water and marine environments. They often overwinter in fresh water drainages, then disperse into coastal waters during summer to feed on small fishes and marine invertebrates (Morrow 1980). In Cook Inlet, Dolly Varden spawn annually in rivers during the fall from late August to October (Scott and Crossman 1973; Morrow 1980). Like other salmonids, Dolly Varden lay eggs in hollowed out redds (shallow cavities dug into streambeds where salmonids spawn) located in swift moving water; hatching occurs the following spring. Juvenile Dolly Varden remain in their natal streams for 2 to 3 years (SAIC 2002).

White sturgeon (*Acipenser transmontanus*) are anadromous fish found in northern Cook Inlet. They are believed to spend most of life near shore in water depths of 30 meters or less (98 feet). Although little is known about white sturgeon migrations while in salt water, one tagged specimen was captured 1,056 km (656 miles) from where it was tagged (Morrow 1980). In the spring, most mature white sturgeon enter the estuaries and lower reaches of river systems. They spawn over rocky bottoms in swift water where the sticky eggs adhere to the river bottom. The amount of time needed for the eggs to hatch is not known (SAIC 2002). After spawning, the adults return to sea (Morrow 1980).

4.3.2 Pelagic Fish

Eulachon (*Thaleichthys pacificus*) are small anadromous forage fish (up to approximately 23 cm (9 inches) long; MMS 1995) found throughout the Cook Inlet. Mature eulachon, typically 3 years old, spawn in May soon after ice-out in the lower reaches of streams and rivers. The Susitna River supports a run of eulachon estimated in the millions (Barrett et al. 1985). Females broadcast their eggs over sand or gravel substrates where the eggs anchor to sand grains. Eggs hatch in 30 to 40 days, depending on the water temperature. Eulachon larvae are then flushed out of the drainage and mature in salt water. As juveniles and adults, they feed primarily on copepods and plankton. As the spawning season approaches, eulachon gather in large schools at stream and river mouths. Most eulachon die after spawning (Hart 1973). Eulachon is most important as a food source for other fish, birds, and marine mammals. The Cook Inlet population also supports small dipnet fisheries in upper Cook Inlet (SAIC 2002).

Pacific herring (*Clupea pallasi*) occur in large schools in the Cook Inlet region in early April and potentially through the early fall. These fish generally spawn during the spring. Spawning occurs in shallow, vegetated areas in intertidal and subtidal zones (MMS 2003). Female herring lay adhesive eggs over rock and seaweed substrates. Depending on water temperature, eggs hatch in 3 to 7 weeks. Herring stay nearshore until cold winter water temperatures drive them offshore to deeper, warmer waters. Herring have been harvested for bait in Cook Inlet as far north as the Forelands (Blackburn et al. 1979). The Cook Inlet herring fishery now targets Kamishak Bay on the west side of lower Cook Inlet. A small herring sac roe fishery has been suspended since the 1998 season because of low herring abundance. Alaska Department of Fish and Game biologists observed about 8,100 tons of herring in the Kamishak Bay District in 2000; biomass must exceed a threshold of 8,000 tons before a commercial sac roe harvest can be considered for Kamishak Bay (SAIC 2002).

Pacific sand lance (*Ammodytes hexapterus*) is a schooling fish that sometimes bury themselves in beach sand (Hart 1973). Pacific sand lance spawn within bays and estuaries, typically between December and March (SAIC 2002). Eggs are demersal, but will suspend in turbulent waters (Williams et al. 1964). Pacific sand lance larvae are found both offshore and in intertidal zones (Fitch and Lavenberg 1975; Kobayashi 1961). Early juvenile stages are pelagic, while the adult burrowing behavior develops gradually (Hart 1973). Major food items of the juvenile sand lance include copepods, other small crustaceans, and eggs of many forms (Hart 1973; Fitch and Lavenberg 1975). This species is commonly preyed upon by lingcod, Chinook salmon, halibut, fur seals, and other marine animals (Hart 1973) and appears to be an important forage species. Pacific sand lance have been caught off Chisik Island, southwest of West Foreland (Fechhelm et al. 1999).

Capelin (*Mallotus villosus* [Muller]) is a major forage fish of the Cook Inlet region. Populations of capelin are large and are generally found in pelagic waters. They are mainly filter feeders, thriving on planktonic organisms including euphausiids and copepods. They spawn on beaches and in deeper waters and require specific conditions (e.g., temperature, tide, and light) for successful spawning. Capelin eggs attach to beach and bottom gravels. They hatch, depending on temperature, within 15 to 55 days. These fish currently have no economic value to Alaska, but they are used extensively for food by other fish, marine mammals, and seabirds (MMS 2003).

4.3.3 Groundfish

The Pacific halibut (*Hippoglossus stenolepis*) is a large flatfish that occurs throughout Cook Inlet. Halibut concentrate on spawning grounds along the edge of the continental shelf at water depths of 182 to 455 meters (597–1,493 feet) from November to March. Significant spawning sites in the vicinity of lower Cook Inlet are Portlock Bank, northeast of Kodiak Island, and Chirikof Island, south of Kodiak Island (IPHC 1998). Temperature influences the rate of development, but typically eggs hatch in 20 days at 5ºC (ADFG 1986). As eggs develop into larvae, they float in the water column and drift passively with ocean currents. Halibut larvae’s specific gravity decreases as they grow.

Three- to 5-month old larvae drift in the upper 100 meters (329 feet) of water where they are pushed by winds to shallow sections of the continental shelf. At 6 months old, juveniles settle to the bottom in nearshore waters where they remain for 1 to 3 years (Best and Hardman 1982). Juvenile halibut then move further offshore (IPHC 1998). Halibut migrate seasonally from deeper water in the winter to shallow water in summer. Accordingly, the fishery is most active in deep areas early in the season (i.e., May) whereas activity can be as shallow as 20 meters (about 65 feet) during midsummer. A recreational fishery in central Cook Inlet targets Pacific halibut (SAIC 2002). The Sport Fish Division of the Alaska Department of Fish and Game estimate that 75,709 halibut were caught by sport fishermen in central Cook Inlet between May 1 and July 31, 1995 (McKinley 1996).

Pacific cod (*Gadus macrocephalus*) are distributed over lower Cook Inlet. They are fast-growing bottom-dwellers that mature in approximately 3 years. They may reach lengths of up to 1 meter (Hart 1973). Cod spawn during an extended period through the winter and eggs may hatch in 1 week depending on water temperature. Cod are harvested offshore in the Gulf of Alaska by trawl, longline, pot, and jig gear. Cod move into deep water in autumn and return to shallow water in spring. Pacific cod populations sustain a rapid turnover due to predation and commercial fishing (SAIC 2002). The Gulf of Alaska stock is projected to decline as a result of poor year-classes produced from 1990 to 1994 (Witherell 1999).

Sablefish (*Anoplopama fimbria*) are also known as black cod. They are found within Cook Inlet, and they are a valued commercial species. These fish probably spawn during the spring, but little is known about their spawning behavior or egg-larval development. They feed on a large variety of benthic and pelagic fauna (MMS 2003).

Starry flounder (*Platichthys stellatus*) have been caught in central Cook Inlet (Fechhelm et al. 1999) and are likely to occur in northern Cook Inlet. Starry flounder spawn from February through April in shallow water (Hart 1973). They generally do not migrate, although one starry flounder was caught 200 km (124 miles) from where it had been tagged (Hart 1973). Starry flounder tolerate low salinities, and some have been caught within rivers (SAIC 2002).

Arrowtooth flounder (*Atheresthes stomias*) and yellowfin sole (*Pleuronectes asper*) may also extend into Cook Inlet. Little is known about the life history of these flatfish (SAIC 2002). Arrowtooth flounder larvae have been taken from depths of 200 meters (about 650 feet) to the surface in June off British Columbia (Hart 1973). Both have been caught off Chisik Island in central Cook Inlet (Fechhelm et al. 1999).

Pacific hake (*Merluccius productus*) can be found throughout the Cook Inlet in small numbers. They could spawn up to several months in this region, with the pelagic eggs hatching in as little as 3 days depending on the size of the fish. Larvae hake consume copepods and other similarly-sized organisms while adult hake consume euphausiids, sand lance, anchovies, and other forage fishes. Hake are prey for other marine fish, marine birds, and marine mammals (MMS 2003).

Walleye pollock (*Theragra chalcogramma*) are found throughout the Cook Inlet. They spawn in the spring in large aggregations and there is some extended spawning in smaller numbers throughout the year. Eggs hatch in about 10 to 20 days. Adult fish consume shrimp, sand lance, herring, small salmon, and similar organisms they encounter. Walleye pollock are also cannabilistic (MMS 2003).

Smaller numbers of yellowfin sole, Atka mackerel, and other groundfish inhabit Cook Inlet. These species generally are found in the same habitats as the groundfish species described above (MMS 2003).

4.3.4 Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Act (MSA), PL-104-267, which regulate fishing in U.S. waters, included substantial new provisions to protect important habitat for all federally managed species of marine and anadromous fish. The amendments created a new requirement to describe and identify *essential fish habitat* (EFH) in each fishery management plan. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Federal agencies are required to consult with the National Marine Fisheries Service (NMFS) on all actions undertaken by the agency that may adversely affect EFH (SAIC 2002).

This mandate was intended to minimize adverse effects on habitat caused by fishing or non-fishing activities and to identify other actions to encourage the conservation and enhancement of this habitat. Cook Inlet contains EFH for a total of 35 species including walleye pollock, pacific cod, and salmon. Routine operations and accidents can effect EFH by damaging habitats used for breeding, spawning, feeding, or growth to maturity (SAIC 2002).

Fishery management plans are obliged to identify habitat areas of particular concern (HPC) within EFH. HPCs include living substrates in shallow water that provide food and rearing habitat for juvenile fish and spawning grounds that may be impacted by shore-based activities. Estuarine and nearshore habitats of Pacific salmon (e.g., eelgrass [*Zostera sp*.] beds) and herring spawning grounds (e.g., rockweed [*Fucus sp*.] and eelgrass] are HPCs that can be found in Cook Inlet. Offshore HPCs include areas with substrates that serve as cover for organisms including groundfish. Areas of deepwater coral are also considered HPC, but populations are concentrated off southeast Alaska, out of the proposed project area. All anadromous streams qualify as HPC (SAIC 2002).

4.4 SHELLFISH

4.4.1 Razor Clam (Siliqua patula)

This clam is harvested extensively throughout its range by commercial and sports fisheries. Breeding occurs between May and September and is closely associated with rising water temperatures. Toward the end of their larval free-swimming period (veliger stage), which can list 5 to 16 weeks, the shells begin to form, and they start resembling clams. The young clams take up residence in sand. These clams live in surf-swept and somewhat protected sand beaches of the open ocean. Large numbers are found in waters near Augustine Island of western Cook Inlet. They feed on phytoplankton and zooplankton filtered from the surrounding sea water (MMS 2003).

4.4.2 Pacific Weathervane Scallop (Patinopecten caurinus)

These scallops generally are sexually mature at 3 or 4 years of age and are a commercially harvestable size at 6 to 8 years. Spawning occurs in June and July where spermatozoa and ova are released into the water. Ova that are fertilized settle to the bottom and after approximately 1 month, hatching occurs and the larvae drift with the tidal currents. After 2 to 3 weeks, the larvae gain weight, settle to the bottom, and attach themselves to seaweed. There are two scallop beds east of Augustine Island in Cook Inlet that are commercially harvested. Weathervane scallops feed on microscopic plankton that they filter from the surrounding water (MMS 2003).

4.4.3 Pandalid Shrimp

Five species of pandalid shrimp of various commercial and subsistence values are found in the cool waters off the coast of Alaska. Coonstripe shrimp (*Pandalus hypsinotis*) were the target shrimp of Cook Inlet fisheries. Coonstripe shrimp are generally associated with rock piles, coral, and debris-covered bottoms. Pandalid shrimp generally spawn in the fall and hatch in the spring but timing varies with species and range. Females carry fertilized eggs for about 6 months before the eggs hatch into planktonic, free-swimming larvae. After the last larval molt, they transform into juveniles and settle to the bottom. Pandalid shrimp are opportunistic bottom feeders that feed on a wide variety of items including worms, diatoms, detritus, algae, and various invertebrates. They are often the diet of large predator fish including Pacific cod, walleye pollock, flounders, and salmon (MMS 2003).

4.4.4 Dungeness Crab (Cancer magister)

Dungeness crabs are found in Cook Inlet, and they mate from spring through autumn. The female crab extrudes the fertilized eggs under her abdomen and carries them around until they hatch. After hatching, the young crabs take about 4 months to a year before molting into the first of six juvenile stages. Dungeness crabs are widely distributed subtidally and prefer a muddy bottom in the sea. They scavenge for organisms that live partly or completely buried in the sand along the seafloor. They are also predators that will eat shrimp, mussels, small crabs, clams, and worms (MMS 2003).

4.4.5 Tanner Crabs (Chionoecetes bairdi and C. opilio)

Tanner crabs are found in Cook Inlet. After fertilization, eggs are incubated on the female's abdominal flap for a year. Hatching occurs late the following winter and spring, with the peak hatching period usually occurring during April to June. The young, free-swimming larvae molt several times and after several years of growth, females mature at approximately 5 years, and males mature at approximately 6 years. Tanner crabs feed on assorted worms, clams, mussels, snails, crabs, other crustaceans, and fish parts. They are consumed by groundfish, pelagic fish, and humans (MMS 2003).

4.5 OTHER NONENDANGERED FISH AND INVERTEBRATE SPECIES FOUND IN COOK INLET

Other nonendangered fish and invertebrate species found in Cook Inlet include those listed below.

- Pacific Ocean perch
- Alaska king crab
- Rock sole
- Alaska plaice
- Rex sole
- Dover sole
- Flathead sole
- Shortraker rockfish
- Rougheye rockfish
- Northern rockfish
- Thornyhead rockfish
- Yellowhead rockfish
- Dusky rockfish
- Sculpins
- Skates
- Squid

4.6 MARINE BIRDS

4.6.1 Seabirds

Lower Cook Inlet is one of the most productive areas for seabirds in Alaska. Approximately 27 species, composed of an estimated 100,000 seabirds (USFWS 1992), occur in Cook Inlet, and about 18 species breed in the Inlet. Seabird breeding colonies occur along the coastline of the Gulf of Alaska and the lower Cook Inlet (DeGange and Sanger 1987; USFWS 1992). Species breeding in lower Cook Inlet include glaucous-winged gulls; black-legged kittiwake; common murre; pigeon guillemot; horned and tufted puffins; parakeet auklet; and red-faced, double-crested, and pelagic cormorants (SAIC 2002). Large seabird concentrations (about 30,000 birds) on the west side of Cook Inlet occur at the Chisik-Duck Islands (MMS 2003).

Large concentrations of seabirds occur in Cook Inlet and the Gulf of Alaska during the spring when returning breeding species and migrants from breeding grounds in the southern hemisphere move into the area. The numbers remain high throughout the summer and decline in the fall as they begin to migrate to their wintering grounds (DeGange and Sanger 1987). Seabird numbers in Cook Inlet are lowest during the winter

(SAIC 2002). Major prey species for seabirds during the spring and summer seasons in the Cook Inlet area (MMS 2003) include capelin, pollock, sand lance, herring, euphausiid crustaceans, and squid (Baird and Moe 1978; Sanger et al. 1978; Hatch 1984; Baird 1991; Piatt 2002).

4.6.2 Shorebirds

Approximately 30 shorebird species occur as breeding birds and migrants in Cook Inlet. Although shorebirds nest in Cook Inlet, the most important areas for shorebird use are the migratory stopover areas in the northern Gulf of Alaska/lower Cook Inlet where birds stop to rest and feed. An important location for shorebirds during migration is western Cook Inlet (DeGange and Sanger 1987). These include the intertidal zones of Drift River, Iniskin Bay, and Chinitna Bay. Kachemak Bay in lower Cook Inlet is also an important feeding and resting area for shorebirds during migration (SAIC 2002).

The Pribilof Islands rock sandpiper (*Calidris ptilocnemis*) winters along the intertidal mudflats from the Susitna River south to Redoubt Bay (Gill and Tibbets 1999). The sandpipers, which begin arriving in November and remain through mid-April, feed on a small bivalve (*Macoma balthica*) found in high densities in the intertidal area. The mean count of the Pribilof Island rock sandpiper during aerial surveys conducted in winter (1997 to 1999) was 17,530 birds (MMS 2003).

During spring migration, millions of shorebirds congregate at coastal intertidal mudflats to feed before continuing their northward migration. Most birds pass through the area between late April and mid-May with the peak of the migration in early May. The two most common species are dunlin and western sandpiper. Turnover is high, and individual birds probably only stop to feed and rest for a few days before continuing (SAIC 2002).

4.6.3 Waterfowl

The most abundant waterfowl species in lower Cook Inlet (MMS 2003) include scoters, long-tailed ducks, eiders, and goldeneyes (Agler et al. 1995). Large numbers of waterfowl migrate through the Cook Inlet area in the spring (Arneson 1980; Gill and Tibbitts 1999). Waterfowl densities increase in winter and are higher in eastern Cook Inlet than on the western side (Arneson 1980). Sea ducks feed primarily on benthic invertebrates, including clams and mussels (Sanger and Jones 1984).

4.6.4 Coastal Birds of Prey

The bald eagle is a breeding, year-round resident along the coast of lower Cook Inlet (MMS 1995). Populations in southeastern Alaska have been stable or increasing. Bald eagles feed primarily on fish or act as scavengers (MMS 2003).

4.7 NONENDANGERED MARINE MAMMALS

Marine mammals that range throughout the Gulf of Alaska, including Cook Inlet, are described below. These species are protected under the Marine Mammal Protection Act

(MMPA) and are managed by the U.S. Fish and Wildlife Service (USFWS) and NMFS (SAIC 2002).

4.7.1 Minke Whale (Balaenoptera acutorostrata)

Minke whales occur in the North Pacific from the Bering and Chukchi Sea south to near the equator (Leatherwood et al. 1982). Minke whales are relatively common in the nearshore waters of the Gulf of Alaska (Mizroch 1992) but are not abundant in any other part of the eastern Pacific (Brueggeman et al. 1990). Minke whales are unlikely to migrate into Cook Inlet, but it is possible (SAIC 2002).

Minke whales breed in temperate or subtropical waters throughout the year (SAIC 2002). Peaks of breeding activity occur in January and June (Leatherwood et al. 1982). Calving occurs in winter and spring (Stewart and Leatherwood 1985). Females are capable of calving each year (SAIC 2002), but a 2-year calving interval is more typical (Leatherwood et al. 1982).

Minke whales in the North Pacific prey mostly on euphausiids and copepods (SAIC 2002) but also feed on schooling fishes including Pacific sand lance, northern anchovy, and squid (Leatherwood et al. 1982; Stewart and Leatherwood 1985; Horwood 1990).

No estimates of the number of minke whales in the north Pacific or Alaskan waters have been made (Hill and DeMaster 2000). The annual human-caused mortality is considered insignificant (SAIC 2002). Minke whales in Alaska are not listed as depleted under the MMPA or considered a strategic stock (Hill and DeMaster 2000).

4.7.2 Gray Whale (Eschrichtius robustus)

Gray whales historically inhabited both the North Atlantic and North Pacific oceans. A relic population survives in the western Pacific. The eastern Pacific or California gray whale population has recovered significantly and now numbers about 23,000 (Hill et al. 1997). The eastern population has recovered significantly and now numbers about 23,000 (Hill et al. 1997). The eastern Pacific stock was removed from the Endangered Species List in 1994 and is not considered a strategic stock by the NMFS (SAIC 2002).

The eastern Pacific gray whale breeds and calves in the protected waters along the west coast of Baja, California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the breeding and calving season, most of these gray whales migrate about 8,000 km (5,000 mi) north, generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (SAIC, 2002).

Gray whale occurrences in Cook Inlet are most likely uncommon. As they move through the Gulf of Alaska on their northward and southward migrations, gray whales closely follow the coastline (Calkins 1986). They generally tend to bypass Cook Inlet as they pass through the Barren Islands and the waters south of Kodiak Island (Calkins 1986).

However, a cow and a calf were observed in lower Cook Inlet as recently as the summer of 2000 (Eagleton 2000).

4.7.3 Killer Whale (Orcinus orca)

Killer whales occur along the entire Alaska coast (Dahlheim et al. 1997) from the Chukchi Sea, into the Bering Sea, along the Aleutian Islands, Gulf of Alaska, and into Southeast Alaska (Braham and Dahlheim 1982). Seasonal concentrations occur in Shelikof Strait and the waters around Kodiak Island (Calkins 1986). Killer whales are known to inhabit Cook Inlet waters during the summer and have been observed pursuing beluga whales in Cook Inlet (Eagleton 2000). Killer whales using Cook Inlet are most likely from the Eastern North Pacific Northern resident stock of killer whales (SAIC 2002), which is estimated at 717 individuals (Hill and DeMaster 1999). The killer whale population is regarded as abundant in the Gulf of Alaska and Cook Inlet region (MMS 2003). The peak breeding period is May through July (Nishiwaki and Handa 1958, as cited by Consiglieri et al. 1982).

4.7.4 Harbor Porpoise (Phocoena phocoeana)

The harbor porpoise is distributed in waters along the continental shelf and is most frequently found in cool waters with high prey concentrations (Watts and Gaskin 1985). The range of the harbor porpoise within the eastern North Pacific Ocean is primarily restricted to coastal waters and extends from Point Barrow, along the coast of Alaska (SAIC 2002), and the west coast of North America to Point Conception, California (Gaskin 1984). They have been observed in Cook Inlet during winter months (Hansen and Hubbard 1999). Harbor porpoise densities are much greater in their southern range (Washington, northern Oregon and California) than in Alaskan waters (MMS, 2003). Harbor porpoises are not migratory. Little information on the population dynamics of harbor porpoises is known; however, they occur in Cook Inlet (Calkins 1983). The most recent population estimate for the harbor porpoise in Alaskan waters is 30,000 (Hill and DeMaster 1999).

The major predators on harbor porpoises are great white sharks and killer whales. Unlike other delphinids, harbor porpoises forage independently, feeding on small schooling fishes such as northern anchovy as well as squid (SAIC 2002).

4.7.5 Dall's Porpoise (Phocoenoides dalli)

Dall's porpoises are widely distributed along the continental shelf (SAIC 2002) as far north as 65°N (Buckland et al. 1993) and are abundant throughout the Gulf of Alaska (Calkins 1986). Dall's porpoises prefer water depths greater than 20 meters (66 feet) deep (SAIC 2002) and are commonly found in lower Cook Inlet (Calkins 1983). The only apparent gaps in their distribution in the Gulf of Alaska are in upper Cook Inlet and Icy Bay (Consiglieri and Braham 1982). The current estimate for the Alaska stock of Dall's porpoises (SAIC 2002) is 83,400 (Hill and DeMaster 1999). Dall's porpoises (MMS 2003) feed on squid, crustaceans, and deepwater fish (Leatherwood and Reeves 1987).

4.7.6 Harbor Seal (Phoca vitulina richardsi)

Harbor seals range from Baja California, north along the western coast of the United States, British Columbia, and Southeast Alaska, west through the Gulf of Alaska and the Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. Hill and DeMaster (2000) estimated 29,000 individuals in the Gulf of Alaska stock (SAIC 2002). The Gulf of Alaska populations around Kodiak and Tugidak Islands have grown since the early 1990s (Small 1996; Withrow and Loughlin 1997) but overall, the stock numbers are in decline (Hill and DeMaster 2000). They are distributed in coastal waters along virtually the entire lower Cook Inlet coastline and are generally nonmigratory. Current population estimates for Cook Inlet are 2,244 (MMS 2003).

Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows. They are generally nonmigratory, but move locally with the tides, weather, season, food availability, and reproduction activities (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969; Bigg 1981). Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows. The mother and pup remain together until weaning occurs at 3 to 6 weeks (Bishop 1967; Bigg 1969). Little is known about breeding behavior in harbor seals. When molting, seals spend the majority of the time hauled out on shore, glacial ice, or other substrates. Harbor seals consume a variety of prey in estuarine and marine waters. Prey type varies regionally and seasonally in the Gulf of Alaska. Walleye pollock are the dominant prey in the eastern Gulf, and octopus are the dominant prey in the western Gulf (SAIC 2002).

4.7.7 Other Nonendangered Marine Mammals

Occasionally, Pacific walruses are sighted in the Cook Inlet area. These unusual sightings generally occur during the winter or spring during years when the Bering Sea pack ice extends into the southern Bering Sea and near the Aleutian Islands. Stray walruses apparently move through the passes into the Gulf of Alaska/Shelikof Strait into Cook Inlet (MMS 2003).

Other nonendangered marine mammals that rarely or infrequently occur in the Gulf of Alaska and Cook Inlet region (MMS 2003), include the short-finned pilot whale, Risso’s dolphin, northern right whale dolphin, north Pacific giant bottlenose whale, goosebeak whale, and Bering Sea beaked whale (Consiglieri et al. 1982).

5.0 POTENTIAL IMPACTS OF DISCHARGES ON MARINE ORGANISMS

5.1 CHEMICAL TOXICITY OF DISCHARGES

5.1.1 Drilling Fluids Toxicity

Drilling fluids (muds) are complex mixtures, and there appears to be no single explanation for toxicity. Some of the apparent (actual) toxicity may be due to physical effects, such as particle size coagulations, abrasions, and so on. There is, however, a form of toxicity producing and contributing, in part or in combination with chemical toxicity, to the end points (death) of the organism in acute toxicity tests (Tetra Tech 2005b).

Oxygen demand appears strongly correlated with toxicity in laboratory toxicity tests. Spearman Rank correlations of 96-hour LC_{50} data and BOD/UOD data showed a remarkably strong correlation, especially with BOD_5 data derived with artificial sea water and activated seed. These data showed a correlation of 0.97 with toxicity. All BOD/UOD values showed correlations of 0.87 to 0.97 (BOD) and 0.91 to 0.95 (UOD), but TOC/chemical oxygen demand (COD) values gave correlations of 0.64 to 0.67. Given the absence of oxygen demand data, no such correlation could be developed for nongeneric fluids. Another indicator of the large inherent oxygen demand of drilling fluids is that dissolved oxygen levels in test environments dropped below normal, despite the continuous aeration of test media that followed pre-aeration of the test material. This was especially noted during the first day of testing, during which dissolved oxygen levels were depressed concentration dependently by the test fluids (Tetra Tech 2005b).

A variety of Alaskan marine organisms have been exposed to drilling fluid in laboratory or field experiments. Most of these studies have addressed short-term acute effects in a relative or *screening* sense, with little effort directed at separating chemical from physical causes. A few studies have looked at chronic sublethal effects and bioaccumulation of heavy metals from drilling fluid. Chronic refers to a stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span of an organism or more (USEPA 1991). Chronic tests assess the effect on survivability, growth, maturation, or reproduction, and the results are typically reported as median effective concentrations (EC_{50}s [concentrations at which a designated effect is displayed by 50 percent of the test organisms]). Because drilling discharges are episodic and typically only a few hours in duration, organisms that live in the water column are not likely to have long-term exposures to drilling fluids; risks to these organisms are best assessed using acute toxicity data. Benthic organisms, particularly sessile species, are likely to be exposed for longer time periods; risks to these organisms are best assessed with chronic toxicity data (Tetra Tech 2005b).

Drilling fluid toxicity tests have been performed using whole fluids or various component fractions, such as the suspended particulate phase or fluid aqueous fraction. The variability and complexity in the composition of fluids is reflected in the results and interpretation of toxicity tests. Test results of sample splits of the same fluid performed at two different laboratories have differed by an order of magnitude. In such cases, laboratory procedure or sample handling is a significant factor. Different batches of the same generic fluid have shown significantly different toxicities. In this case, different proportions of major constituents (as allowed by fluid type definition) may be a factor. EPA has attempted to improve consistency in toxicity test results by requiring standard procedures for sample handling and testing that has resulted in consistent test results. The current effluent guidelines require toxicity testing for the suspended particulate phase. The extrapolation of single species toxicity tests to overall effects in the ecosystem still has a large, inherent uncertainty (Tetra Tech 2005b).

5.1.1.1 Acute Lethal and Sublethal Effects

The effects of drilling fluids on biological organisms are most commonly assessed by conducting acute laboratory toxicity tests. Unfortunately, in many cases, comparison of toxicity test results obtained in different studies are difficult because different drilling fluids were used, the animals were exposed to different portions of drilling fluid (liquid, suspended particulates, or solids) that may have been prepared in a different manner, or experimental procedures differed between investigators. Nevertheless, results obtained in the majority of studies to date have generally indicated low toxicity (Tetra Tech 2005b).

In a summary of over 415 toxicity tests of 68 fluids using 70 species, 1–2 percent exhibited LC_{50}s ranging from 100 to 999 ppm, 6 percent exhibited LC_{50}s ranging from 1,000 to 9,999 ppm, 46 percent exhibited LC_{50}s ranging from 10,000 to 99,999 ppm, and 44 percent exhibited LC_{50}s greater than 100,000 ppm (USEPA 1985b). Two to three percent of the data were not usable. A significant difference was noted between the toxicity of generic fluids, which appear to have acute, lethal toxicity characteristics similar to the distribution of the larger data set described above, and a series of 11 nongeneric fluids provided to EPA by the Petroleum Equipment Supplies Association. These latter fluids, as a group, appear to be substantially more toxic than would be anticipated from the toxicity distribution of either the generic fluids or the larger data set. Whole fluids appear to be more toxic than aqueous or particulate fractions. The suspended particulate phase appears to be more toxic than the other individual phases (Tetra Tech 2005b).

Under the proposed NPDES general permit, discharge of fluids with an LC_{50} of less than 30,000 ppm SPP (suspended particulate phase) is prohibited. The toxicity (LC_{50}) of the fluids used to drill 39 production wells in Cook Inlet between August 1987 and February 1991 (under older permits) ranged from 1,955 to greater than 1,000,000 parts per million for a marine shrimp (Tetra Tech 2005b). The percentage of the wells with toxicities

- greater than 100,000 parts per million was 79 percent
- between 10,000 and 100,000 parts per million was 10 percent
- between 1,000 and 10,000 parts per million was 10 percent (MMS 2003)

Drilling fluid toxicity data compiled by EPA Region 10 from Alaskan exploratory and production wells indicate that the fluids used in all current and recent operations are acutely toxic only to a slight degree to *Mysidopsis bahia.* LC_{50}s for the 91 valid toxicity test data points ranged from 2,704 to 1,000,000 ppm SPP with a mean of 540,800 ppm. Only 7 of the 91 tests had LC_{50}s less than the 30,000 ppm limit. Some of the records in this database were not included in the above statistics due to pH or other protocol breaches, incomplete reports, and other reasons. (Tetra Tech 2005b).

Petrazzuolo (1981) has ranked organisms according to their sensitivity to drilling fluids in tests and found the following order of decreasing sensitivity: copepods and other plankton, shrimp, lobsters, mysids and finfish, bivalves, crabs, amphipods, echinoderms, gastropods, and polychaetes, and isopods. Larval organisms are more sensitive than adult stages (maximally 20-fold); animals are more susceptible during molting (Tetra Tech 2005b).

The majority of Alaskan organisms apparently show high tolerance to acute exposure to drilling fluid. Sublethal effects observed following acute exposure have included alteration of respiration and filtration rates, enzyme activities, and behavior. There are several Alaskan taxa that have not been exposed to drilling fluid but may be relatively sensitive. The temperate copepod, *Acartia tonsa,* has exhibited one of the lowest LC_{50}s (100 ppm) of any organism in a drilling fluid. Alaskan copepods have not been tested, but there is no reason to believe their tolerances would fall outside variability in tolerances of other marine copepods (Tetra Tech 2005b).

In general, planktonic and larval forms appear to be the most sensitive of the Alaskan organisms that have been exposed to drilling fluid in acute lethal bioassays; however, not all planktonic organisms are sensitive to short-term exposure to drilling fluids. Carls and Rice (1981) found several drilling fluids to have low toxicity to the larvae of six Alaskan species of shrimp and crab. The 96-hour LC_{50}s for the suspended particulates phase of a drilling fluid sea water mixture ranged from 500 to 9,400 ppm. Toxicity was far less when the particulates were removed: the 96-hour LC_{50}s ranged from 5,800 to 119,000 ppm (Tetra Tech 2005b).

Houghton et al. (1981) conducted a study on several species of crustaceans, including a shrimp (*Pandalus hypsinotus*), a mysid (*Neomysis integer*), an amphipod (*Eogammarus confervicolus*), and an isopod (*Gnorimosphaeroma oregonensis*), and pink salmon fry (*Onchorhyncus gorbuscha*). These species were exposed to used high-density lignosulfonate drilling fluid from lower Cook Inlet, Alaska. Pink salmon fry were the most sensitive with a 96-hour LC_{50} of 3,000 ppm for SSP. The lowest crustacean concentration was ten times higher (Avanti 1991).

Seven arctic polymer drilling fluids were used for toxicity testing of salmon (Houghton et al. 1981). Five of the seven fluids displayed a 96-hour LC_{50} of less than 40,000 ppm for the SSP fraction; the most toxic fluid had a 96-hour LC_{50} of 15,000 ppm, and the least toxic fluid a 96-hour LC_{50} of 190,000 ppm. Clam worms (polychaetes), soft-shelled clams, purple shore crabs, and sand fleas had approximately the same sensitivity to the fluids as did the salmon. These invertebrate 96-hour LC_{50}s ranged from 10,000 to more than 560,000 ppm (Avanti 1991).

Unlike the water-based drilling fluids, the synthetic-based drilling fluids (SBFs) are water insoluble and do not disperse in the water column as do water-based drilling fluids, but rather sink to the bottom with little dispersion (USEPA 2000). Since 1984, EPA has used the suspended particulate phase toxicity test, an aqueous-phase toxicity test, to evaluate the toxicity of drilling fluids, including SBFs. Using the SPP toxicity test, SBFs have routinely been found to have low toxicity; however, an inter-laboratory variability study indicated that SPP toxicity results are highly variable when applied to SBFs (USEPA 2000). In general, benthic test organisms appear to be more sensitive to the SBFs than water-column organisms. The ranking for SBF toxicity from least toxic to most toxic is: esters < internal olefins < linear alpha olefins < polyalphaolefins < paraffins (USEPA 2000).

5.1.1.2 Chronic Effects

Few studies have evaluated impacts on Alaskan species following chronic exposure to drilling fluids; the species that have been tested are all invertebrates. The few chronic data are consistent, however, and indicate that chronic lethal toxicity is not likely to be more than some 20-fold greater than acute lethal toxicity; chronic sublethal toxicity appears to range from 3-fold to 75-fold greater than acute lethal toxicity, which is within the same range as chronic lethal effects. However, the chronic sublethal data are much more difficult to interpret, physiologically and ecologically. Sample sizes routinely are very small. Most importantly, observations that sublethal effects occur *close* to lethal effect levels miss the point; for most studies, changes were also noted at the lowest level tested. Thus, estimating No-Observable-Effect-Levels (NOELs) are not possible for much of the reported data (Tetra Tech 2005b).

Laboratory studies on recruitment and development of benthic communities suggest that drilling fluid and barite can affect recruitment and alter benthic communities or depress abundances. These data are corroborated by results from artificial substrate experiments conducted in the Beaufort Sea; these showed significantly different colonization rates at drilling fluid test plots and control plots, especially for amphipods and copepods (Tetra Tech 2005b).

The lowest reported concentration of drilling fluid producing a significant sublethal chronic effect was 50 mg/L for 30 days of continuous exposure with bay mussels, and there was no attempt to separate chemical from physical effects (USEPA 1985b).

A laboratory study examined the chronic toxicity of cuttings from Beaufort Sea wells on the sand dollar *(Echinarachnius parma)* (Osborne and Leeder 1989). Exposure to mixtures as low as 10 percent cuttings and 90 percent sand were found to affect the survival of the benthic organisms, with 100 percent mortality occurring within 23 days in some test cases (Tetra Tech 2005b).

5.1.2 Toxicity of Mineral and Diesel Oil

In the past, the oil industry has added diesel oil to drilling fluid systems to free stuck drilling pipes and for other specialized applications. Diesel oil is highly toxic to aquatic life, and much of the toxicity of drilling fluids has been attributed to its presence. Studies have found high correlations of toxicity with added diesel and mineral oil to whole fluid (diesel oil $r = 0.88$; mineral oil $r = 0.97$). Toxicity did not correlate quite as well with the oil levels determined in a variety of fluid samples ($r = 0.81$). The available data indicate that this may be partially due to various types of sequestrations within the drilling fluid matrix as well as the variable presence of toxic constituents in drilling fluids other than diesel or mineral oil (Tetra Tech 2005b).

Because of the toxicity of diesel oil, EPA has prohibited its discharge in fluids and cuttings. Instead, EPA allows the use of mineral oils to free stuck pipes and the discharge of residual amounts of mineral oil pills, provided that the pill and a buffer of drilling fluid on either side of the pill are removed and not discharged. The residual mineral oil concentration in the discharged fluid should not exceed 2 percent (volume-volume [v/v]) and must comply with all previous permit conditions (Tetra Tech 2005b).

According to the API Hydrocarbon Usage Survey and the OOC Spotting Fluid Survey (USEPA 1993a), diesel oil was still being used for lubricity agents and spotting fluids as of 1986 (Tetra Tech 2005b). With the advent of Best Practicable Control Technology Currently Available (BPT) effluent limitation guidelines, however, current diesel oil usage for these purposes is assumed to be zero (USEPA 1993a).

Mineral oils differ from diesel oils in that they contain a lower concentration of aromatic hydrocarbons (15–20 percent vs. 20–61 percent for diesel oil). In addition, saturated aliphatics (paraffinics) generally represent a larger percentage of mineral oils compared to diesel oil. Aromatic hydrocarbons are generally more toxic and resist biodegradation to a greater degree than do paraffinics (Petrazzuolo 1983a). Research studies indicate that some mineral oils are much less acutely toxic (5 to 30 times less) to certain marine organisms than diesel oil (Tetra Tech 2005b). Despite the reduced toxicity of some mineral oils as compared to diesel oils, mineral oils do contribute potentially toxic organic pollutants to drilling fluids to which they are added (Tetra Tech 2005b).

Neither mineral nor diesel oils possess constituents that can be biomagnified. The hazard to aquatic life from consuming organisms or inhabiting water contaminated with diesel oils is greater than that for mineral oil because the aromatics in diesel oils tend to be more soluble and biologically active than paraffinic hydrocarbons, although the PAHs contained in mineral oils have been shown to be highly soluble in adipose tissue and lipids (Sittig 1985). Organisms will assimilate hydrocarbons in both types of petroleum products, but the hazard associated with the residues is not expected to be significant (Tetra Tech 2005b).

5.1.3 Toxicity of Produced Waters

In addition to fluid and cuttings, produced water constitutes a major discharge from offshore production operations. Water brought up from the hydrocarbon-bearing strata with the produced oil and gas includes brines trapped with the oil and gas in the formation and possibly water that was injected into the reservoir to increase productivity. (Water injected to increase hydrocarbon recovery is normally injected into wells other than the producing wells.) The actual amount of produced water derived from each site is a function of the geological formation encountered and the method of recovery. The proportion of water in the produced fluids may vary from 0 to over 90 percent and can increase, decrease, or remain constant over the lifetime of a well (Menzie 1982). In Cook Inlet, produced fluids have increased in water content as most fields have matured. The generation of produced water is a relatively continuous feature of producing platforms, unlike the intermittent discharge of drilling fluid and cuttings from exploration, development, and production operations (Avanti 1991).

Brines are the major form of produced water, and the major inorganic constituents are chlorides. Menzie (1982) reports typical dissolved solids concentrations of 80,000–100,000 mg/L in produced water, although a range from a few mg/L to approximately 300,000 mg/L has been observed. In comparison, sea water of 30 ppt salinity has a dissolved concentration of 30,000 mg/L (Avanti 1991). In upper Cook Inlet, dissolved solids concentrations in produced waters are typically 24,700 mg/L (Lysyj and Curran 1983).

In most oil fields, treatment of the total fluid to separate oils from produced water ranges from simple gravity separation at offshore facilities to multi-step processes at centralized onshore facilities. Any gas co-produced with the oil is separated out. Use of the multi-step processes can lead to reduction of oil content, volatile aliphatic hydrocarbons, and volatile aromatic hydrocarbons. The gas is either flared at the platforms, used for energy, or sold and is not part of the final discharge (Avanti 1991).

Potential biological effects occurring as a result of produced water discharges include osmotic stress if salinity varies significantly from ambient sea water, respiratory stress if DO levels are low, bioaccumulation of various components, and toxic effects from hydrocarbon and heavy metal constituents. The probability of these effects occurring in Cook Inlet is a function of the total volume discharged within the waterbody and the dilution and dispersion of the effluent plume. The latter also may be affected by salinity of the discharge. Low saline produced water (relative to ambient sea water) will tend to rise to the surface, whereas briny produced water will tend to sink to the bottom layer. The mixing rates of these types of discharges depend on current and wave conditions and the density difference between the effluent and the receiving water (Avanti 1991).

If the salinity of the produced water is similar to ambient sea water, osmotic stress is improbable and respiratory stress is likely to be restricted to localized, nearfield areas. Minimal impact of this type is likely unless the quantity (volume) of discharge is such that DO is measurably depressed within the water mass. This is most likely to occur only in shallow, poorly flushed embayments (Avanti 1991).

5.1.3.1 Acute Lethal Effects

The toxicity of the produced waters from the oil and gas fields of upper Cook Inlet was determined by using a standard 96-hour static acute-toxicity test to the mysid shrimp *Mysidopsis bahia* (EBASCO Environmental 1990a); this test measures the concentration killing 50 percent of the test animals in 96 hours (LC_{50}). (*M. bahia* routinely has been used to evaluate the toxicity of effluents from municipal wastewater treatment plants, refineries, and chemical manufacturing plants to marine organisms [Brown et al. 1992]). The LC_{50} toxicities of the produced waters ranged from 0.27–82.47 percent of the effluent (Table III.A-9); these concentrations equal 2,700–824,700 parts per million. On the basis of the qualitative toxicity levels described in section IV.B.1.a(3)(c)1), the produced waters sampled during the Cook Inlet Discharge Monitoring Study Program would range in toxicity from slightly toxic to practically nontoxic prior to discharge and subsequent mixing in the water column (MMS 2003).

5.1.3.2 Chronic and Sublethal Effects

Although the acute toxic effects of produced water appear to be low (when biocides are absent), chronic lethal and sublethal effects must be considered. Such effects are expected to occur at concentrations below those that are acutely toxic. Chronic exposures to organisms in the water column could occur in areas where the hydrocarbons discharged to the water column are not rapidly removed from the system and where there is a continuous input. The potential for buildup of hydrocarbons in the water column would be greater in semi-enclosed coastal embayments with limited flushing than in offshore regions (Avanti 1991).

In areas where a hypersaline produced water plume contacts the bottom, mortality can be expected to occur as a result of anoxic and hypersaline conditions. The extent of these effects will depend on the duration, volume, and dispersion of the plume. It is likely that the benthic community, especially infauna and less mobile epiphauna, would be severely disrupted in the immediate vicinity of the discharge. Armstrong et al. (1979) noted severe disruption of benthos within 150 meters (490 feet) of the discharge point in Trinity Bay, Texas (Avanti 1991).

Farther from the discharge site, chronic effects may occur and are likely to impact benthos over a larger area. Chronic effects may occur primarily from exposure to dissolved or deposited materials and hydrocarbons (Avanti 1991). In other areas, it has been noted that compounds at very low concentrations in produced water, especially substituted napthalenes, can accumulate to high concentrations in sediments and in biota (Armstrong et al. 1979). This occurs even in areas where the discharge plume dilutes rapidly (Armstrong et al. 1979).

5.1.3.3 Bioaccumulation Potential of Produced Water

The environmental accumulation potential of selected trace metal and organic constituents of produced waters has been previously estimated from predetermined sorption coefficients (K_d) and bioconcentration factors (BCFs). On the basis of data derived from the ODCE for Southern California (JRB Associates 1984) as shown in Table 4, the affinity of trace metals to suspended particulate matter or sediments (i.e., their partitioning potential) is very high. Among the elements studied, lead, manganese, and mercury have the highest coefficient value; chromium, copper, silver, and zinc comprise a group that has medium partitioning potential; antimony, arsenic, iron, cadmium, nickel, selenium, and thallium show the lowest potential as compared to the other elements. The range of BCF values for each element is large, and therefore, definitive patterns cannot be deciphered. However, looking at the maximum estimated values, it appears that zinc, thallium, mercury, and cadmium exhibit the highest bioaccumulation potential, with antimony, arsenic, and copper sharing a medium tendency, and silver, selenium, nickel, lead, chromium, and beryllium exhibiting the lowest values (Avanti 1991).

For trace organic constituents evaluated in the Southern California study (JRB Associates 1984), benzo(a)pyrene has the highest sorption value followed by three compounds having similar K_d values (acenaphthalene, phenanthrene, and anthracene) but of lower magnitude (one or two orders of magnitude). Benzene and toluene, being volatile compounds have the least tendency for sorption. All the listed compounds except the volatiles and naphthalene show similar bioaccumulation capacity (Avanti 1991).

On the basis of the magnitude of the K_d and BCF values listed in Table 4, each of the constituents were ranked according to their relative environmental accumulation potential. The rankings are designated as high (H), medium (M), low (L) and combinations among these. These rankings, coupled with the rankings for toxicity, should present a first approximate determination of which compounds appear to be of concern (Avanti 1991).

Table 4. Estimated Accumulation Factors of Selected Trace Metals and Petroleum Components in Produced Waters.

Component	Sorption[1] coefficient ($K_d \times 10^4$)	Bioaccumulation[2] factor ($BCF \times 10^4$)	Relative accumulation potential
Trace Metals			
Antimony	2	0.004-2	L
Arsenic	2	0.003-2	L
Beryllium	1	0.01	L
Cadmium	6	0.01-10	M
Chromium	30	0.001-0.1	M
Copper	20	0.01-0.1	M
Lead	90	0.001-0.01	MH
Manganese	100	NA	UND[3]
Mercury	250	0.1-10	H
Nickel	8	0.001-0.1	L
Selenium	6	0.01	L
Silver	20	0.01-0.1	M
Thallium	3	0.001-10	MH
Zinc	20	0.01-10	MH
Hydrocarbons			
Benzene	0.0019	0.0045	L
Toluene	0.0023	0.0052	L
Xylene	NA	NA	UND
Naphthalene	0.026	0.035	ML

Table 4. Estimated Accumulation Factors of Selected Trace Metals and Petroleum Components in Produced Waters. (Continued)

Component	Sorption[1] coefficient (K_d x 10^4)	Bioaccumulation[2] factor (BCF x 10^4)	Relative accumulation potential
Hydrocarbons			
Anthracene	0.25	0.035	M
Phenanthrene	0.30	0.22	M
Benzo(a)pyrene	15.14	0.1	H
Ethylbenzene	NA	NA	UND
Acenaphthalene	0.12	0.12	M

Source: JRB Associates 1984.

1 Sorption coefficients for trace metals were determined from field measurements in estuarine waters; coefficients for the organic constituents were estimated from octanol/water partition coefficient.

2 Bioaccumulation factors for trace metals were estimated from Versar (1979) as cited in JRB Associates 1984; trace organics were estimated from octanol/water partition coefficients.

3 UND = Undetermined.

5.1.4 Toxicity of Other Discharges

Sea water is the principal component of most of the other permitted discharges associated with oil- and gas-production activities in Cook Inlet, and in some cases, it is the only constituent. There is a wide range of concentrations of the various additives in the discharges. Produced water treatment additives include biocides, scale inhibitors, emulsion breakers, and corrosion inhibitors (MMS 2003). The range of maximum concentrations and toxicities (96-hour LC_{50}) for the (1) biocides is about 5–640 ppm, (2) scale inhibitors is about 30–160 ppm, (3) emulsion breakers is about 10 ppm, and (4) corrosion inhibitors is about 20–160 ppm (Neff 1991).

5.1.5 Metals Accumulation Potential

The potential accumulation of metallic compounds in biota represents an issue of concern in the assessment of oil and gas impacts. Sublethal effects resulting from bioaccumulation of these highly persistent compounds are most often measured. Gross metal contamination from drill fluids might also cause mortality, particularly in benthic species. Sources of metals include drill fluids, formation waters, sacrificial anodes, and contamination from other minor sources. Drill fluids and formation waters are the primary sources of concern for arsenic, barium, chromium, cadmium, copper, mercury, nickel, lead, vanadium, silver, and zinc (Avanti 1991).

Field studies of metal concentrations in sediment around platforms suggest that enrichment of certain metals may occur in surface sediments around platforms (Tillery and Thomas 1980; Mariani et al. 1980; Crippen et al. 1980; and others). In the review of these studies conducted by Petrazzuolo (1983b), enrichment of metals around platforms is generally distance dependent with maximum enrichment factors seldom exceeding 10. In platforms studied, enrichment of metals that could be attributed to drilling activities was either generally distributed 300–500 meters around the platform, or distributed downcurrent in a plume to a larger distance from the structure (Avanti 1991).

The concentrations of metals required to produce physiological or behavioral changes in organisms vary widely and are determined by factors such as the physiological characteristics of the water and sediments, the bioavailability of the metal, the organism's size, physiological characteristics, and feeding adaptations. Metals are accumulated at different rates and to different concentrations depending on the tissue or organ involved. Laboratory studies on metal accumulations as a result of exposure to drill fluids have been conducted by Tornberg et al. (1980), Brannon and Rao (1979), Page et al. (1980), McCulloch et al. (1980), Liss et al. (1980), and others. Maximum enrichment factors for the metals measured were generally low (< 10) with the exception of barium and chromium, which had enrichment factors of up to 300 and 36, respectively (Avanti 1991).

Depuration studies conducted by Brannon and Rao (1979), McCullough et al. (1980), and Liss et al. (1980) have shown that organisms tested have the ability to depurate some metals when removed from a zone of contamination. In various tests, animals were exposed to drill fluids from 4–28 days, followed by a 1–14 day depuration period. Uptake and depuration of barium, chromium, lead, and silver were monitored and showed a 40–90 percent decrease in excess metal in tissues following the depuration period. Longer exposure generally meant a slower rate of loss of the metal. In addition, if uptake was through food organisms rather than a solute, release of the excess metal was slowed (Avanti 1991).

The available laboratory data on metals accumulation are difficult to correlate with field exposure and accumulation. Petrazzuolo's review (1983b) notes that in the field, bioaccumulation of metals in the benthos will result from exposure to the particulate components of drilling fluids. However, laboratory studies have almost always used either whole fluids or fluid-aqueous fractions, and thus are either over- or underestimating potential accumulation (Avanti 1991).

Field studies of metal accumulation in marine food webs off southern California have been conducted by Schaefer et al. (1982) and others. These data have indicated that most metals measured (including chromium, copper, cadmium, silver, and zinc) do not increase with trophic level either in open water or in contaminated regions such as coastal sewage outfalls. Mercury, however, may be an exception to this, as biomagnification has been observed in a number of studies. Other studies have shown that croakers, scorpionfish, and sea urchins can detoxify inorganic metals through a protein synthesis process that excludes contaminants from cellular enzyme pools (Avanti 1991).

Bioaccumulation of metals in southern and central California offshore waters may not be a significant environmental problem. However, Petrazzuolo (1983b) states that due to the persistence of metals, the high toxicity of some metals, the paucity of laboratory data on mercury, and the inability to correlate field and laboratory measures, a finding of no significant potential effect is inappropriate at this time (Avanti 1991).

5.2 HUMAN HEALTH IMPACTS

Adverse human health effects from drilling fluids and produced water are unlikely to result from the exploration and production discharges because direct human exposure will be low. Ingestion of organisms that have accumulated significant concentrations of heavy metals or other contaminants from drilling fluids and produced water is the potential principal source of adverse human health effects caused by offshore oil and gas drilling operations. Three metals are of special concern: mercury and cadmium because they biomagnify in food webs, and barium, which is present in large concentrations in drilling fluids. Benzo(a)pyrene is also of special concern because of its presence in produced waters. Barium could accumulate in marine organisms, but human ingestion of contaminated seafood in a short enough period of time to pose a human health threat is unlikely. Petrazzuolo (1981) assessed human health risk on the basis of reported barium concentrations in biota and concluded that a human would have to eat 5 to 15 kg (11 to 13 pounds) of contaminated seafood in a short period of time (biological half-life of barium is less than 24 hours) to be at risk. This event is highly unlikely (USEPA 1994).

Organic mercury is readily taken up by marine biota and accumulates in the liver and kidney (Hamer 1986). Mercury accumulation by pilot whales can be high enough to pose a health risk to human inhabitants of the Faroe Islands (Andersen et al. 1987), and seal meat has been found to contain high levels of mercury (Botta et al. 1983). The potential for chromosome mutagenicity was high in Greenlandic Eskimos with a high proportion of seal meat in their diets, and seal meat consumption was positively correlated with human blood concentrations of mercury and cadmium (Wulf et al. 1986).

The body burden of metals in birds and animals from areas remote from major human activity (the Antarctic and the Canadian Arctic) is relatively high (Steinhagen-Schneider 1986, Easton and Farant 1982). The increases in metal body burdens of animals consumed by humans that are attributable to drilling fluid discharges are expected to be minor, because drilling fluid discharges are periodic and of small volume. However, incrementally small additions of heavy metals from diverse sources do increase the potential for bioaccumulation of metals through the food chain. Metal content of drilling fluids should, therefore, be minimized (USEPA 1994).

On the basis of qualitative comparisons made between Cook Inlet fish contaminant concentrations and Columbia River or FDA market basket sample results (USEPA 2002; USFDA 2000; USFDA 2003, as cited in USEPA Region 10 2003) in EPA's *Survey of Chemical Contaminants in Fish, Invertebrates and Plants Collected in the Vicinity of Tyonek, Seldovia, Port Graham, and Nanwalek—Cook Inlet, AK* (USEPA Region 10 2003), organochlorine pesticide (dieldrin, DDT, chlordane) and PAH concentrations were greater in either or both Columbia River or FDA market basket samples than in Cook Inlet fish samples. Mercury concentrations were also greater in most Columbia River or FDA market basket samples except for Cook Inlet chinook and sea bass samples, which had concentrations similar to or between the concentrations detected in Columbia River and the FDA market basket study. Cadmium concentrations were detected at levels less than 30 ppm, which is the high end of the Agency for Toxic Substances and Disease Registry (ATSDR) range of cadmium concentrations detected in edible meat or marine shellfish (ATSDR 1999, as cited by USEPA Region 10 2003). Hexachorobenzene was one contaminant that was detected in Cook Inlet chinook and sockeye samples in greater concentrations than those detected in Columbia River. Overall, with the exception of hexachlorobenzene concentrations in Cook Inlet chinook and sockeye samples, contaminants detected in Cook Inlet fish were less than or comparable to contaminants detected in regional or national studies.

5.3 PHYSICAL EFFECTS OF DISCHARGE

Sanitary effluent from exploration, development, and production facilities must meet the effluent limitations for TSS (30 to 56 mg/L, depending on the treatment unit used) required in the proposed NPDES general permit.

Excess cement slurry may contain up to 200,000 mg/L of TSS (daily maximum). However, because this wastestream is intermittent and the volume is small (about 4,200 gallons per event), it is not predicted to cause adverse impacts to marine organisms (SAIC 2001).

Estimates of the annual suspended solids discharged from the municipalities (2.03 thousand tonnes), refinery (0.03 thousand tonnes), and drilling fluids and cuttings (0.93 thousand tonnes) in Cook Inlet are only a fraction of the suspended sediments (36,343 thousand tonnes) discharged by the Knik, Matanuska, and Susitna Rivers (Table 5). Estimates of the annual discharge of biochemical oxygen demand or organic wastes from municipalities (4.27 thousand tonnes), seafood processors (2.52-8.58 thousand tonnes), and produced waters (3.67 thousand tonnes) are all about the same order of magnitude (MMS 2003).

Table 5. Estimates of Selected River and Point Source Discharges into Cook Inlet for 1 Year

Discharge Source	Total discharges (million cubic meters)	Suspended sediments (tonnes)	BOD or organic wastes (tonnes)	Oil and grease (tonnes)	Settleable solids (tonnes)
Rivers	70,100	36,343,000	---	---	---
Knick, Matanuska, Susitna (Gold Creek)	54,820				
Susitna River (Gold Creek) (Minimum) (Maximum)	8,900 (5,000) (11,630)	3,370			
Ninilchik	1,080				
Municipalities					
Permitted discharge rates-MAL	67.6	6,264	7,443		
Anchorage-Point Woronzof-MAL	60.8	6,078	7,294		---

Table 5. Estimates of Selected River and Point Source Discharges into Cook Inlet for 1 Year (Continued)

Discharge Source	Total discharges (million cubic meters)	Suspended sediments (tonnes)	BOD or organic wastes (tonnes)	Oil and grease (tonnes)	Settleable solids (tonnes)
Anchorage-Point Woronzof-1993	41.4	2,032	4,268	889	
Seafood processing	---	---	2,520-8,580	---	---
Produced Waters	7.36	---	3,670	250	---
Drilling fluids and cuttings (11 wells/year)	---	930	---	---	8,351
Refinery	---	30	30	---	---

BOD = Biochemical oxygen demand; MAL = monthly average limitation.
Source: MMS 2003

Dilution rates as high as 1,000,000:1 may occur for drilling solids within a distance of 200 meters (0.13 square kilometers) of a platform with surface currents of 30-35 centimeters per second (about 0.6–0.7 knots) (National Research Council 1983). Tidal currents in lower Cook Inlet may have velocities of 102–153 centimeters per second (about 2–3 knots), or more. The currents associated with the Cook Inlet circulation regime, especially the strong tidal currents and the morphometry of the inlet produce considerable crosscurrents and turbulence in the water column during both ebb and flood tides. The cumulative effects of hydrodynamic processes suggest the water column in lower Cook Inlet generally is vertically well mixed. The similarities between the respective suspended particulate matter concentrations, salinities, and temperatures at the surface and near the bottom suggest not only vertical mixing but also show the cross-channel gradients that exist in the water column. These gradients indicate that dilution, rather than deposition, is the major process controlling suspended particulate matter concentrations in the central part of the inlet (MMS 2003).

Only part of the solids in the drilling fluids and cuttings discharged into Cook Inlet may accumulate on the seafloor near the discharge. The bottom currents in lower Cook Inlet are strong enough to prevent the deposition of sand-size and smaller particles (Sharma 1979; Hampton 1982). Regional sediments indicate sorting by present-day transporting currents (Hampton, et al. 1981). Silts and muds are moved southward to outermost Cook Inlet and Shelikof Strait (Sharma and Burrell 1970; Carlson et al. 1977; Hampton 1982; Boehm 2001).

The flow of Cook Inlet water generally is to the southwest. Discharged substances that are dissolved or remain in suspension generally would be transported out of Cook Inlet and into the Gulf of Alaska within about 10 months (Kinney et al. 1969, 1970). The density of any drilling fluids discharged into Cook Inlet should range within 1,000–2,000 parts per thousand wet weight. This is a typical density range for used drilling fluid. For example, Adams (1985) stated a range between 1,080 and 1,800 ppt and the National Research Council (1983) a range (for OCS wells) of 1,190–2,090 ppt (MMS 2003).

With a dilution rate of 10,000:1, the concentration of drilling fluid initially would be reduced to 0.10–0.20 ppt (100–200 ppm) within 100 meters of the discharge site; a dilution rate of 1,000,000:1 would reduce the concentrations to 0.001–0.002 ppt (1–2 ppm) within 200 meters of the discharge site. Rapid settling of the heavier particles would result in greater reductions in the concentrations of the drilling fluids inside 100–200 meters from discharge than were estimated by using only the dilution factors. The concentration of suspended particulate matter in the water column of lower Cook Inlet ranges from 1–50 ppm. Thus, within about 100–200 meters of the discharge site, the concentration of particulate matter in the fluids and cuttings discharged into the water column is expected to be reduced to levels comparable to the levels of naturally occurring suspended-particulate matter (MMS 2003).

Therefore, no physical effects of the discharges from exploration, development, and production facilities are predicted.

5.4 SUMMARY

5.4.1 Lower Trophic Level Organisms

Routine, anticipated activities during exploration, development, and production in Cook Inlet probably would not have measurable effects on local populations of lower trophic-level organisms (MMS 2003).

During the hypothetical 5-year term covered under the proposed NPDES general permit, 11 wells would be drilled each year in Cook Inlet. Permitted discharges would include an estimated 3,690 tonnes (metric dry weight) of drilling fluids, 5,590 tonnes of drill cuttings, and 930 tonnes (metric dry weight) of suspended solids during a 5-year period. In Section 5.3 of this ODCE, it is noted that these amounts of material are a fraction of the particulate matter that rivers discharge daily into Cook Inlet. Discharges would become diluted rapidly as high as 1,000,000:1 with a distance of 200 meters (656 feet) of a platform, and there would be no effect on planktonic organisms, such as shrimp (National Research Council 1983). The drilling fluids and cuttings that accumulate on the seafloor in relatively shallow water might affect some benthic organisms for a short period close to the discharge point (MMS 1995). This assessment confirms the conclusion of the previous one that the effect probably would be sublethal for adults and might be lethal for immature stages within 1,000 meters of platforms that were actively discharging (i.e., for a few months or about a generation for typical benthic organisms) drilling fluids and cuttings. This assessment also confirms the conclusion in the water quality section that mixing in the water column would reduce the toxicity of drilling fluids to levels that would not be harmful to organisms in the water column. If drilling fluids and cuttings were not discharged during exploration, this local effect would not occur (MMS 2003).

In summary, the routine activities associated with exploration in upper Cook Inlet have not had a documented effect on lower trophic-level organisms. It is expected that the routine activities associated with exploration, development, and production would be similar, and no measurable effects on the local populations are expected from these routine activities (MMS 2003).

5.4.2 Fish

Fisheries resources (i.e., pelagic finfish, ground finfish, and shellfish) in the lower Cook Inlet area are described in Section 6. MMS performed an analysis on population-level impacts; its definition of a population is defined as a group of organisms of one species occupying a defined area (the central Gulf of Alaska encompassing the South Alaskan Peninsula, Kodiak Archipelago, Shelikof Strait, Cook Inlet, and Prince William Sound) and usually isolated to some degree from other similar groups. Routine activities associated with this alternative that may adversely affect fisheries resources include permitted drilling discharges. It is not expected that the various effects to fisheries resources, taken altogether, would cause population-level changes in the central Gulf of Alaska (MMS 2003).

The effects of exploration- and production-related activities on fisheries resources are expected to be essentially the same. Although there may be minor differences in the frequency or type of activities between exploration and production, those differences would not make a measurable difference on fisheries resources (MMS 2003).

5.4.3 Marine Birds

Platform discharges are not expected to have an effect on marine and coastal birds because of the high degree of dilution that would occur and the fact that bioaccumulation of associated pollutants is not expected (SAIC 2000).

5.4.3.1 Effects from Exploration

Routine operations associated with exploration that may have an effect on marine and coastal birds include well abandonment. Well abandonment could harm seabirds under certain circumstances. As part of the delineation well abandonment, the casings for these wells may be cut either mechanically or with explosives. The use of explosives raises the possibility of impacts to seabirds. Although no injuries to seabirds from well abandonment with explosives have been reported, brown pelicans, cormorants, gulls, and phalaropes have been killed or injured due to other sources of underwater explosions (Fitch and Young 1948). To be killed or injured during well abandonment with explosives, a bird would have to be submerged at the moment of the explosion. Although safety information is not available for birds, research on fish (Goertner 1981) and marine mammals (Young 1991) indicates that, for the amount of explosives used in well abandonment, a safe distance for these animals ranges from about 305–610 meters (1,000–2,000 feet), depending on the species. However, explosive charges probably would be set several feet below the seafloor, which would dampen the effect of the blast and reduce the area in which birds could be killed or injured. Because of the water depth of the wells and the damping effect of the position of the charges below the seafloor, a bird probably would have to be submerged directly above the well to be injured during well abandonment. The seabirds that might be injured are those that forage underwater. These include loons, shearwaters, scoters, and alcids. Many of these species remain relatively close to shore and would not be affected. Gulls might be attracted to the area by the dead fish that result from underwater explosions, but gulls feed on the surface and would not be affected. On the basis of the damping effect of the explosions being below the sea floor and the very low probability that seabirds would be both submerged at the moment of an explosion and in close enough proximity to be killed or injured, no impacts to marine and coastal birds from well abandonment would be expected (MMS 2003).

5.4.3.2 Effects from Development and Production

Routine operations associated with development and production that may have an effect on marine and coastal birds include: platform construction and operation and pipeline construction. However, most of these activities, including the vast majority of pipeline construction, will be conducted either well away (at least 5 kilometers [3 miles]) from any seabird colony or in ports where, at most, there are only a few nesting birds. These activities also can disturb birds at sea, but these effects would be limited to the immediate vicinity of the disturbance and would be very short in duration (for example, a few days to a few weeks).

Turbidity and disturbance of prey organisms in shallow nearshore waters from pipeline construction could have temporary effects on the availability of food sources of some sea ducks. This would be limited to the relatively small number of birds that forage along the shallow, nearshore portion of the pipeline corridor and would be short (i.e., one season) in duration. The greatest potential for impacts to birds would be at the site of the pipeline landfall. Impacts due to the construction of the pipeline landfall could include the temporary displacement of feeding and roosting birds from the immediate vicinity of the construction site. Impacts to nesting birds would be more severe and could include nest desertion, nest failure, lowered reproductive success, and reduced chick growth rates. These impacts likely would affect only birds nesting near (within .4 kilometer [one-quarter mile]) the construction site and would be short in nature (one season) (MMS 2003). A few birds nesting within .4 kilometer [one-quarter mile] of pipeline-landfall construction sites could suffer impacts during one breeding season (MMS 2003).

5.4.4 Marine Mammals

Seven species of nonendangered marine mammals numbering in the hundreds to thousands commonly occur year-round or seasonally in a portion of or throughout the Cook Inlet Planning Area and could be exposed to some OCS exploration, development, and production activities in Cook Inlet. These include the harbor seals and northern fur seals; Southcentral Alaska sea otters; killer, minke, and gray whales; and Dall's and harbor porpoises. Pollution and alteration of habitats could adversely affect these marine mammals found within Cook Inlet.

In the subsections below, it should be noted that the term *regional population or population within the region* is defined as the number of animals of a species that occur seasonally or year-round within the Cook Inlet Planning Area. A portion of a population in the region, for example, would be the number of harbor seals occurring in Kamishak Bay during the spring-summer breeding and molting periods (MMS 2003).

5.4.4.1 Effects From Exploration

Effects to nonendangered marine mammals would result from routine operations. The effects of exploration would occur primarily from routine operations (MMS 2003).

5.4.4.2 Effects of Development and Production

The effects of routine operations are expected to occur if the proposed leasing occurs and results in exploration, development, and production activities. Routine operations that may affect nonendangered marine mammals include disturbances from pipelines (MMS 2003).

If one 40-kilometer (25-mile) long gas offshore pipelines is laid per year in Cook Inlet, from the assumed one production platform in Cook Inlet during that time, this activity likely would alter a few square miles of benthic habitat very near, or within 1.6 or 3.2 kilometers (1 or 2 miles), of the pipelaying operation due to turbidity and removal of some prey organisms along the pipeline route. This would represent a short-term (one season) effect. The development of a pipeline terminal site might displace a small number (probably fewer than 10) of harbor seals near the site but would have no measurable effect on local populations (MMS 2003).

5.4.4.3 Effectiveness of Mitigating Measures

The stipulation on Protection of Biological Resources primarily concerns protection of benthic habitats that may be buried or covered by drill-platform installation. The amount of benthic habitats (probability 1 square kilometer or 0.386 square mile) is not expected to be of consequence to most nonendangered marine mammal populations, with the possible exception of gray whales that may feed in the area; thus, this stipulation is not expected to provide much protection to nonendangered marine mammals (MMS 2003).

5.4.5 Human Health

Increases in metal body burdens of animals consumed by humans that are attributable to drilling fluid discharges are expected to be minor. The proposed NPDES general permit will ensure increased compliance with produced water oil and grease ELG limits through the new produced water sheen monitoring requirement and it does not authorize new development or production facilities to discharge produced water. Also most contaminants detected in Cook Inlet fish are less than or comparable to contaminants detected in regional or national studies. Because of these reasons above and because additional permitted discharges from the existing and new platforms are minimally toxic, adverse human health effects are unlikely to result from Cook Inlet exploration and production discharges. Metal content of drilling fluids should be minimized through adherence to the effluent limitations in the proposed NPDES general permit to decrease the amount of heavy metals discharged to Cook Inlet (Tetra Tech 2005b).