8. FISH HABITAT OFFSETTING PLAN

8.1. LNG Canada's Approach

The goal of LNG Canada's offsetting strategy is to balance project effects to fish and fish habitat through implementation of offsetting measures that will benefit commercial, recreational, and Aboriginal fishery species in the Kitimat River estuary and Kitimat Arm.

The proposed offsets for *serious harm to fish* from construction of the marine terminal were selected based on the following prioritization (in order of highest to lowest):

1. In-kind habitat in the immediate vicinity of affected habitats, benefiting the affected fish species and life stages
2. Out-of-kind habitat in the immediate vicinity of affected habitats, benefiting the affected fish species and life stages
3. In-kind habitat in the same watershed or waterbody as affected habitats (i.e., Kitimat River system, Kitimat Arm), benefiting the affected species and life stages

To identify fisheries management objectives and local restoration priorities, LNG Canada has worked with Haisla Nation and key stakeholders to discuss offsetting opportunities, reviewed the habitat restoration priorities identified by Haisla Nation in the lower Kitimat River and estuary, and reviewed fisheries management objectives identified in DFO's Integrated Fisheries Management Plans. This offsetting plan will provide long term benefits to affected CRA fishery species and includes measures to address any time lags or uncertainty associated with the effectiveness of the offsets. Habitat effectiveness monitoring will allow LNG Canada to monitor the long-term effectiveness of offsetting measures and to determine whether contingency measures should be implemented.

The offsetting measures presented in this plan are the result of a detailed evaluation of marine and estuarine offsetting options, as well as discussions with Haisla Nation. Throughout 2014 and 2015, biologists and other scientists have conducted site visits, desktop and field studies to assess the feasibility of the various offsetting options. Through this process, a number of offsetting options were determined to be not feasible and were removed from the plan due to land ownership and various biophysical factors (e.g., existing fish habitat, limited access and other constraints). As a result, the proposed offsetting measures described in this plan represent the best available options for offsetting residual *serious harm to fish* from the Project and for supporting the sustainability and ongoing productivity of affected CRA fisheries in the Kitimat region.

8.2. Consideration of Local Restoration Priorities and Fisheries Management Objectives

Development of LNG Canada's fish habitat offsetting plan considered local restoration priorities identified during the Lower Kitimat River and Estuary Watershed Planning Meeting in January 2013, and fisheries management objectives identified in DFO policy documents and Integrated Fisheries Management Plans, including:

- DFO's national fisheries management objectives
- Canada's Policy for Conservation of Wild Pacific Salmon
- DFO's Salmon Northern BC Integrated Fisheries Management Plan
- DFO's Pacific Herring Integrated Fisheries Management Plan
- DFO's Groundfish Integrated Fisheries Management Plan
- DFO's Intertidal Clams Integrated Fisheries Management Plan
- DFO's Prawn and Shrimp by Trap Integrated Fisheries Management Plan
- DFO' Crab by Trap Integrated Fisheries Management Plan

LNG Canada carefully considered the habitat restoration priorities identified by Haisla Nation in 2013 (Lower Kitimat River Watershed Planning Meeting Minutes 2013). As outlined in Section 3, LNG Canada met with representatives from Haisla Nation during development of this fish habitat offsetting plan to discuss potential offsetting measures. Input and feedback from Haisla Nation on habitat enhancement and creation priorities was a key consideration in the development of the offsetting plan.

A description of how LNG Canada considered local restoration priorities and fisheries management objectives is provided in Table 8-1.

Table 8-1 Consideration of Applicable Local Restoration Priorities and Fisheries Management Objectives

Fisheries Management Objectives	Consideration
Lower Kitimat River and Estuary Watershed Priorities[a]	
Minette Bay fish habitat enhancement	Haisla Nation identified Minette Bay as a priority site for fish habitat enhancement (Priority Project No. 11) because of its importance to salmon, and this was a key consideration in the selection of Minette Bay as the site for habitat creation and enhancement for LNG Canada's fish habitat offsetting plan.
DFO National[b]	
Meet conservation objectives and ensure healthy and productive fisheries and ecosystems.	Throughout Project construction, LNG Canada will implement measures to avoid and reduce effects to fish and fish habitat, and maintain the health and productivity of the Kitimat River estuary. LNG Canada's fish habitat offsetting plan will provide long-term benefits the local ecosystem and fisheries by providing high quality habitat that supports life processes of salmon, herring, flatfish, and Dungeness crabs.
Base management decisions on the best available scientific information.	The information used to support this application for a *Fisheries Act* authorization is based on the best available scientific information, including baseline data collected by LNG Canada and the results of published scientific studies by Fisheries and Oceans Canada, environmental consultants, and academics.
Work collaboratively with commercial and recreational sectors to provide fishing opportunities in a manner that ensures the long term sustainability of the resource.	Potential Project effects to commercial and recreational fisheries have been a key consideration throughout the Project's environmental assessment process. As outlined in the Environmental Assessment Application, LNG Canada is proposing mitigation measures to reduce Project effects to commercial and recreational fisheries.
Provide stability and predictability in fisheries management and improved governance through an open and transparent consultation process.	LNG Canada has consulted Haisla Nation and local stakeholders throughout the Project planning and environmental assessment process, and during the development of the fish habitat offsetting plan.
Foster shared stewardship.	Members of Haisla Nation have been key participants in field studies to characterize fish and fish habitats at the marine terminal and habitat offsetting sites. LNG Canada has engaged Haisla Nation throughout the environmental assessment process and development of the fish habitat offsetting plan. Fish habitat restoration priorities identified by Haisla Nation during the Lower Kitimat River and Estuary Watershed Planning Meeting in January 2013 were a key consideration in the development of LNG Canada's fish habitat offsetting plan.
Canada's Policy for the Conservation of Wild Pacific Salmon[c]	
Maintain habitat and ecosystem integrity	LNG Canada's fish habitat offsetting plan will fully offset Project effects and maintain local habitat and ecosystem integrity by providing productive foraging and rearing habitat for species that support CRA fisheries.

Fisheries Management Objectives	Consideration
Salmon Northern BC Integrated Fisheries Management Plan[d]	
North coast chum – Rebuild weak wild runs, while providing opportunities to harvest surplus stocks.	The only directed chum fishery in Fisheries Management Area 6 is for hatchery stock returning to the Kitimat River Hatchery. LNG Canada's fish habitat offsetting plan will provide productive foraging and rearing habitat for juvenile chum salmon.
Pacific Herring Integrated Fisheries Management Plan[b]	
Ecosystem Processes Conservation and protection of Pacific herring stocks, their habitat, and management of ecosystem impacts of fish harvest activities will be ensured through the application of scientific management principles applied in a risk averse and precautionary manner based on the best scientific advice available, and through comprehensive monitoring of fish harvest activities.	The design and location of the salt marsh and rock reef habitats that are the basis of LNG Canada's fish habitat offsetting plan considered scientific information about preferred herring spawning substrate and spawning locations in the Kitimat River estuary. These offsets will provide productive foraging and rearing habitat for juvenile herring, and quality spawning substrate for adult herring.
Invertebrate Resource Management[e,f,g]	
To ensure conservation and protection of invertebrate stocks and their habitat through the application of scientific management principles applied in a risk averse and precautionary manner based on the best scientific advice available.	LNG Canada conducted field surveys and a thorough review of scientific literature to characterize invertebrate habitat and life processes occurring in the Project area. LNG Canada used this scientific information to develop mitigation measures to reduce Project effects to invertebrate habitat, and maintain incidental mortality to invertebrates from Project activities to a level that will not affect the sustainability or ongoing productivity of local invertebrate fisheries. Habitat creation projects associated with LNG Canada's fish habitat offsetting plan are located in habitats where shrimp and Dungeness crab are unlikely to be affected, and bivalve shellfish harvesting is prohibited.

NOTES:

[a] Lower Kitimat River and Estuary Watershed Planning Meeting minutes. January 2013. Haisla Nation and Fisheries and Oceans Canada. Canada-BC Watershed Planning Fund. Unpublished.

[b] Fisheries and Oceans Canada. 2014. Pacific Region Integrated Fisheries Management Plan, Pacific Herring November 7, 2014 to November 6, 2015. Fisheries Management Branch, Fisheries and Oceans Canada. 152 pp.

[c] Fisheries and Oceans Canada. 2005. Canada's Policy for Conservation of Wild Pacific Salmon. Fisheries and Oceans Canada. Vancouver, BC.

[d] Fisheries and Oceans Canada. 2014. Pacific Integrated Fisheries Management Plan, Salmon Northern BC June 1, 2014 to May 31, 2015. Fisheries Management Branch, Fisheries and Oceans Canada. 154 pp.

[e] Fisheries and Oceans Canada. 2013. Pacific Region Integrated Fisheries Management Plan, Intertidal Clams January 1, 2013 to December 31, 2015. Fisheries Management Branch, Fisheries and Oceans Canada. 35 pp.

[f] Fisheries and Oceans Canada. 2015. Pacific Region Integrated Fisheries Management Plan, Prawn and Shrimp by Trap May 1, 2015 to April 30, 2016. Fisheries Management Branch, Fisheries and Oceans Canada. 44 pp.

[g] DFO. 2015. Integrated Fisheries Management Plan Summary - Crab by Trap Pacific Region - January 1 to December 31, 2015. Fisheries Management Branch, Fisheries and Oceans Canada. 45 pp.

8.3. Offsetting Strategy

LNG Canada is proposing to offset all residual *serious harm to fish* from the marine terminal that will result in a localized effect to fish populations (Table 7-2). The following sections describe proposed offsetting measures.

8.3.1. Creation of Salt Marsh and Rock Reef Habitat

The creation of salt marsh habitat and rock reef habitat in the Kitimat River estuary is the recommended measure to offset residual *serious harm to fish* from the marine terminal. Creating salt marsh and rock reef habitat aligns with DFO's offsetting objectives and priorities because it represents the creation of highly productive habitats in the immediate vicinity of the affected habitats, and it will provide direct benefits to affected CRA fish populations over the long-term.

LNG Canada is proposing to create salt marsh habitat and rock reef habitat at two sites in Minette Bay (Minette Bay North and Minette Bay South), and has identified an alternative site at the mouth of Wathl Creek near Kitamaat Village (Figure 8-1). The alternative site near Kitamaat Village will only be considered as a contingency measure in the event that LNG Canada's fish habitat offsetting objectives cannot be achieved in Minette Bay. The total area of habitat created to offset *serious harm for fish* from the marine terminal will be 184,558 m^2 in Minette Bay, consisting of 171,858 m^2 of salt marsh habitat and 12,700 m^2 of shallow subtidal and intertidal rock reef habitat.

8.3.1.1. Environmental Background

Minette Bay is located at the head of Kitimat Arm in Douglas Channel. The bay is located in the eastern part of the Kitimat River estuary, and extends northeast from the river delta. Minette Bay is bowl-shaped with a maximum depth of approximately 32 m in the middle (Cottrell and Hall 1981; Stantec 2015a). The entrance to the bay is shallow and enables only limited vessel access from Kitimat Arm except during high tides. During extreme low tides, the entrance to the bay can dry out completely (Stucchi and Juhasz 1997). There is a shallow, gently sloping foreshore on the west and north sides with extensive mudflats interspersed with beds of silts, sands, and gravels and a steep, forested slope on the east side of the bay (Cottrell and Hall 1981; Stantec 2015a). The southwestern shore is a deltaic mud flat (Cottrell and Hall 1981). The seabed consists of mud and silt substrates with abundant submerged woody debris (Stantec 2015a).

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APPLICATION FOR PARAGRAPH 35(2)(B) FISHERIES ACT AUTHORIZATION FOR MARINE TERMINAL

LOCATION OF PROPOSED SALT MARSH BENCHES

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
16-JUN-15	8-1

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Minette Bay is characterized by high turbidity, low dissolved oxygen levels in bottom waters, low salinity surface waters, and limited mixing at depth. Freshwater influence in Minette Bay includes a surface layer from Kitimat River and input from seven smaller streams along the shores of the bay (Cottrell and Hall 1981). This results in a low salinity surface layer extending to depths of 2 m to 10 m during periods of high stream flow (Levings 1976; Cottrell and Hall 1981). Below this layer, salinity levels are typical of marine waters (Cottrell and Hall 1981).

Intertidal areas are characterized by salt marsh, predominantly sedge (*Carex lyngbyei*), along the western and northern shores of the bay; and rockweed (*Fucus* spp.) growing on scattered gravel and woody debris (Paish 1974; Cottrell and Hall 1981). There is relatively low marine invertebrate diversity in Minette Bay, which is most likely a result of the large freshwater input into the bay (Levings 1976; Cottrell and Hall 1981). Soft-shell clams, saltwater clams, blue mussels, isopods, and amphipods are the most common species living among the intertidal mudflat and salt marsh habitats in the bay (Stantec 2015a).

Minette Bay is used extensively by juvenile chum, chinook, and coho salmon from April through August (Paish 1974; Birch et al. 1981; Slaney et al. 1982; Orr 1985; Cambria Gordon 2009). These fish are likely downstream migrants from the Kitimat River and its tributaries, and from the three creeks used by coho and pink salmon for spawning that flow into the bay: Pine Creek, Cordella Creek, and Minette Bay Creek (MOE 2014). Fish sampling programs in the Kitimat River estuary has found that juvenile salmon are more abundant in the vegetated intertidal areas of Minette Bay and the central estuary, than in the unvegetated areas of the central and western estuary (Paish 1974; Orr 1985). This is explained by the close association between two benthic invertebrates (*Anisogammarus* sp., *G. oregonensis*) and sedge and rockweed habitats (Paish 1974; Higgins and Schmidt 1975; Orr 1985). These invertebrates serve as the primary food source for juvenile salmon in the Kitimat River estuary. Herring spawn abundance in Minette Bay has been characterized as “heavy”, compared to “light” in other areas of the estuary (Paish 1974). Other fish species that are known to occur in Minette Bay include shiner surfperch, Pacific staghorn sculpin, and starry flounder (Cambria Gordon 2009).

8.3.1.2. Habitat Function and Benefits to Fish

Salt marshes are among the most highly productive fish habitats. In these habitats, nutrient-rich detritus produced by terrestrial and aquatic plant communities sustain diverse communities of vegetation and benthic invertebrates (Figure 8-2). Salt marshes provide direct benefits to CRA fishery species (including salmon and herring) by providing opportunities for rearing, foraging, growth, refuge from predators, and salinity acclimation (Figure 8-2; Higley and Holton 1981; Miller and Simenstad 1994, 1997; Bottom et al. 2005). In the salt marshes of the Kitimat River estuary, benthic invertebrates such as amphipods and isopods live among beds of algae (*Fucus* sp.) and sedge (*Carex lyngbyei*) (Levings 1976; Bell and Kallman 1976; Cottrell and Hall 1981; Stantec 2014). These invertebrates serve as an important food source for a variety of CRA fishery species including juvenile chinook, chum, and coho salmon, Dungeness crab, cod, and flounder (Grosse et al. 1986; Quinn 2005; Love 2011). Paish (1974) analyzed stomach contents of juvenile salmon in the Kitimat River estuary and found amphipods and isopods to be the principal food item of juvenile salmon.

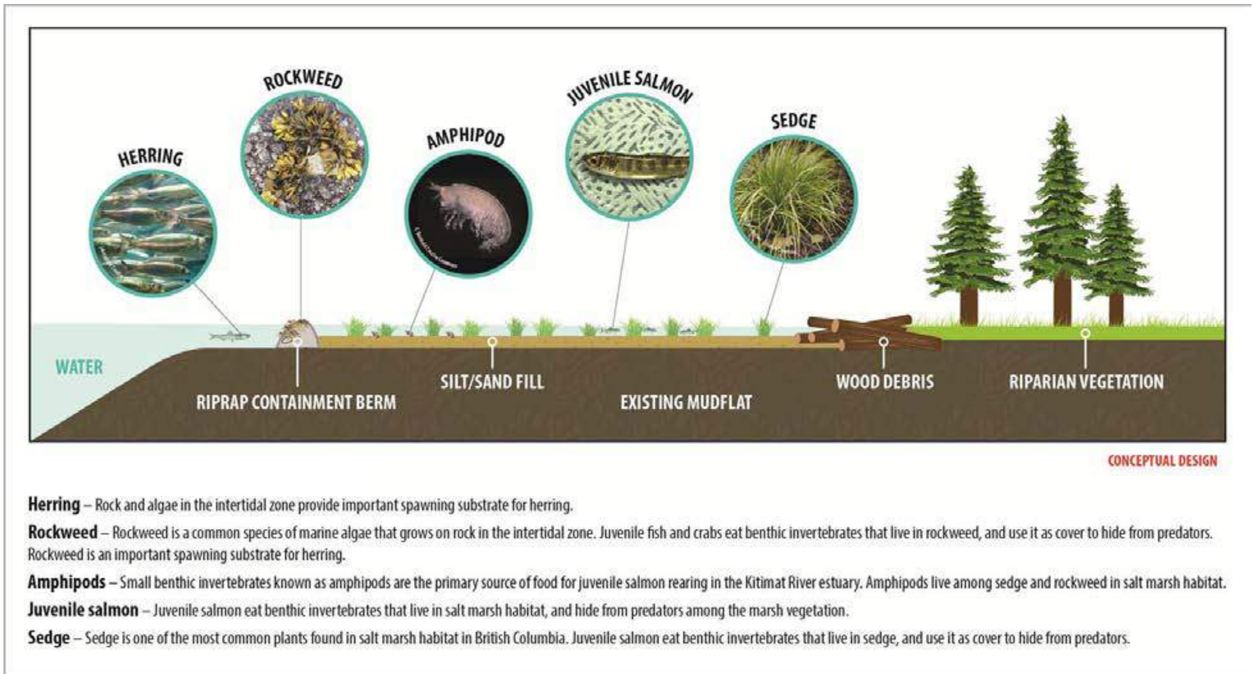

Figure 8-2 Benefits to CRA Fishery Species from Salt Marsh Habitat

The rock berms surrounding the perimeter of the salt marsh benches will be designed to function as rock reefs, providing additional benefits to CRA fishery species. Rock reefs provide fish with structural habitat and interstitial spaces for refuge and spawning, and provide invertebrates and algae with substrate for attachment (Beauchamp et al. 1994; Pondella et al. 2002; Gratwicke and Speight 2005; Toft et al. 2007; Pister 2009). These habitats attract and support a variety of marine fish species and serve as good sport fishing sites (Ambrose and Swarbrick 1989; Pister 2009). Commercial, recreational and Aboriginal fishery species that are expected to use and benefit from intertidal rock reefs in the Kitimat River estuary include juvenile salmon, surfperch, herring, and Dungeness crab (Cottrell and Hall 1981; Buckley and Hueckel 1985; Hueckel et al. 1989; Pister 2009). In the Kitimat River estuary, shallow subtidal and intertidal rocky habitats are typically colonized by benthic invertebrates and algae including rockweed, barnacles, mussels, amphipods, and isopods (Levings 1976; Bell and Kallmman 1976; Cottrell and Hall 1981; Stantec 2014).

Recent fish sampling and habitat surveys have been conducted at the marine terminal and at the proposed offsetting sites in Minette Bay (Cambria Gordon 2009; Stantec 2014; Triton 2014; Stantec 2015b). The key CRA fishery species, support fish, and biogenic habitats that occur in the Eurocan Basin also occur in Minette Bay (Table 8-2), and the offsetting habitats will provide benefits to the same fish species that are affected by the marine terminal.

Table 8-2 Key CRA Fishery Species, Support Fish, and Biogenic Habitats at the Eurocan Basin Impact Site and Minette Bay Offset Site

Species	Description	Eurocan Basin Impact Site				Minette Bay Offset Site			
		Fish Sampling[a]	Intertidal Habitat[b]	Subtidal Habitat[b]	Salt Marsh Habitat[b]	Fish Sampling[a]	Intertidal Habitat[c]	Subtidal Habitat[c]	Salt Marsh Habitat[c]
Lyngbye's sedge *Carex lyngbyei*	Plant – biogenic habitat		✓		✓		✓		✓
Rockweed *Fucus* spp.	Algae – biogenic habitat		✓	✓	✓		✓	✓	✓
Eelgrass *Zostera marina*	Seagrass – biogenic habitat		✓						
Clam Bivalvia	Invertebrate – CRA fishery species		✓				✓		
Amphipod spp.	Invertebrate – food supply		✓		✓		✓		✓
Stubby isopod *G. oregonensis*	Invertebrate – food supply		✓		✓		✓		✓
Chinook salmon *Oncorhynchus tshawytscha*	Fish – CRA fishery species	✓				✓			
Chum salmon *Oncorhynchus keta*	Fish – CRA fishery species	✓				✓			
Coho salmon *Oncorhynchus kisutch*	Fish – CRA fishery species	✓				✓			
Sockeye salmon *Oncorhynchus nerka*	Fish – CRA fishery species	✓							
Pink salmon *Oncorhynchus gorbuscha*	Fish – CRA fishery species	✓				✓			
Starry flounder *Platichthys stellatus*	Fish – CRA fishery species	✓		✓		✓		✓	

Species	Description	Eurocan Basin Impact Site				Minette Bay Offset Site			
		Fish Sampling[a]	Intertidal Habitat[b]	Subtidal Habitat[b]	Salt Marsh Habitat[b]	Fish Sampling[a]	Intertidal Habitat[c]	Subtidal Habitat[c]	Salt Marsh Habitat[c]
Pandalid shrimp	Invertebrate – CRA fishery species			✓				✓	
Dungeness crab *Cancer magister*	Invertebrate – CRA fishery species			✓				✓	

SOURCES:

[a] Cambria Gordon (2009); Triton (2014)

[b] Stantec (2014)

[c] Stantec (2015a)

8.3.1.3. Design

Design drawings and engineering specifications for each of the salt marsh benches are provided in the Marine Terminal Fish Habitat Offsetting Design Report (Appendix 5). The designs are based on an established method for creating salt marsh habitat which involves raising the elevation of intertidal and shallow subtidal tidal flats to extend existing marsh habitat seaward (Envirowest 1990; Stevens and Vanbianchi 1993; Adam and Williams 2004). This method involves placing a rock berm on the mudflat along the seaward edge of the site to provide protection and stability for the marsh. At the Minette Bay North site, additional rock will be placed in the intertidal and shallow subtidal zone in front of the berm to provide more rock reef habitat. The area landward of the berm is filled with fine sediment (e.g., silt, sand) to an elevation that provides the soil characteristics (i.e., salinity, moisture content) suitable for colonization by marsh vegetation. This habitat feature is known as a salt marsh bench. An existing salt marsh bench created in the Nass River estuary is shown in Photo 8-1.

Photo 8-1 Salt Marsh Bench in the Nass River Estuary

8.3.1.4. Confidence and Effectiveness

There is high confidence that the salt marsh benches will be effective because this technique has been shown to successfully increase productivity and provide direct benefits to the CRA fishery species in similar environments throughout British Columbia, including in the estuaries of the Kitimat, Skeena, Nass, Fraser, and Campbell rivers in British Columbia (Brownlee et al. 1984; Dawe et al. 2000; Adams and Williams 2004). The salt marsh habitat being lost at the marine terminal is itself created marsh that was constructed to offset effects to fish habitat from the expansion of the former Eurocan Pulp and Paper Co. terminal (Tera 1988, 1991). Studies have shown that the productivity of salmonid rearing habitat in created marshes at sites across the northeast Pacific Ocean is comparable to natural marshes (Tutty et al. 1983; Shreffler et al. 1990; Miller and Simenstad 1994, 1997).

There is also high confidence the rock reefs will provide direct benefits to CRA fishery species over the long-term because this has been demonstrated at a number of sites along the Pacific coast including Roberts Bank, Barkley Sound, Puget Sound, San Clemente, and San Diego (Gascon and Miller 1980; Buckley and Hueckel 1985; Cheney et al. 1994; Elwany et al. 2011). Studies suggest that fish species typically begin using riprap habitat for shelter, feeding, and spawning purposes immediately following implementation (Bohnsack and Sutherland 1985), so time-lag is expected to be minimal.

The sites in Minette Bay and at the mouth of Wathl Creek were selected for several reasons. First, the sites are immediately adjacent to existing salt marsh. As such, there is high confidence these areas will provide the physical and environmental conditions (e.g., nutrient regime, soil characteristics, substrate particle size, current speed, exposure, seed sources) suitable to sustain the created salt marsh habitat (Envirowest 1990; Stevens and Vanbianchi 1993; Adams and Williams 2004). Second, fish studies in Minette Bay and the eastern area of the Kitimat River estuary have shown that these areas are used extensively by juvenile chum, chinook, and coho salmon for rearing and foraging, and by herring for spawning (Paish 1974; Higgins and Schmidt 1975; Bell and Kallman 1976; Birch et al. 1981; Slaney et al. 1982; Orr 1985; Cambria Gordon 2009).

In September 2014, biologists conducted field studies to characterize existing salt marsh and intertidal mudflat habitats in Minette Bay (see Stantec 2015a in Appendix 3). The results of the study confirm that existing salt marsh habitat at the proposed offsetting sites supports intertidal vegetation and invertebrate communities that provide quality rearing and foraging habitat for affected CRA fishery species (i.e., sedge, rockweed, amphipods, isopods).

LNG Canada has undertaken a variety of site-specific investigations and modelling to inform the design specifications of the salt marshes and rock reefs including the following:

- Tide circulation modelling
- Wind climate analysis
- Wave analysis (hind-casting, run-up, and overtopping)
- Light detection and ranging (LiDAR) and bathymetric mapping
- Sediment sampling and characterization (chemical composition, particle size)
- Shallow electronic piezocone penetration test soundings to assess geotechnical properties and constraints and analysis of site stability

Using this information to inform the design of the salt marsh benches will increase confidence that they will be constructible, stable and will provide the intended ecological functions over the long-term.

Eelgrass transplanting and seeding was considered a top priority for offsetting the loss of 250 m^2 of eelgrass habitat associated with dredging in the Eurocan Basin (see Section 7.2.3; Table 7-2). LNG Canada conducted eelgrass surveys in the Project area in September 2014 to characterize the distribution and abundance of eelgrass, and to assess the potential for eelgrass transplanting as an offsetting measure (Stantec 2015b). In addition to the eelgrass identified in the Eurocan Basin, eelgrass was identified at Hospital Beach southwest of the marine terminal, at the mouth of Minette Bay, and immediately south of Kitamaat Village. None of these sites were deemed suitable for eelgrass transplant for the following reasons:

- Hospital Beach is not suitable because of its proximity to the proposed RTA Terminal A Extension Project (Worley Parsons Canada Services Ltd. 2014).
- Kitamaat Village is not suitable because the existing eelgrass at this location is subtidal, growing at water depths of 0 to -6.0 m CD; while the eelgrass in marine terminal is predominantly intertidal, growing at water depths above -2.0 m CD (Stantec 2015b). There is low confidence that eelgrass transplanted from intertidal to subtidal water depths will survive due to differences in plant morphology and the environmental conditions at each location.
- The eelgrass bed at the mouth of Minette Bay is not suitable because the spatial extent of the existing bed covers all potential transplant areas at the site, and because of the high tidal currents in this area (Photo 8-2; Stantec 2015b). There is low confidence that eelgrass transplanted from the Eurocan Basin will be able to establish here because the eelgrass is likely to be uprooted by the current before it can take hold. Transplant methods that take a portion of the sediment surrounding the roots may reduce the likelihood of uprooting by tidal currents, but are not suitable because of the historic contaminants in seabed sediments where the affected eelgrass is growing.

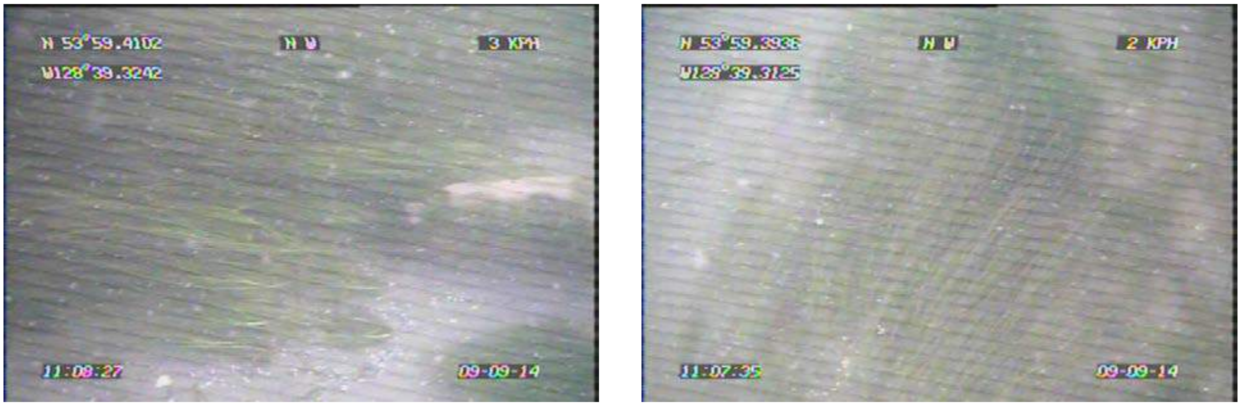

Photo 8-2 Eelgrass at the Mouth of Minette Bay Under Influence by Tidal Currents

The creation of additional salt marsh habitat in the Kitimat River estuary to offset the loss of eelgrass was determined to have a higher likelihood of success than eelgrass transplants. There is low confidence that eelgrass transplanting and/or seeding will be successful because of the uncertainty associated with the physical and environmental conditions limiting the establishment of eelgrass at potential transplanting sites.

8.3.2. Uncertainty, Time Lag, and Existing Productive Capacity at Offset Sites

LNG Canada's fish habitat offsetting plan has carefully considered uncertainty, time lag, and the existing productive capacity of habitat at the offsetting sites in Minette Bay. To reduce uncertainty, LNG Canada has conducted a variety of site-specific investigations and modelling to confirm feasibility of the offsetting habitats, inform design specifications, and confirm that the offsetting sites will provide benefits to affected CRA fishery species at the marine terminal.

To minimize time lag between the loss and alteration of habitat at the marine terminal, and benefits to CRA fisheries from creation of the salt marsh and rock reef habitat, LNG Canada will build the offsetting habitats within five years of the start of construction at the marine terminal. Wherever practicable, rock and vegetation will be salvaged from the marine terminal for use in the offsetting habitats to expedite colonization by marine species. Planting at marsh sites to encourage the expansion of vegetation cover will also help to reduce time lag.

Construction of the proposed salt marsh benches involves placement of rock riprap and soft sediment (i.e., silt, sand) on mudflats in Minette Bay. The fill material will have similar characteristics to the existing sediment and placement will not immediately change the habitat type or prevent fish or invertebrates from using the area. Over time, the site is expected to be colonized by vegetation species typical of salt marsh habitat such as Lyngbye's sedge, rockweed, rush, and grasses (Stantec 2015a). The vegetation will increase habitat complexity, diversity, and productivity in the area which will remain accessible to fish and invertebrates throughout the transition period. As a result, placement of fill is not expected to result in the permanent alteration of habitat because it will not limit or diminish the ability of fish to carry out their life processes, or result in a localized effect to fish populations. Any temporary reductions in productive capacity at the offsetting sites will be balanced by the increased productivity provided by the salt marsh and rock reefs.

8.4. Offset-Impact Ratios and Balance Sheet

The total area of residual *serious harm to fish* from the LNG Canada marine terminal to be offset in marine and estuarine environments is 153,283 m^2 (Table 7-2). The offset-impact ratios for habitat offsetting are presented in Table 8-3. These ratios are based on a consideration of the relative productivity of affected and offsetting habitats, time lag time lag between when the offset starts and the benefits begin to accrue, and uncertainty associated with the effectiveness of the offsetting measures. The type and quantity of the proposed offsetting measures are designed to balance residual *serious harm to fish* from the Project. LNG Canada is proposing an offset-impact ratio of 2:1 based on area for loss of salt marsh and eelgrass habitats, an offset-impact ratio of 1:1 for loss of constructed (rocky) intertidal habitats, and an offset-impact ratio of 0.5:1 for loss and alteration of intertidal mudflat habitat (Table 8-3).

Table 8-3 Offset-Impact Ratios

Impact Habitat	Offset Habitat	Offset-Impact Ratio (Area)	Rationale
Intertidal Mudflat	Salt Marsh	0.5:1	• High productivity of salt marsh habitat relative to mudflat habitat will offset habitat loss/alteration from marine terminal. • High confidence in effectiveness of offset habitat. Variety of site-specific investigations and modelling conducted to inform design specifications and reduce uncertainty. • Low quality of impact habitat relative to similar habitats in the Kitimat River estuary due to industrial activities.
Constructed (Rocky) Intertidal	Shallow Subtidal and Intertidal Rock Reef	1:1	• In-kind habitat offset; offset habitat has similar productivity per unit area compared to impact habitat. • High confidence in effectiveness of offset habitat. Variety of site-specific investigations and modelling conducted to inform design specifications and reduce uncertainty. • Minimal time lag associated with benefits to CRA fishery species from offset habitat.

Impact Habitat	Offset Habitat	Offset-Impact Ratio (Area)	Rationale
Eelgrass	Salt Marsh	2:1	• High productivity of salt marsh habitat and offset-impact ratio will offset habitat loss/alteration at marine terminal. • High confidence in effectiveness of offset habitat. Variety of site-specific investigations and modelling conducted to inform design specifications and reduce uncertainty. • Low confidence in effectiveness of in-kind habitat offset (i.e., eelgrass transplanting) due to lack of suitable transplant sites in Project area. • Some time lag associated with offset habitat. Time lag will be reduced by planting at marsh sites to encourage expansion of vegetation cover, and fully offset through 2:1 ratio.
Salt Marsh	Salt Marsh	2:1	• In-kind habitat offset; offset habitat has similar productivity per unit area compared to impact habitat. Offset-impact ratio will offset habitat loss/alteration at marine terminal. • High confidence in effectiveness of offset habitat. Variety of site-specific investigations and modelling conducted to inform design specifications and reduce uncertainty. • Some time lag associated with offset habitat. Time lag will be reduced by planting at marsh sites to encourage expansion of vegetation cover, and fully offset through 2:1 ratio.

Productive capacity varies between habitat types, with some habitats contributing more to fisheries productivity per unit area than others. The relative productivity of impact and offset habitats is an important consideration in the selection of the habitat type and the offset-impact ratios for balancing Project effects. One measure of the productive capacity of a habitat is the level of primary production it provides. The average annual primary production of various habitat types from scientific literature is presented in Table 8-4. Salt marsh has the highest relative productivity, followed by rocky intertidal, eelgrass, and mudflat (Williams and Associates Ltd. 2005). Increased primary production in the Kitimat River estuary is expected to translate into increased productivity for CRA fishery species. Amphipods are the primary food item of juvenile salmon in the Kitimat River estuary (Paish 1974). Amphipods live among sedge and algae that grows in rocky intertidal and salt marsh habitats, and feed on decaying plant material (Paish 1974, Levings 1976, Grosse et al. 1986, Stantec 2014). Salt marsh and rock reef habitats also have greater structural complexity compared to mudflat habitats; creating feeding opportunities for fish and invertebrates and refuge from predators.

Table 8-4 Average Annual Primary Production by Habitat Type

Habitat Type	Average Annual Production ($g\ C.m^{-2}.y^{-1}$)[a]
Mudflat	<250
Eelgrass	120-600
Rocky Intertidal	100-1000
Salt Marsh	200-3000

NOTE:
[a] Source: Williams and Associates Ltd. 2005

Loss and alteration of intertidal mudflat will be offset with salt marsh habitat at an offset-impact ratio of 0.5:1. This ratio was selected because salt marsh habitat has much greater productive capacity than mudflat habitat (see Table 8-4), provides increased food supply for CRA fishery species, and has increased structural complexity creating refuge and increased surface area. The productive capacity of the mudflat habitat in the Eurocan Basin has also been diminished from previous industrial activities and elevated levels of PAHs in the upper sediment layer (see Section 5.3.2.3). Loss of constructed intertidal habitat will be offset with shallow subtidal and intertidal rock reef habitat at an offset-impact ratio of 1:1. This ratio was selected because of the implementation of in-kind habitat offsets, minimal time lag, and the expectation that the rock reefs will provide higher quality habitat than the 4,405 m^2 of constructed intertidal habitat bordering the marsh in the Eurocan Basin, which is characterized by low invertebrate abundance and sparse algal cover (see Section 5.3.2.4). Loss of salt marsh and eelgrass habitat will be offset with salt marsh habitat at an offset-impact ratio of 2:1. This ratio was selected to account for the time lag between construction of the offsetting habitats and the full functioning of the created salt marsh and rock reef habitats.

An impact-offset balance sheet showing how residual *serious harm to fish* from the Project will be balanced by implementation of LNG Canada's fish habitat offsetting plan is provided in Table 8-5. Habitat offsets involve creation of 184,558 m^2 of habitat, consisting of 171,858 m^2 of salt marsh habitat and 12,700 m^2 of rock reef habitat (Table 8-5). All of the proposed offsetting measures for *serious harm to fish* in marine and estuarine habitats will benefit the same species and life stages that are affected by the Project, and are located in the immediate vicinity of the habitats affected by the Project (see Section 8.2.1; Table 8-1).

Table 8-5 Impact-Offset Balance Sheet

Residual *Serious Harm to Fish*	Impact Habitat Type	Impact Habitat Area (m²)	Offset-Impact Ratio	Offset Habitat Type	Offset Habitat Area (m²)
Loss of constructed intertidal from marine construction	Constructed (rocky) intertidal	12,684	1:1	Rock reef	12,700
Permanent alteration of intertidal mudflat habitat from dredging	Intertidal mudflat	46,279	0.5:1	Salt marsh	23,140
Loss of intertidal mudflat habitat from marine construction	Intertidal mudflat	26,615	0.5:1	Salt marsh	13,308
Loss of salt marsh habitat from marine construction	Salt marsh	67,455	2:1	Salt marsh	134,910
Loss of eelgrass habitat from dredging	Eelgrass	250	2:1	Salt marsh	500

8.5. Implementation and Monitoring

8.5.1. Implementation Schedule

Construction of the salt marsh benches will be completed within five years of the habitat losses associated with the marine terminal. Construction sequencing and methods are described in the Marine Terminal Fish Habitat Offsetting Design Report (Appendix 5).

8.5.2. Site Access

The salt marsh benches will be located on provincially owned aquatic Crown land. The Minette Bay North site is located on District Lot 7343 and the land immediately upland of the site is owned by Haisla Nation. The Minette Bay South site is located on unsurveyed aquatic Crown land and the land immediately upland of the site is owned by the District of Kitimat. LNG Canada will be applying for a Licence of Occupation or a Lease, and an authorization from the Government of BC under the *Land Act* to develop on these aquatic lands, and working to obtain a letter of support from Haisla Nation and District of Kitimat for construction of the salt marsh benches.

8.5.3. Avoidance and Mitigation Measures

Field studies conducted at the proposed offsetting sites (Stantec 2015a, 2015b) characterized existing fish habitat and identified biological constraints. The main biological constraints associated with salt marsh creation in Minette Bay are: the presence of rearing juvenile salmon from April through August in the bay and in the eastern estuary; the mussel bed habitat and juvenile Dungeness crabs in the channel area south of the proposed marsh creation sites in Minette Bay; and the existing salt marsh habitat in the mid to high intertidal zone above the proposed marsh creation sites.

Measures to avoid and mitigate effects on fish and fish habitat during implementation of this fish habitat offsetting plan are described below.

A qualified environmental monitor will be present during construction of the salt marsh benches to verify compliance with the terms of the *Fisheries Act* authorization and relevant environmental management plans. Monitoring information will be reported to DFO in accordance with the terms and conditions of the *Fisheries Act* authorization. If any fish mortalities are observed in the Eurocan Basin during dredging or in-water marine construction, the activity will cease until the environmental monitor can confirm that all applicable mitigation measures are employed and DFO will be notified. Activity will resume upon confirmation by the environmental monitor that appropriate mitigation measures have been put in place. If there is a need for additional avoidance and mitigation measures, these will be determined in consultation with DFO.

8.5.3.1. Site Selection

LNG Canada conducted field studies in September 2014 to characterize fish habitat in the eastern portion of the Kitimat River estuary and identify biological constraints (Stantec 2015a, 2015b). The offsetting sites were selected to avoid effects to existing eelgrass and mussel bed habitats in the Kitimat River estuary.

8.5.3.2. Timing

Placement of the rock containment berm and fill material will be conducted during a September 1 to February 15 timing window to avoid peak periods of abundance for certain species (e.g., juvenile salmon) in the project area, and periods during which sensitive life processes of fish occur (see Appendix 4). Grading and transplanting marsh vegetation at the sites may occur year-round.

8.5.3.3. Sediment Control

The need for sediment control measures will be determined based on the characteristics of the fill material and the placement methods selected by the construction contractor. Fill material consisting of a high proportion of fines (i.e., silt, clay) are more likely to disperse in marine waters during placement and grading than sand.

8.5.3.4. Equipment

Low ground pressure equipment and swamp mats will be used below the high tide mark to minimize disturbance to existing habitat and prevent stranding of equipment.

8.5.3.5. Site Access

The number and spatial extent of access corridors from upland areas to intertidal work areas will be minimized to reduce effects to existing fish habitat. The location of access corridors will be selected to minimize disturbance to sensitive habitats (e.g., existing marsh). Swamp mats or similar methods will be used to cross existing marsh vegetation within the access corridors to minimize disturbance to this habitat by equipment and foot traffic.

8.5.4. Contingency Measures

The salt marsh benches will be monitored during and after construction to determine whether performance criteria have been achieved (see Section 8.4.3). If a deficiency is identified, the first priority would be to identify their cause and develop a plan to address the issue (e.g., change methods, design modifications). If it is later determined that habitat effectiveness criteria cannot be achieved at a particular site, a new site will be selected for salt marsh creation based on a constraints analysis of alternative sites, and any associated time-lag will be offset. LNG Canada has investigated a number of alternative sites in the region that have potential to support salt marsh creation. These sites were strategically selected based on their close proximity to salmon-bearing streams so that the created marsh will contribute to the productivity of CRA fisheries. The preferred alternative site is located at the mouth of Wathl Creek near Kitamaat Village (Figure 8-1).

8.5.5. Monitoring and Reporting

Implementation of the marine terminal fish habitat offsetting plan will be accompanied by a monitoring program with a twofold focus: 1) compliance monitoring to ensure offsetting measures are constructed according to final design specifications; and 2) at least five years of habitat effectiveness monitoring to ensure offsetting measures are successful. Assessing adherence to the conditions of the *Fisheries Act* authorization will be a key feature of both monitoring programs. Monitoring will be conducted in cooperation with Haisla Nation. Detailed monitoring plans are described below.

8.5.5.1. Compliance Monitoring

The purpose of compliance monitoring is to confirm that offsetting measures are implemented according to the plan and in compliance with the terms and conditions of the *Fisheries Act* authorization. Compliance monitoring will take place during the construction of the offsetting features. At least one experienced supervisor will be on site during start-up and at critical periods of construction. Information that will be documented during construction will include:

- Written and photo-documented sequence of events during construction
- Any changes in the design necessary to adapt to unanticipated conditions
- Technical issues that arise during construction and how they were addressed
- Confirmation that all offsetting components meet design requirements
- Confirmation that relevant terms and conditions of the fisheries act authorization are met

Any anticipated significant changes to the design of offsetting features will be submitted to DFO in writing prior to implementation.

8.5.5.2. Compliance Reporting

At the conclusion of construction of the offsetting features, a report will be prepared summarizing the information listed above. The report will include detailed 'as built' drawings, descriptions of what was completed, any effects, as well as mitigation measures that were employed during construction of offsetting features. The effectiveness of these mitigation measures at reducing or avoiding effects on fish habitat will also be described. This report will be submitted to DFO within 90 days of completion of construction of offsetting features.

8.5.5.3. Habitat Effectiveness Monitoring

Effectiveness monitoring following construction will confirm that created habitats are functioning as intended. Specific success criteria, monitoring methods, and measurable parameters have been tailored to the offsetting measures described in this fish habitat offsetting plan and will adhere to the requirements outlined under the *Fisheries Act* authorization from DFO. Monitoring will focus on physical stability, establishment of marsh vegetation, and the demonstrated use by fish and invertebrates at the offsetting habitats and will be assessed through a number of quantitative and qualitative criteria. If it is determined that the success criteria are not met after sampling and analysis during each year of the monitoring program, an adaptive work plan will be developed and additional monitoring or offsetting may be undertaken in consultation with DFO, Haisla Nation, and stakeholders until success criteria are met. An alternative site located near Kitamaat Village at the mouth of Wathl Creek has been identified should anything prevent implementation of the offsetting plan at one of the other sites in Minette Bay (see Figure 8-1 and Appendix 5). Monitoring will continue until the habitat offsetting measures are determined to be functioning as intended.

8.5.5.3.1. Habitat Effectiveness Criteria

The scope of the habitat effectiveness monitoring includes the physical (structural) stability of the rock containment berm, the establishment of marsh vegetation, and habitat use by fish and invertebrates. Measureable parameters and success criteria for each of these objectives are listed in Table 8-6.

Table 8-6 Habitat Effectiveness Criteria

Objective(s)	Measurable Parameter(s)	Success Criteria
Physical (structural) stability	• Horizontal and vertical movement of rock containment berm • Final elevations and slope of fill used to create marsh benches	• No significant horizontal or vertical movement of rock containment berm between annual sampling events • Final elevations are stable and within the range capable of supporting salt marsh habitat; slopes provide positive drainage during the ebbing tide limiting the formation of extensive salt pannes and pools
Vegetation establishment	• Areal extent of marsh vegetation (frequency and/or cover)	• Increasing annual trend of marsh vegetation frequency and/or cover during the five year monitoring period
Habitat use	• Species composition	• Presence of juvenile salmon at created salt marsh habitat by year 5 • Presence of benthic invertebrates at created salt marsh habitat by year 5 • Presence of sessile invertebrates and algae on rock reef habitat by year 5

8.5.5.3.2. Monitoring Methods

LNG Canada will survey the marsh and rock reef creation sites prior to construction to provide a baseline of existing species diversity and abundance, and a report summarizing the results of the survey will be compiled and submitted to DFO prior to commencement of construction. LNG Canada has already completed one fish and fish habitat study in Minette Bay at the proposed offsetting sites (Stantec 2015a; see Appendix 3). The salt marsh benches and two nearby natural marshes and rocky habitats (reference sites) will be monitored annually in years one to five post-construction to assess habitat effectiveness. The reference sites will be used to determine whether observations from the created salt marsh benches are consistent with observations from existing in-kind habitats in the area.

Physical Stability

Physical stability of the salt marsh benches will be measured once per year (years one to five post-construction) based on the horizontal and vertical movement of the rock containment berm. Important grade control points such as the invert elevation at each tidal channel outlet and crest elevation of the rock berm will be surveyed and recorded. Annual surveys of the horizontal position and vertical elevation of these features will be compared to as-built measurements recorded immediately following construction. Each salt marsh bench will be deemed physically stable if both the horizontal location and vertical height of these critical grade control structures have not changed in such a way as to affect the functioning of the structures between annual sampling events.

Vegetation Establishment

The areal extent of marsh vegetation will be measured at each of the salt marsh benches and two reference sites immediately following transplanting, and once per year (years one to five post-construction) during the summer (June/July) to coincide with the peak growth period for intertidal vegetation. Vegetation frequency will be determined using sampling methods such as quadrats located along transects. Vegetation cover will be determined using sampling methods such as either visual estimates using quadrats along transects or the point-intercept method. The appropriate plant attributes (frequency and/or cover), sampling units (quadrats and/or points), and sample size will be refined during pilot-scale monitoring within the first year after planting. To supplement these quantitative methods, the areal extent of marsh vegetation will also be mapped by either walking the outer perimeter of marsh vegetation with a hand-held GPS, or using large scale (1:1,000) aerial photography. Photo-documentation of each site will be conducted from permanently-established photo points. Vegetation establishment will be considered successful if the areal extent of marsh vegetation (according to annual average frequency and/or cover data) steadily increases throughout the five-year monitoring period.

Habitat Use

Use of the natural and created salt marsh habitats by fish and invertebrates will be measured twice annually in spring (April/May) and summer (June/July) at each of the salt marsh benches and two reference sites prior to construction and in years one to five post-construction. The spring sampling event is intended to coincide with the beginning of the growing season for intertidal vegetation and the seaward migration of salmon smolt from the Kitimat River, while the summer sampling event is intended to coincide with peak abundance of intertidal vegetation and the peak period of estuarine rearing by juvenile chum, chinook, and coho in Minette Bay (Birch et al. 1981; Slaney et al. 1982; Higgins and Schmidt 1975; Orr 1985; Cambria Gordon 2009; Triton 2014). Habitat use will be measured by species composition.

Fish sampling will use two different passive methods to allow for a greater community-level sampling success across the complex, vegetated environment of the salt marsh and to ensure adequate fish sampling coverage. Methods being considered include a lift/pop net and a trap net. The first method involves using a bottomless lift/pop net to target both pelagic and benthic fish assemblages and to avoid escapement of benthic species through gaps in the bottom of the net caused by epibenthic debris and vegetation (Rozas 1992; Connolly 1994; Cambria Gordon 2009). The use of passive sampling through the lift/pop net design allows the net to be set during low tide and released at the following day's incoming tide to avoid both startling and escapement of fish species. The second method involves using a seine net with a cod end trap (Conlin and Tutty 1979; Levy and Northcote 1982) to capture fish in tidal channels within the marshes. The nets will be strung across the tidal channels at high tide slack and secured to the banks of the channel with stakes. As the tide ebbs, fish upstream of the net trap will enter the cod end trap. Any remaining fish species that become trapped upstream in the tidal channels but do not enter the cod end will be subsequently herded into the cod end seine or beach seined out separately. At each tidal channel, one set per day will occur coinciding with the daily tide. Captured fish will be identified to species, enumerated and transferred back to the estuary using live wells, fish transport buckets or coolers.

Invertebrate sampling will occur simultaneously with fish sampling described above through use of pitfall traps, a common passive amphipod sampling technique (Spence and Niemelä 1994). Amphipods are a key food source of juvenile salmonids in the Kitimat River estuary and a good indicator of salt marsh productivity (Higgins and Schmidt 1975). Pitfall traps will be deployed at randomly selected stations within each marsh and amphipod abundance and presence will be recorded. This cost and time efficient method of amphipod sampling is effective for all life stages and most surface-active species (Mantzouki et al. 2012).

8.5.5.4. Habitat Effectiveness Reporting

Results of the effectiveness monitoring program will be compiled annually and submitted to DFO for review at the end of each calendar year. Furthermore, these reports would also be provided to Haisla Nation and local stakeholders. Annual monitoring reports will include maintenance and management recommendations to address identified issues that may affect the Project's success criteria.

After year five of the effectiveness monitoring program, a summary report will be issued with recommendations based on the success of the offsetting measures.

8.6. Cost Estimate

A cost estimate for the offsetting measures proposed in this Fish Habitat Offsetting Plan is provided in Table 8-7. LNG Canada has already submitted Letters of Credit to DFO to cover the costs of implementing the fish habitat offsetting plan.

Table 8-7 Cost Estimate for Implementation of Marine Terminal Fish Habitat Offsetting Plan

Item	Cost Estimate
Construction of salt marsh benches: Minette Bay North and Minette Bay South	$17,000,000
Compliance Monitoring and Reporting	$1,000,000
Habitat Effectiveness Monitoring and Reporting (5 years)	$2,000,000
Total	**$20,000,000**

9. CLOSURE

With submission of this application, LNG Canada Development Inc. is requesting an authorization for *serious harm to fish* associated with construction of the marine terminal for its proposed liquefied natural gas export facility in Kitimat, BC.

LNG Canada will implement measures to protect fish and fish habitat and to avoid and mitigate *serious harm to fish* during dredging and construction of the marine terminal. Marine terminal construction and dredging in the Eurocan Basin will result in *serious harm to fish* including the following:

- Loss of 67,455 m^2 of salt marsh habitat
- Loss of 250 m^2 of eelgrass habitat
- Loss of 26,615 m^2 of intertidal mudflat habitat
- Loss of 12,684 m^2 of constructed (rocky) intertidal habitat
- Permanent alteration of 46,279 m^2 of intertidal mudflat habitat

This *serious harm to fish* will be offset by the creation of 184,558 m^2 of salt marsh and rocky intertidal habitats in the Kitimat River estuary. These habitat offsets will balance *serious harm to fish* by providing direct benefits to affected fish species.