Appendix D

Confluence Report

Jamestown S'Klallam Tribe – Shellfish Aquaculture and Bird Interactions

November 2018

Jamestown S'Klallam Tribe
SHELLFISH AQUACULTURE AND BIRD INTERACTIONS

Prepared for:

Jamestown S'Klallam Tribe

November 2018

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1.0 INTRODUCTION

The Jamestown S'Klallam Tribe (the Tribe) is proposing to culture Pacific oyster (*Crassostrea gigas*) shellfish in inner Dungeness Bay, Clallam County, Washington (Figure 1). This area was originally used for shellfish aquaculture by the Tribe from 1991 to 2005, but had to be abandoned after water quality conditions degraded in the estuary. In 1997, fecal coliform bacteria counts were identified near the mouth of the Dungeness River as exceeding the federal limit. In 2000, the Washington State Department of Health (WDOH) downgraded 300 acres of commercial shellfish harvest area in Dungeness Bay from "Approved" to "Prohibited year-round" and additional downgrades occurred in subsequent years (Clallam County 2018). These downgrades prompted years of monitoring, cleanup actions, and public outreach by Washington State Department of Ecology (Ecology), the Tribe, Clallam County, Clallam Conservation District, and other partners (Clallam County 2014). The result of these efforts led to an upgrade by WDOH in April 2011 for 500 acres in Dungeness Bay from "Prohibited" to "Conditionally Approved" for shellfish harvest. Recent sampling suggests that conditions in inner Dungeness Bay continue to improve (WDOH 2017) and portions of the bay are anticipated to be upgraded in the future.

Along with the water quality improvements and shellfish harvest area upgrades, the Tribe is planning to re-start shellfish aquaculture again in Dungeness Bay. The lease area is in a location currently designated as "Conditionally Approved" and anticipated to be upgraded to "Approved" assuming that future sampling continues to show water quality observations meeting the criteria for that status. The proposed farm is located on 50 acres leased from the Washington Department of Natural Resources (WDNR) and is within the Dungeness National Wildlife Refuge (the Refuge). The Refuge is operated by the U.S. Fish and Wildlife Service (USFWS). The proposed farmable acreage of the lease is 34 acres, and the proposed cultivation of Pacific oysters would include on-bottom bag methods. Once oysters are large enough to survive on the intertidal, culture may be spread onto the intertidal for subsequent hand harvest. The farmable acreage of the lease is reduced from the total lease area because eelgrass within the lease area would be avoided using a 25-foot buffer, which is larger than the 16-foot buffer allowed under the current Nationwide Permit 48 conditions (NMFS 2016).

During discussions related to permitting the proposed farm, U.S. Army Corps of Engineers (Corps) raised concerns with the Tribe over potential negative interactions between the proposed Pacific oyster shellfish aquaculture operations and marine birds, specifically black brant (*Branta bernicla nigricans*) and other shorebirds and waterfowl. The Refuge provided a detailed comment letter that describes potential concerns relating to aquaculture and birds in Inner Dungeness Bay (USFWS 2018). The information presented in this report provides an overview of existing information and scientific literature on the potential interactions between shellfish aquaculture and marine birds within intertidal habitat of Dungeness Bay.

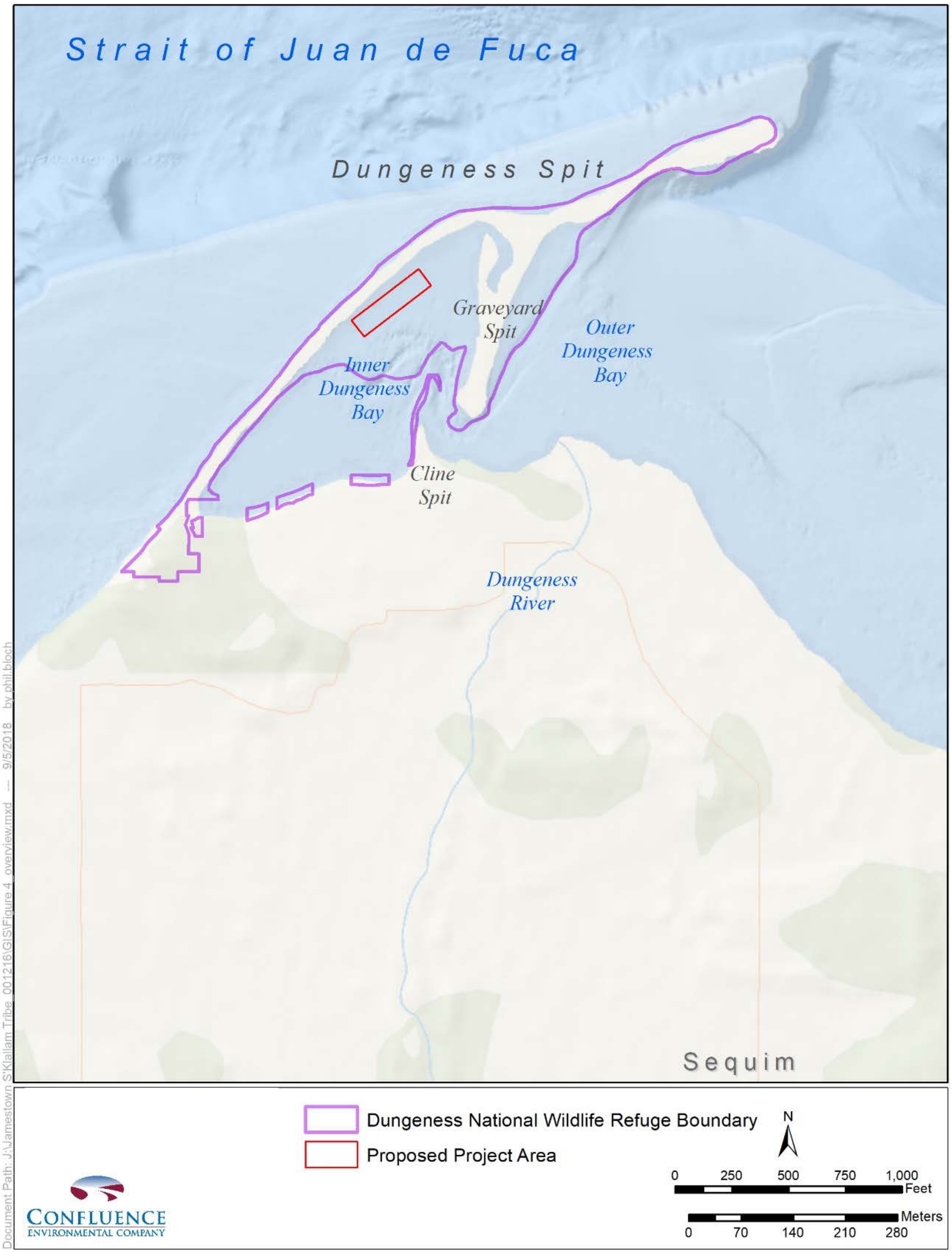

Figure 1. Project Area for the Proposed Pacific Oyster Farm in Inner Dungeness Bay

2.0 MARINE BIRD USE OF DUNGENESS BAY

Dungeness Bay and the adjacent Dungeness Spit are used by many bird species throughout the year. Bird species using the area include resident, migratory, overwintering, and summer nesting species. The Refuge has compiled a list of 244 species of birds that have been or are predicted to be observed within the Refuge boundaries (USFWS 2014). This listing recognizes 11 species as abundant, occurring in large numbers, that use the bay, open marine, tideflats, or sand spit habitats. These species include brant (*Branta bernicla*), American wigeon (*Anas americana*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta fusca*), black-bellied plover (*Pluvialis squatarola)*, dunlin (*Calidris alpina*), Heermann's gull (*Larus heermanni*), glaucous-winged gull (*Larus glaucescens*), and glaucous-winged/western gull hybrid. In addition, the following species are known to nest or breed in the vicinity of the bay, open marine, tideflats or sand spit habitats: Canada goose (*Branta canadensis*), mallard, killdeer (*Charadrius vociferus*), black oystercatcher (*Haematopus bachmani*), glaucous-winged gull, glaucous-winged/western gull hybrid, Caspian tern (*Hydroprogne caspia*), arctic tern (*Sterna paradisaea*), and pigeon guillemot (*Cepphus columba*). Additional species use the adjacent upland areas and may be seen in aquatic areas. Significant aggregations of birds that occur in Dungeness Bay include a Caspian tern colony which has hosted in excess of 1,000 pairs and is one of the largest in the Pacific Northwest (Pacific Seabirds 2008), and black brant wintering and migration staging which also use Padilla, Samish, Fidalgo, and Willapa bays and portions of Hood Canal (Pacific Flyway Council 2018). Recent counts of brant using Dungeness Bay have exceeded 1,000 wintering individuals, with several thousand additional individuals feeding in the bay during spring migrations (Spragens, WDFW Waterfowl Section Manager, pers. com.). The Refuge continues to collect unpublished data describing bird observations within Dungeness Bay (USFWS 2018).

3.0 POTENTIAL INTERACTIONS BETWEEN SHELLFISH AQUACULTURE AND BLACK BRANT

The black brant is a sea goose that relies on Pacific coastal habitats. Brant nest in the arctic, including areas in Alaska and western Canada during the summer nesting season (Pacific Flyway Council 2004). The majority of the brant population (over 75%) migrate directly to wintering areas in Baja California and mainland Mexico, but approximately 10% of the population use coastal bays from Alaska to California for wintering (i.e., the Pacific Flyway). Black brant are a part of the Pacific Flyway, and managed as a hunted species with a population objective of 162,000 birds. The Pacific Flyway Management Plan, a joint management plan prepared for the Pacific Flyway Council, the Commonwealth of Russian States, the Dirección General de Conservación Ecológica de Recursos Naturales, the U.S. Fish and Wildlife Service and the Canadian Wildlife Service, for the Pacific Population of Brant (Brant Management Plan) recommends protecting critical brant habitat in the species' range, including pursuing mitigation (i.e., avoidance, minimization, and compensatory mitigation) for loss or degradation of eelgrass beds, grit sites, and loafing sites.

3.1 Presence in Dungeness Bay

Dungeness Bay is a wintering area and spring staging site for brant migrating along the Pacific Flyway. The total Pacific Flyway black brant population estimates based on midwinter surveys had 3-year averages of 162,898 from 2011 to 2016, which is consistent with the management target of maintaining 3-year average counts of 162,000 brant (Pacific Flyway Council 2018). Brant observed in Washington are from 2 sub-species groupings – black brant and Western High Arctic (WHA) gray-bellied brant (Pacific Flyway Council 2018). Detections of WHA brant in Washington State are limited to Samish Bay, Padilla Bay, and the vicinity of Bellingham Bay (Boyd et al. 2013). Washington is estimated to be visited by an average of 9% of the flyway population (11,708 birds), based on midwinter surveys from 1981 to 1990 (USFWS data *as cited in* Wilson and Atkinson 1995). The share of the flyway population observed in Washington State has varied over time, from a low of 3,113 birds in 1983 to a peak of 53,950 in 1942, with the most recent average count representing approximately 10% (15,878 birds) of the total stock in 2017 (Pacific Flyway Council 2018). Washington State's mid-winter counts and Dungeness Bay's average mid-winter counts have been increasing since the late 1980s (Spragens, unpublished data; Figure 2).

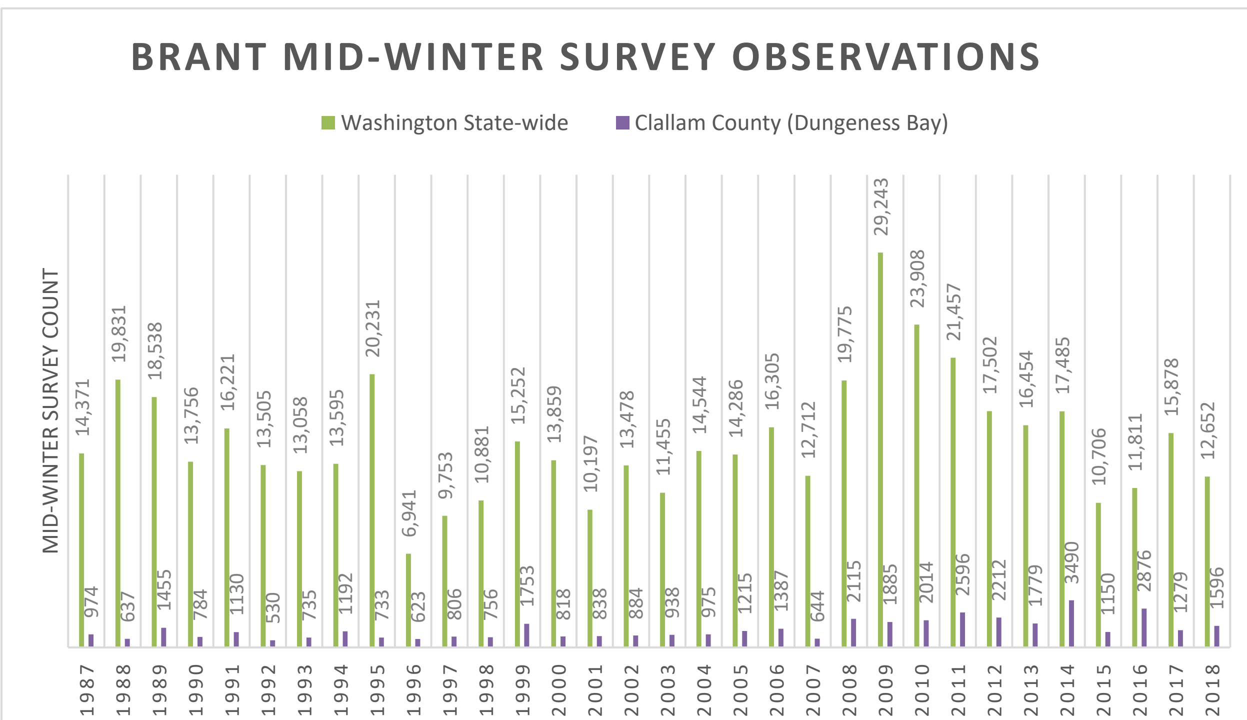

Figure 2: Mid-Winter Brant Survey Counts in Clallam County and Washington State.

Spring staging is the primary use of estuaries along the Pacific Flyway, and Washington estuaries are estimated to be visited by >80% of the Pacific Flyway population in the spring (Pacific Flyway Council 2004). During a 7-year study (fall 1986 through spring 1993), the number of brant in Dungeness Bay was shown to be positively correlated with eelgrass area, especially during the spring staging period when brant increase their food intake to build up energy reserves important for migration and breeding success in the summer (Wilson and Atkinson 1995). The wintering period in Dungeness Bay extends from late October to February, with an average of 1,500 birds at the Refuge (USFWS 2018). The wintering population of brant in Dungeness Bay ranged from 600 to 1,700 birds in the 1990s (Pacific Flyway Council 2004). The number of birds using Dungeness Bay increases between March and May, with an annual peak (~4,000 birds) of black brant in the estuary in April (Wilson and Atkinson 1995), due to brant migrating north coming into Dungeness Bay during the spring staging period before nesting in the artic. All brant occurring in Dungeness Bay are assumed to be black brant.

Black brant are hunted recreationally in Dungeness Bay, where there is a 2 bird/day daily bag limit allowed on January 6, 10, and 13 (Spragens, pers. com.). A minimum of 1,000 birds must be observed before a 3-day hunt is authorized in Clallam County. While hunts in Clallam County had not occurred for many years, a hunt occurred in 2018 and one is anticipated for 2019 (Spragens, pers. com.). Washington hunters have haravested an average of 447 brant per year over the 10 years from 2006-2016, with all of the harvest effort occurring in Skagit and Pacific counties (Pacific Flyway Council 2018).

3.2 Foraging Behavior

Black brant feed most commonly on native eelgrass (*Zostera marina*) (Ward et al. 1997, 2005; Moore et al. 2004). Black brant have been observed to forage on other aquatic plants and macroalgae during the non-breeding season, such as wigeongrass (*Rupia maritima*), surfgrass (*Phyllospadix sp.*), non-native eelgrass (*Z. japonica*), ulvoids (e.g., *Ulva* and *Ulvaria* sp.), salt marsh plants, and upland plants (Ward 1983, Moore et al. 2004, Ward et al. 2005). However, these food sources only comprise a small portion of black brant diet as compared with other populations of brant geese in North America and Europe (Ward et al. 2005).

Eelgrass varies in quantity and quality, and is unavailable to brant during 2 high tides per day, making the achievement of energy demands challenging (Clausen 2000, Moore and Black 2006). Brant have been documented repeatedly returning to eelgrass beds that are relatively high in quality (high density, biomass, and nutrient content), and have been seen waiting over eelgrass beds until tides recede (Moore and Black 2006), suggesting that brant are making foraging decisions based on prior experience and performance. This observation also suggests that eelgrass quality is important to the ability of brant to meet energetic demands for migration. There is no evidence (e.g., areas of complete eelgrass grazing, use of other less desirable food sources, etc.) that overall eelgrass abundance has been insufficient within the last 50 years to support wintering and staging brant in Dungeness Bay, and brant appear to meet their energetic requirement foraging on a relatively stable and abundant source of eelgrass, except in rare circumstances when heavy rains and tide conditions can constrain foraging efforts.

3.3 Potential Interactions

3.3.1 Foraging Opportunities

Eelgrass in Dungeness Bay has been mapped as including approximately 147.1 hectares (363.5 acres) of eelgrass area that is roughly evenly distributed between inner Dungeness Bay and outer Dungeness Bay (Norris and Fraser 2009). Eelgrass mapped within inner Dungeness Bay is located south and west of the proposed aquaculture site. Thus, the site is along one edge of the eelgrass being used as a food resource by wintering and migrating brant. Foraging brant aggregations are not anticipated on the proposed aquaculture area, and there are limited, if any, feeding opportunities for brant within the proposed aquaculture area (Confluence 2018). Another important resource for brant is grit, where brant ingest grit from repeatedly used sites to support digestion and potentially as a source of calcium (Lee et al. 2004). Grit sites have not been mapped in Dungeness Bay, however, brant aggregations on Graveyard Spit (USFWS 2018) suggest that area may represent a gritting or resting area.

Aquaculture frequently co-occurs with or near eelgrass habitat along the U.S. West Coast. While brant density is positively correlated with eelgrass coverage (area), the relationship is complex and influenced by factors like frequency of winter storms, foraging dynamics due to tides, and spatial relationship of eelgrass beds (Dumbauld et al. 2009). While several studies have evaluated the interactions of birds with aquaculture and eelgrass areas, few have taken an experimental approach, and none has directly evaluated the type of aquaculture gear proposed for Dungeness Bay. Wilson and Atkinson (1995) noted that brant use of Dungeness and Willapa bays is correlated to eelgrass abundance and suggested that where oyster aquaculture is associated with declines of eelgrass it may affect brant usage of these bays because the quantity of eelgrass available may be limiting brant use. However, for the proposed project, as noted elsewhere, the aquaculture would be located in areas where eelgrass is naturally absent and includes measures to protect eelgrass adjacent to the culture activities.

Several studies have occurred in Humboldt Bay where some aquaculture activities occur within dense eelgrass beds. HT Harvey & Associates (HTH) conducted a survey in April 2015 (HTH 2015) within oyster longline aquaculture (aquaculture plots) and adjacent reference plots. Oyster longline aquaculture extends approximately 1 foot above the sediment surface and occurs in eelgrass beds.

The HTH (2015) survey indicated that tidal height is the most influential driver in black brant use of an area. During high tides, brant were observed at similar densities in aquaculture plots (mean density=1.0 birds/acre) and reference plots (mean density=1.3 birds/acre). During low tides, brant were consistently observed at higher densities in reference plots (mean density=2.6 birds/acre) compared to aquaculture plots (mean density=0.1 birds/acre). Supplemental time-lapse recordings taken during the April survey period demonstrated that brant forage in both aquaculture and reference plots when water is sufficiently high to swim, but are less abundant in plots with oyster longlines at lower tides when the gear is exposed. The study authors postulated that the presence of lines during low tide interfered with brant movement and led to brant preferentially using areas with eelgrass that were adjacent to off-bottom culture plots. Monitoring in Humboldt Bay during the 2017-2018 wintering and migratory period found no significant difference in brant usage in culture and adjacent reference plots (HTH 2018) suggesting that earlier observations may be the result of eelgrass abundance within culture areas rather than the presence of culture gear. HT Harvey (2018) found that brant use is comparable or higher within culture areas compared to adjacent areas, particularly during higher tides when bed feeding may not be available to brant. It appears that brant may occur at higher concentrations in areas with aquaculture gear where feeding opportunities may exist during higher water levels. Collectively, this evidence suggests that brant utilize their preferred method of foraging in shallow water when the tidal height provides sufficient access to rooted eelgrass. The presence of structure can affect their foraging when the structure impedes their ability to easily swim through aquaculture plots.

Based on the location and methods of proposed oyster culture in Dungeness Bay and the location of existing eelgrass beds, there would be limited interaction between black brant foraging areas and the proposed oyster aquaculture activities. The proposed oyster culture is located a minimum distance of 25 feet from eelgrass observations of 3 or more turions of eelgrass per square meter, and approximately 100 feet from contiguous eelgrass beds. Further, the culture methods proposed (e.g., on-bottom beach and on-bottom bag) would result in a minimal increase in the bottom profile within this area, unlike oyster longlines, which extend approximately 1 foot above the bottom profile. Therefore, the low relief of the proposed culture methods would not inhibit black brant access to the area, and due to the lack of eelgrass in the culture area, there would be no impact to foraging.

3.3.2 Human Disturbance

Disturbance near brant foraging, gritting, or roosting habitat, including loud noise or the presence and movement of people, may alter brant behavior. Studies have evaluated flushing responses to waterbirds (Rodgers and Schwikert 2002, Peters and Otis 2006), wading birds (Bratton 1990), and some individual seabirds such as marbled murrelets (Bellefluer et al. 2007). Species distributions in Dungeness Bay are likely driven by calendar date, tidal stage, and water body width (Peters and Otis 2006). Studies indicate that responses to boat traffic varies based on boat speed, species, and habitat context. Faster boats create flushing response at greater distances (Bellefleur et al. 2007, Rodgers and Schwikert 2002). Birds in trees or on docks are considerably less likely to flush compared to birds in the water or along banks (Bratton 1990).

The average flushing distance for waterbirds from outboard-powered boats is between 23 and 53 meters, with birds flushing between 9 and 140 meters from vessels (Rodgers and Schwikert 2002). Bratton (1990) found that in a bay ecosystem, approximately 80% of birds did not flush in response to boats passing 25 or more meters away.

Reduced foraging time and increased flight time can deplete energy reserves of brant (Ward et al. 1994), thus reducing the potential for brant to migrate and breed. Disturbance that interrupts other behaviors such as resting or gritting can result in similar energetic constraints. Stillman et al (2015) developed a modeling approach to estimate the response of brant to human disturbance and changes in foraging opportunities. This model identified 3 potential responses of brant to increased human disturbance: reduced likelihood of successful emigration, increased stopover duration, and reductions to weight gain. Brant may stay in a wintering or migration staging area until they are able to acquire enough energy resources to support long-distance migration. The likelihood of successful emigration or departure is relatively unaffected by human disturbance requiring more than 30% of brant foraging time lost due to disturbance before an effect is detected. However, stopover duration and mass gain may change with even relatively small levels of disturbance, potentially causing slower mass gain and longer stopover stays (Stillman et al. 2015). This model was calibrated for conditions in Humboldt Bay; however, general trends and observations are likely applicable to Dungeness Bay. Stillman et al.'s (2015) observations in Humboldt Bay suggest that even 300+ acres of aquaculture activity may be having minimal or no impact on brant.

Kelly et al (1996) studied the relationship between aquaculture and bird distribution in Tomales Bay, where culture methods used are similar to those proposed in Dungeness Bay. Although human disturbance has not been studied in Dungeness Bay, the work in Tomales and Humboldt bays can again be used as a proxy to understand potential disturbance in Dungeness Bay given the similarities of the 2 systems: both are embayments with eelgrass used by wintering and migrating brant, and both have national wildlife refuges protecting a significant portion of the bay. According to a study by Henry (1980), hunting, recreational clamming, and aircraft resulted in the highest levels of disturbance to black brant in Humboldt Bay. A similar study by Schmidt (1999) found that the majority of brant disturbances were from small boats (those under 23 feet; 27%), the presence of people (22%), and large boats (those over 23 feet; 21%). Natural disturbances (caused mainly by birds) resulted in disturbance approximately 10% of the time. Schmidt (1999) also noted that larger, slower-moving vessels were less likely to elicit a response from brant, compared to smaller and faster-moving vessels.

The Tribe uses boats that are up to 30 feet in length with up to 150-horsepower 4-stroke outboard motors. Because of the shallow habitat in the proposed project area, boats typically travel at slow speeds in inner Dungeness Bay (<10 mph). It is estimated that 50 to 90 annual round-trip boat trips would be needed to support the proposed oyster farm in Dungeness Bay, with an estimated 1-2 round-trip boat trips on a weekly basis. An individual trip length extends for up to 8 hours during maintenance visits and harvests. Oysters would be harvested and planted every 1.5 to 3 years, depending on culture method, conditions, species of oyster, and other factors. Between harvests, visits would occur at a rate of approximately once a week to perform maintenance or harvest. During winter these visits will occur primarily during darkness due to the lack of winter daytime low tides.

Inner Dungeness Bay is approximately 1,200 acres, and the farm area is approximately 3% of that total area. Due to the limited project area, the small level of activity associated with on-bottom oyster aquaculture maintenance, and the lack of eelgrass in the farm area, the project is not expected to cause significant disturbance to brant. Therefore, human activities to support the proposed farm would result in a less than significant impact to black brant from human disturbance. Furthermore, the areas with the largest flocks of wintering and spring migrant brant in Washington State are Samish and Willapa bays. These areas are also used for intensive aquaculture production and these resources have successfully co-occurred for more than 60 years.

4.0 POTENTIAL INTERACTIONS BETWEEN SHELLFISH AQUACULTURE AND OTHER MARINE BIRDS

4.1 Presence of Other Marine Birds in Dungeness Bay

The 2 groups of other marine birds discussed in this report include migratory shorebirds and waterfowl. Information on the presence of these birds in Dungeness Bay is provided below.

4.1.1 Migratory Shorebirds

Dungeness Bay has been designated as a Site of International Importance in the Western Hemisphere Shorebird Reserve Network because it is considered an important estuary for migrating and wintering shorebirds in the Pacific Flyway. Numerous species, sometimes numbering in the thousands, use Dungeness Bay during migration. As many as 32 shorebird species and over 80,000 individuals have been recorded during a spring migration (as observed during surveys conducted in April 1991). However, shorebird counts conducted during the 1990s reflect a decline relative to historic estimates (Colwell 1994). Various non-breeding shorebird species use intertidal habitats of Dungeness Bay for foraging, although specific habitat use may be differential based on species morphology, as well as habitat conditions such as water depth (related to tidal cycles) and substrate type. Observations from 2001 and 2002 indicate that birds use both inner and outer Dungeness Bay with total abundance often similar in both sub-areas (Rensel 2003). Monthly counts indicated that gulls, ducks and cormorants, and geese combine to comprise up to approximately 4,000 individuals on the bay in winter months and 1,500 birds during the summer months (Rensel 2003).

Several shorebird species that occur in Dungeness Bay are USFWS Birds of Conservation Concern, including the lesser yellowlegs (*Tringa flavipes*), whimbrel (*Numenius phaeopus*), long-billed curlew (*Numenius americanus*), marbled godwit (*Limosa fedoa*), red knot (*Calidris canutus*) and short-billed dowitcher (*Limnodromus griseus*).

In addition to intertidal habitats, shorebirds in Dungeness Bay also exploit non-tidal habitats, particularly agricultural fields when intertidal mudflats are inundated (Colwell and Dodd 1997; Long and Ralph 2001). Shorebird use of pastures is correlated with (and dependent on) rainfall, as shorebirds likely exploit increased prey availability when pastures are wet, or possibly their use of pastures is related to a decrease in prey availability on mudflats during rainfall (Colwell and Dodd 1997). Shorebird use of non-tidal habitats has been observed in other estuaries, including in San Francisco Bay where shorebirds regularly use salt ponds, salt pans, marsh ponds, and other habitats (HTH 2005).

4.1.2 Waterfowl

Dungeness Bay is a significant waterbird migration stopover and wintering area between the mouth of the Columbia River and Alaska. Common waterfowl species in Dungeness Bay during winter include dabbling ducks: American wigeon, green-winged teal (*Anas crecca*), northern pintail (*A. acuta*), and mallard; diving ducks: greater and lesser scaup (*Aythya marila* and *A. affinis*), bufflehead (*Bucephala albeola*), and surf scoter; and other waterbirds such as the American coot (*Fulica americana*) (USFWS 2014). Wigeon are one of the first species to arrive in fall, and often the most abundant waterfowl species in Dungeness Bay, followed by northern pintail and diving ducks (e.g., USFWS 2018). Surf scoters also occur in Dungeness Bay and may occur at the shellfish culture sites, because they are strongly attracted to and feed on biofouling mussels that accumulate on the shellfish aquaculture gear (Kirk et al. 2007, Žydelis et al. 2009).

4.2 Foraging Behavior of Other Marine Birds

Shorebirds and waterfowl are very flexible in their diets and consume prey opportunistically, with considerable dietary overlap among species and foraging guilds (Skagen and Oman 1996). Marine birds typically take prey in accordance with availability, concentrating where prey is most dense (Goss-Custard 1970, 1977, 1979). Therefore, observed distribution of foraging birds likely reflects an abundance of available prey in those locations.

4.2.1 Migratory Shorebirds

Shorebirds typically concentrate at the edge of a receding tideline, where worms, crustaceans, and bivalves occur close to the surface and are available for consumption. Thus, hydrologic regimes and ecosystem processes that maintain abundant invertebrate populations are more important than the presence of specific invertebrate taxa for shorebirds. Near the waterline, shorebird microhabitat use usually depends on each species' leg length, as well as the size and shape of their bills. For example, short-billed semipalmated plovers (*Charadrius semipalmatus*) and black-bellied plovers (*Pluvialis squatarola*) often feed on recently exposed mud, using visual foraging methods. Small sandpipers, such as western sandpiper (*Calidris mauri*) and Least Sandpipers (*Calidris minutilla*), forage on recently uncovered mud and shallow water. Mid-sized birds such as dunlin, long-billed dowitchers (*Limnodromus scolopaceus*), and short-billed dowitchers can forage in slightly deeper water (by probing with their bills), and larger shorebirds such as willets (*Tringa semipalmatus*), long-billed curlews (*Numenius americanus*), and marbled godwits are able to probe in deeper water (although these species will forge in exposed areas as well). In addition to bill shape and leg length, sediment type can dictate where shorebird species forage and sediment particle size influences shorebird distribution in Humboldt Bay. For instance, sanderlings (*Calidris alba*) tend to select areas with coarser sediments and American avocets (*Recurvirostra americana*) tend to occur in areas with finer sediments (Danufsky and Colwell 2003).

4.2.2 Waterfowl

American wigeon is the waterfowl species, other than black brant, most likely to be affected by shellfish culture, based on their habitat use, food preferences, and relative abundance in the winter. Wigeon utilize a variety of habitat types in and around Dungeness Bay including permanent freshwater ponds in fall, shifting to tidal habitats in mid-winter, then moving to flooded pastures in spring, presumably to maximize foraging performance (Brendan 2015). When using tidal habitats of the bay, they are often found in the vicinity of the large eelgrass beds (Denson and Bentley 1962), where they are known to feed on both emergent and free-floating eelgrass (invasive *Zostera japonica* and endemic *Z. marina*), and generally occur in low densities (maximum of 1.4 birds/acre from winter 2014 surveys) (Brendan 2015). Other dabbling ducks that occur in the bay, including pintails, mallard, scaup, and teal, are also known to feed on eelgrass, although it makes up a smaller proportion of their diets than it does for wigeon (Baldwin and Lovvorn 1994, Nienhuis and Groenendijk 1986). Feeding on emergent eelgrass generally occurs during low tides when the birds have direct access to eelgrass beds (Baldwin and Lovvorn 1994, Brendan 2015).

4.3 Potential Interactions

Aquaculture activities may affect shorebirds by affecting their forage opportunities or through human disturbance of roosting, foraging, or nesting birds. Forage opportunities may be positively or negatively affected through the introduction of culture gear and organisms onto the intertidal. The arrival, departure, and activities performed by staff attending to site maintenance, planting, and harvest may disturb or displace birds that would otherwise use the culture area. The sensitivity and response of birds to these activities depends on the intensity and timing of the activity.

4.3.1 Foraging Opportunities

Migratory Shorebirds

There are few studies of migratory shorebirds in on-bottom oyster culture, but there are studies looking at shorebirds in oyster longline plots. A study conducted by Connolly and Colwell (2005) in Humboldt Bay compared low-tide shorebird use of oyster longline plots to adjacent intertidal flats without shellfish aquaculture (control plots). The results indicated that there was greater species diversity on oyster longline plots compared to control plots for 5 species (willet, whimbrel, dowitchers, small sandpipers, and black turnstone [*Arenaria melanocephala*]). The authors suggested that increased abundance of these shorebirds on longline plots may be related to an increase in foraging opportunity or an increase of prey density or diversity. One species (black-bellied plover) was more abundant only on control plots. Kelly et al. (1996) studied on-bottom culture and found that Least Sandpipers may forage on oyster bags and willets were attracted to aquaculture plots, while western sandpipers and dunlin often forage between oyster bags and were less abundant in aquaculture areas. The authors suggest that greater use of control plots by black-bellied plovers may be a result of greater abundance of their principal prey items, or factors related to reduced foraging efficiency related to their visual foraging methods.

Similarly, the HTH (2015) survey also suggests that shorebirds readily forage under oyster longlines. In imagery taken by one camera on a longline plot, shorebirds were observed in large numbers foraging in and adjacent to the aquaculture plots when water levels were low enough for shorebirds to access the site. Although no quantitative assessment of the camera imagery was conducted, shorebird use within and outside of the aquaculture plots (i.e., within view of the camera) appeared to be similar. There were no behavioral differences in shorebird use between the longline and reference plots. Shorebirds were observed first accessing the area when water levels were low enough for shorebirds to stand and forage, and they continued to forage until water levels rose to levels that forced them to cease foraging and leave the site. During the recordings, larger marbled godwits would arrive before small species (i.e., small sandpipers [*Calidris* spp.]), as the smaller birds can only access the sites when fully exposed or in very shallow water. Although the camera imagery represents a small sample size, the recordings confirm the previous findings of Connolly and Colwell (2005) and suggest that shorebird foraging occurred irrespective of the presence of aquaculture. Shorebird presence in or out of aquaculture areas was primarily dependent on water levels and access to food resources in shallow water or exposed mudflat.

In terms of prey resources for shorebirds, Ferraro and Cole (2007) compared the benthic invertebrate composition among 7 different habitat types, including oyster ground culture and eelgrass, in Willapa Bay, Washington. Benthic macrofaunal communities did not differ on any of the ecological indicators evaluated in this study in either eelgrass or oyster environments. For example, infauna were similar between all habitat groups, with slightly varying contributions from each invertebrate group (Figure 3).

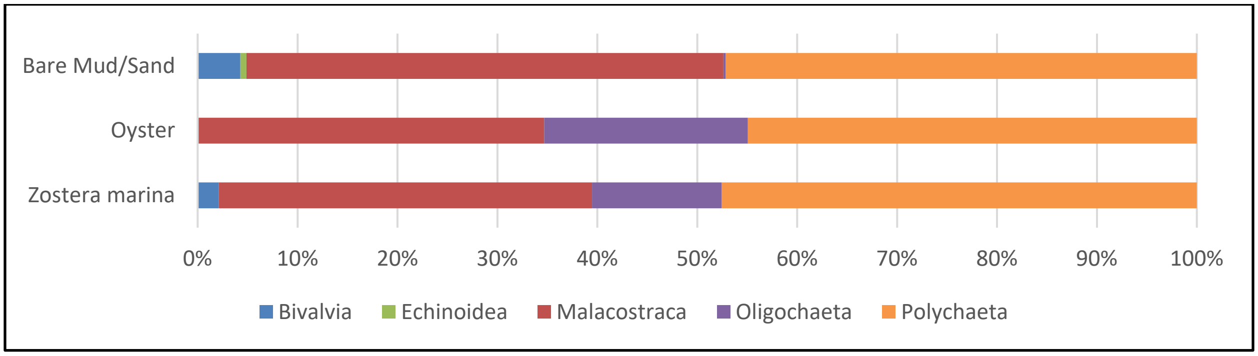

Figure 3. Percent Abundance of Benthic Invertebrates in Willapa Bay
Source: Ferraro and Cole 2007.

Ferraro and Cole (2011, 2012) expanded on this study in Grays Harbor, Washington, and Tillamook Bay, Oregon. Results of both studies indicate that the presence of benthic invertebrates in oyster culture areas along the West Coast are comparable to other structured habitats like eelgrass. In all 3 estuaries, oyster habitat had the highest values for mean species richness, abundance, and biomass of benthic invertebrates, and was considered the same as eelgrass habitat in terms of the potential to provide prey resources. In addition, both eelgrass and oyster habitats had significantly more prey resources than unstructured habitats such as bare mud and sand (Ferraro and Cole 2007, 2011, 2012).

Waterfowl

Unlike black brant, wigeon and other waterfowl are much more flexible in their ability to forage on a wide variety of vegetation, and they forage on intertidal areas for a much shorter duration of their annual cycle (i.e., in mid-winter). There is no indication that other foraging resources are limited for waterfowl in Dungeness Bay. The presence of structures (e.g., on-bottom bags) may slightly impede foraging for waterfowl.

In an Irish estuary, wigeon fed on green algae attached to oyster culture structures, which indicates a willingness to enter and utilize the structures when the tide was high enough to allow them to swim amongst the structures (Higerloh et al. 2001). Therefore, waterfowl are not likely to be constrained from foraging in shellfish beds except when tide levels are too low to allow access to the farm by water.

4.3.2 Human Disturbance

Leased areas will be visited with varied frequency for routine maintenance and harvest activities, averaging 1-2 days per week. Related to these activities, noise will be generated from small boats, movement and maintenance of oyster cultivation gear, small boat-based hydraulic lifts, and verbal communication among aquaculture workers. As described above, the Jamestown S'Klallam Tribe estimates 50-90 visits to the farm per year. Boat traffic and the presence of personnel associated with visits to shellfish culture sites could disturb shorebirds and waterfowl, cause birds to flush from foraging areas, and reduce temporal and/or spatial access to food. As discussed in section 3.3.2, boat speed and species tolerances affect the potential for birds to be flushed by boat traffic, with most flushing occurring at less than 25 meters from passing boats (e.g., Bratton 1990). Kelly (2001) noted that although workers were present in 62% of their counts, the distribution of gulls was not related to presence of workers and that there were "no movements of shorebirds into or out of plots in response to human activities." While shorebirds are likely to respond to human activity on the aquaculture plots, observations reported by Kelly et al. (1996), suggest that shorebirds are unlikely to move away from the aquaculture farm and that the farm's presence is unlikely to significantly affect their distribution.

Migratory Shorebirds

Larger shorebirds, such as curlews and black-bellied plovers, are also susceptible to human disturbance. As noted above, black-bellied plovers were found in oyster longlines plots less than in control plots (Connolly and Colwell 2005). Both curlews and black-bellied plovers demonstrate territoriality in wintering areas (Danufsky and Colwell 2003) and their distribution in intertidal areas may be spaced to reflect winter territories. However, these birds are unlikely to experience substantial human disturbance given the infrequent access to the farm on an annual basis, and that boat traffic in subtidal channels results in little disturbance to shorebirds. Although some territories of curlews and black-bellied plovers may be occasionally impacted, the small potential for individual disturbance is not expected to result in population-level responses that are sufficient to result in a significant impact. Most species of shorebirds have been shown to readily forage in aquaculture plots and may benefit from resources associated with oyster culture.

Waterfowl

As described above, a reduction in mass gain and increase in stopover time was predicted at a 10% level of disturbance for black brant (Stillman et al. 2015). Although energetic requirements and ability to gain mass are likely different for other waterfowl that have different (and more varied) diets, the Stillman et al. (2015) energetics model represents a valid framework for assessing effects of disturbance. Given the limited increase in boat trips and disturbance, the Project is not anticipated to result in sufficiently high levels of disturbance to cause measurable differences in bay-wide foraging, weight gain, or stop-over durations compared to existing conditions. Waterfowl in the bay are already somewhat habituated to the current level of human disturbance from boat traffic and other activities within and surrounding the Refuge. Therefore, any additional energetic costs to waterfowl associated with increased human disturbance generated by the proposed Project are considered less than significant.

5.0 SUMMARY

The scientific record does not support a conclusion that shellfish farming negatively impacts bird use of estuaries. Based on anecdotal observations and existing literature, marine shorebirds, seabirds, and raptors are known to occur on (or near) similar aquaculture activities and gear as would be used by the Tribe for the proposed Pacific oyster aquaculture operations without incident. Based on over 100 years of aquaculture in Puget Sound and California and observations in and around aquaculture gear, the potential for negative interactions appears to be an insignificant risk with proper farm management. Based on the potential to increase foraging opportunities, there may be a net benefit or a neutral effect to birds that use Dungeness Bay.

While there is the potential to negatively affect behavior and foraging for certain species through disturbance (e.g., noise) related to farm activities (Kaiser et al. 1998, Kelly 2001, Connolly and Colwell 2005, Forrest et al. 2009), these effects are expected to be minimal at this site due to the limited scale of activities, the limited total area where activities will occur, and the lack of eelgrass forage resources on-site for brant. Much of the bird activity in Dungeness Bay occurs during winter months when low tides occur at night. Therefore, avoidance and minimization best farm management practices combined with the timing of aquaculture activities limits the potential for effects to birds.

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