3.0 Affected Environment, Potential Impacts and Mitigation

Detailed characterization of pre-project baseline conditions of the affected environment is important for understanding the biological resources and vessel traffic patterns of Totten Inlet that may be potentially impacted by changes resulting from the proposed mussel culture project. Baseline information also provides a basis for estimating the degree of significance of the response to these changes, and for evaluating changes that may be observed during mussel production. If there are significant impacts from the proposed project, mitigation measures will be required to avoid, minimize, or restore affected resources or conditions.

Following Thurston County’s Determination of Significance for the proposed project, and in accordance with the Findings of Fact, Conclusions of Law, and Decision of the Thurston County Hearing Examiner (June 18, 1999), Taylor Shellfish Company, Inc. (Taylor) commissioned several studies to address the four primary biological issues identified for study in a limited-scope EIS:

1. Impacts to bottom-dwelling organisms (benthic community)
2. Impacts to the surrounding water column
3. Impacts to the phytoplankton resource, and the effects this could have on other aquaculture and aquatic life in Totten Inlet.
4. Impacts caused by escapement and propagation of mussels.

The studies conducted include several biological and biochemical studies prepared by Dr. Kenneth M. Brooks of Aquatic Environmental Sciences; water circulation studies conducted by Evans Hamilton, Inc. (2006 and 2008), and a comprehensive assessment of potential water column impacts of mussel raft culture in Totten Inlet by NewFields Northwest (2009). Much of this information was generated by examination of conditions at the proposed site and at existing nearby mussel culture operations in Totten Inlet (for example, the Deepwater Point mussel farm used as a reference site), as well as other areas of Puget Sound and around the world. To assure that the Best Available Science was used in this EIS, Thurston County selected an Independent Technical Review Committee (ITRC) to review and comment on all documents prepared by consultants to Taylor, Inc. to address the four biological issues. The ITRC is comprised of a group of distinguished scientists:

<table>
<thead>
<tr>
<th>Independent Technical Reviewer</th>
<th>Area of Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.E. Jack Rensel, Ph.D.</td>
<td>Phytoplankton, algal blooms, and effects on benthic organisms and finfish.</td>
</tr>
<tr>
<td>Rensel Associates Aquatic Science Consultants</td>
<td></td>
</tr>
<tr>
<td>Mitsuhiro Kawase, Ph.D.</td>
<td>Physical oceanography: Flushing characteristics (circulation) and water quality (eutrophication).</td>
</tr>
<tr>
<td>University of Washington School of Oceanography</td>
<td></td>
</tr>
<tr>
<td>Jan Newton, Ph.D.</td>
<td>Biological oceanography: Water quality (nutrients, oxygen) and phytoplankton productivity.</td>
</tr>
<tr>
<td>University of Washington, Applied Physics Lab</td>
<td></td>
</tr>
<tr>
<td>Ralph Elston, Ph.D.</td>
<td>Mussel genetics: potential escapement and competition issues.</td>
</tr>
<tr>
<td>AquaTechnics, Inc.</td>
<td></td>
</tr>
<tr>
<td>Roger Newell, Ph.D.</td>
<td>Water column and benthic community effects.</td>
</tr>
<tr>
<td>University of Maryland, Horn Point Laboratory</td>
<td></td>
</tr>
</tbody>
</table>
The Independent Technical Review (ITR) process occurred over a period of 9 years (2001–2009) while the technical studies were being prepared. Key information from these independently-reviewed technical studies is summarized in this chapter to describe elements of the environmental baseline and potential effects from construction and operation of the proposed mussel farm. Proposed, required, and other possible mitigation measures are described for each element of the environment below.

3.1 Water

Totten Inlet is one of five embayments in the southern portion of South Puget Sound. It serves as a drainage basin for the Kennedy Creek-Goldsborough Creek watershed, an area dominated by silvicultural and rural residential land use. The inlet is a tidally-influenced, marine embayment classified by the Washington State Department of Ecology as “Extraordinary” (Class AA) waters, indicating that it is a water body that “markedly and uniformly exceeds the requirements for all or substantially all uses” (WAC Chapter 173-201A).

3.1.1 Circulation

**AFFECTED ENVIRONMENT**

Totten Inlet is one of five long, narrow inlets that make up the southern portion of South Puget Sound. The entire Totten Inlet marine water covers a total surface area of 21,000,000 m² (5,189 acres) at 0.0 ft Mean Lower Low Water (MLLW), with an intertidal area of approximately 850,000 m² (210 acres) (Brooks 2000). Relative to the deeper bays in Puget Sound, Totten Inlet is a shallow basin, with a mean depth (0.0 ft MLLW datum) of 8.5 m (28 ft) and a maximum depth of 35 m (115 ft). The average depth is skewed by the long shallow basins in the south. Average offshore depths in the main basin, North Totten Inlet, typically range from 9 to 24 m (30 to 80 ft). Totten Inlet is hydraulically connected to Pickering and Squaxin Passages and to South Puget Sound at its northern terminus (Figure 3-1). The inlet entrance is approximately 600 m (1,969 ft) wide, and has a sill depth of 14.6 m (48 ft).

Totten Inlet is primarily oriented in a southwest to northeast direction, and is divided into a main basin and two distinct inlets, Inner Totten Inlet and Little Skookum Inlet in the south. The main basin is further divided between the deeper northern portion and a shallower southern portion. The northern portion, between the mouth and Windy Point, averages about 18 m (59 ft) deep, with a linear distance of approximately 3.5 km (2.2 mi) and width of 1.1 km (0.7 mi). The southern portion extends from Windy Point south toward the entrances of Skookum Inlet and Inner Totten Inlet, and averages 8 m (26 ft) deep with a linear distance of approximately 2.7 km (1.7 mi) and an average width of 2.2 km (1.4 mi). Little Skookum Inlet and Inner Totten Inlet are generally very shallow (<3 m (10 ft) of water depth), and are approximately 5.6 km (3.5 mi) in length. Totten Inlet receives its primary direct freshwater input from the Kennedy Creek, Skookum Creek, and Schneider Creek watersheds (WSCC 2003). The area receives 127 to 178 centimeters (cm) (50 to 70 inches) of rainfall annually (WDOE 2002), with much of this input occurring between October and March (Brooks 2000; WSCC 2003). The site of the proposed mussel farm is located in the northern portion of the inlet.

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1 A CD of electronic files of documents produced during the Independent Technical Review process is available from the Thurston County Resource Stewardship Department upon request.
Figure 3-1. Hydraulic Linkages between Totten Inlet and surrounding Water Bodies in South Puget Sound, Washington (source: Newfields 2009).
Water currents and circulation in North Totten Inlet were surveyed by Evans-Hamilton (EHI) in 2005, with supplemental survey results provided in 2008 (EHI 2008). The first study (EHI 2006) focused on the “over-all” flushing and circulation of Totten Inlet based on conducting current measurements and water property measurements during one complete tidal cycle on September 26, 2005, as well as long-term (one month) in-situ data collection at the proposed mussel farm site (Figure 3-2). Methods used are described in the *Totten Inlet Circulation Study* (EHI 2006), and the *Totten Inlet Mussel Farm Drogue Study* (EHI 2008).

The *Circulation Study* (EHI 2006) presented numerous oceanographic data products in the form of color current profiles, x-y plots, tabular text, and charts, in relation to the tidally-forced circulation and water properties of Totten Inlet. These data are presented in the Appendix to the EHI report (2006). Equipment descriptions are also attached at the end of that Appendix.

EHI determined current velocity and direction by use of an acoustic Doppler current profiler (ADCP) mounted on a survey vessel that measured vertical and horizontal particle velocity throughout the entire water column (from the bottom to the surface) at a single point, then linked each individual profile collected along a transect together to form a current profile for both velocity and direction across an inlet-wide transect. Four transects were surveyed on six occasions across North Totten Inlet (Figure 3-2) during a full tidal cycle (1.0 ft MLLW at low tide through 13.3 ft MLLW at high tide to second 7.7 ft MLLW at low tide) from 15:15 on September 26 to 02:30 on September 27, 2005. Mean range and spring ranges at the entrance (near the village of Arcadia [Figure 3-3]) are 10.4 ft and 14.4 ft, respectively. The proposed North Totten Inlet mussel farm site is located on Transect 3. Data from transects were collected starting at the beginning of the flood tide and finishing at the end of the ebb tide (Figure 3-2). In total, twenty-five transects were recorded, including a final run of transect line 3 over the acoustic Doppler profiler (ADCP) site before demobilizing.

In addition to the transect surveys, a stationary ADCP was placed at the site of the proposed North Totten Inlet mussel farm. The ADCP continuously recorded horizontal and vertical velocity from the entire water column at the site of the proposed North Totten Inlet mussel farm over the period of one month. The unit was deployed from October 27, 2005 to November 29, 2005.

The summarized results showed some general current patterns. At the ebb-slack prior to the flood tide, water entered North Totten Inlet with a mean velocity of 25 cm/sec (0.83 ft/sec), with lower inward flow velocities occurring at the surface at Transects 1, 2 and 3. Toward the widest portion of the Inlet (Transect 4), flow was slower (~10 to 15 cm/sec) (0.33 to 0.5 ft/sec) with more variable direction, indicating that the transition from slack to flood water movement was just starting.

During the flood tide, higher velocity current (>50 cm/sec or >0.67 ft/sec) entered the Inlet (Transect 1) along the northwestern shore, with a back eddy (<25 cm/sec or <0.83 ft/sec) forming along the southeastern shore of the entrance. South of the inlet mouth (Transect 2), the higher velocity water followed the deeper portion of the Inlet, with velocities of >25 cm/sec (>0.83 ft/sec) along the southeastern shore. Inside of Windy Point (Transects 3 and 4), the Inlet widens and current velocities and direction became more uniform in the main channel. At the site of the proposed North Totten Inlet mussel farm, velocities were <50 cm/sec (<20 in/sec), and the depth-averaged velocity peaked at 25 cm/sec (0.83 ft/sec). A slower counter current was observed along the northwestern shoreline toward the end of the flood cycle.
Figure 3-2. North Totten Inlet Over-the-Side Acoustic Doppler Current Profiler (OTS-ADCP) Transect and Acoustic Doppler Profiler (ADP) Locations (source: Evans-Hamilton Inc. 2006).
Figure 3-3. Location of Proposed Mussel Farm in North Totten Inlet, Washington (source: Newfields 2009).
At the end of the flood tide, water continued to enter North Totten Inlet along the south bank but at lower velocities. Reverse flow velocity along the northwestern shore exceeded the inbound flow velocity along the south shore. At Transects 2 and 3, inbound water continued in the main channel; however, flow reversal had begun along both banks of the Inlet. During the ebb tide, outbound water was observed bank to bank throughout most of North Totten Inlet, with some lateral mixing toward the mouth of the Inlet. Velocities during the ebb tide were generally lower throughout North Totten Inlet; however, it is important to note that the tidal exchange during the ebb was substantially less than that of the flood. Data collected using the fixed ADCP at the site of the proposed North Totten Inlet mussel farm indicate that the depth-averaged flow velocities approach 25 cm/sec (0.83 ft/sec) during larger ebb events (EHI 2006 Appendix A, Figure 39).

These data indicate that flushing occurs through consistent, low-velocity water movement during flood and ebb cycles. Water was constantly moving during the tidal cycle (it does not stop or stagnate). Peak currents at the site ranged from 25 to 50 cm/sec (0.83 to 1.67 ft/sec), with the depth-averaged mean velocity generally ranging from 5 cm (0.17 ft) to 25 cm (0.83 ft)/sec. Slower current velocities and more variable current direction were observed south of the site of the proposed North Totten Inlet mussel farm, corresponding to the widening of the inlet.

Current movements and the fate of parcels of water from the North Totten Inlet site were evaluated in drogue (drifter) studies conducted by Brooks (2005). A drogue is a buoyant kite-like aquatic device that floats within the same parcel of water and is routinely used to track water current, (Figure 3-4). Drogues with panels approximately 0.6 m² (6.5 sq ft) were deployed from the site of the proposed North Totten Inlet mussel farm at depths of 1.5 m (4.9 ft), 7.5 m (24.6 ft), and 15 m (49.2 ft) during the spring ebb tide and the neap ebb and flood tides. During the spring ebb tide (from +11.0 ft to -2.8 ft MLLW; Arcadia mean spring range is 14.4 ft), both the surface (1.5 m) (4.9 ft) and mid-water (7.5 m) (24.6 ft) drogues moved from the North Totten Inlet site to the mouth of Totten Inlet. The subsurface drogue also moved north but did not travel past the base of Sandy Point. Drogues deployed during the flood (from -2.8 to 15.7 ft MLLW) moved southwest toward a small cove off of Hargis Street (Figure 3-3). During the neap flood, the drogues moved towards the Hargis Street cove, and then north into the central basin. The extent of drogue travel during one tidal cycle did not extend beyond the central basin (Brooks 2005).

In 2008, EHI conducted an additional drogue study, using drogues with larger panels (approximately 1 m² [10.8 sq ft]) and low resistance surface buoys (EHI 2008). This study was designed in conjunction with Rensel Associates Aquatic Sciences, the University of Washington, and Taylor. Drogue releases targeted a spring tide on May 20, 2008 and a neap tide on May 29, 2008, both intended to capture a mean tidal exchange. On May 20, 2008, drogues were released from the North Totten Inlet site during different stages of the ebb tide (12.8 ft to -1.5 ft MLLW). Drogues moved northward, parallel to shore towards Sandy Point and Steamboat Island. Those drogues released during the first hour after the slack tide were likely to have moved out of the Inlet; however, grounding and fouling prevented a clear determination of the northern extent of the spring ebb. Those drogues released three hours after the beginning of the ebb moved approximately 750 to 2,000 m (0.47 mi to 1.24 mi) north (south of Sandy Point) before turning southward during the ebb-slack. On May 29, 2008, drogues were released at different stages of the ebb and flood tides (3.3 ft to 9.7 ft to 4.2 ft MLLW). Drogues released during the ebb moved approximately 1,500 m to 3,000 m (0.93 to 1.86 mi) north along the eastern shoreline to the base of Sandy Point. During the flood tide, drogues moved to a location similar to the Brooks (2005) survey, approximately 1,200 m (0.75 mi) south of the North Totten Inlet site, offshore of the Hargis Street cove. Observations from both the Brooks (2005) and EHI (2008) surveys indicate that the southerly extent of the spring and mean tidal excursion from the North Totten Inlet site is approximately 1,200 m (0.75 mi) south of the North Totten Inlet site in the south-central basin. The northerly extent during the ebb is Sandy Point during mean tides and the mouth of the Inlet during spring tides. This gives the extent of the immediate potential impact from the proposed mussel raft site.
Figure 3-4. X-Shaped Drogue of Rip-Stop Nylon
Current signature resulting from the presence of the new mussel raft may be found 1.2 km (0.75 mi) further into the inlet landward and to the mouth of the inlet seaward.

“Water mass residence time” refers to the amount of time it takes for a volume of water within a basin to be replaced with water from outside the system. Residence times are a useful index because they represent the degree of water mixing, with systems that have short residence times being the most connected to adjacent water bodies. Several studies have estimated water residence time in Totten Inlet (EDAW [1998], Brooks [2000], and Albertson et al. [2001]). Using mean flow, the residence time was calculated by Albertson et al. (2001) to be 4.0 days, with a mean flow of 620 m³/sec (163,787 gallons/gal/sec). This relatively short residence time, compared to other South Puget Sound inlets, was likely due to weak stratification (i.e., formation layers of water with different temperature or salinity properties) present in Totten Inlet. It can be concluded from these approaches that water mass residence time in Totten Inlet is relatively brief, with the most accurate model pointing to about 4 days and other more simple models indicating up to 11 days. It is noteworthy that the flushing rate is much faster in the northern end of the inlet (where the North Totten Inlet mussel farm site is proposed) compared to the southern end of the Inlet (Newfields 2009).

The results of the studies summarized above indicate that the proposed North Totten Inlet mussel farm site is well flushed. It appears that water passing through the site can, within a few tidal cycles at most, be transported to the mouth of the Inlet (Newfields 2009).

**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be little risk of adverse impact to water circulation in Totten Inlet during construction because fabrication of mussel raft parts will occur on land at the Taylor Shellfish Lynch Road plant in Mason County, and assembly of the rafts will occur on the beach at the Taylor Shellfish Totten Inlet Old Plant site near Hargis Street (see Figure 3-3).

**Potential Operational Impacts**

**Alternative 1 (Preferred):** The effects of mussel rafts on water circulation within North Totten Inlet were examined using two models: the Alden Model developed by Alden Research Laboratory (2003), based on observations made at the Deepwater Point mussel rafts; and the Blue Hill model: a model developed by Blue Hill Hydraulics (2006) based on the Alden (2003) model and modified to reflect the physical characteristics of the site of the proposed North Totten Inlet mussel farm. These analyses are presented in their entirety in Appendices B and C of the *Assessment of Potential Water Column Impacts of Mussel Raft Culture in Totten Inlet* (Newfields 2009). The detailed raft-scale models predicted the attenuation (slowing) of water flow caused by the floating rafts.

As water entered the simulated raft array using the above-mentioned model, current velocity was reduced inside the rafts and increased outside the rafts (Figures 3-5 and 3-6). With raft strings oriented with the long axis parallel to the predominant direction of flow (i.e., parallel to the shoreline), current velocity inside the raft perimeter was reduced by 60 percent to >80 percent of ambient conditions during (depth-averaged) velocities of 15 cm/sec (6 in/sec).
Figure 3-5. Current Velocity in a String of Six Rafts Based on a Current Velocity of 25 cm/sec (source: Alden Research Laboratory 2003).

Figure 3-6. Modeled Current Velocities in the Vicinity of the Deepwater Point Raft Arrays Based on an Incoming Velocity of 25 cm/sec (source: Newfields 2009).
Mean currents recorded at the Deepwater Point mussel farm on June 18, 2002 (incoming current velocities of 5 to 8 cm/sec [2 to 3 in/sec]) showed slowing of water within a string of six rafts to 1 to 3 cm/sec (0.4 to 1.2 in/sec), as well as a doubling of ambient current speeds along both sides of the string to velocities of >15 cm/sec (>6 in/sec). This difference in current velocity indicated that the volume of water passing through the rafts was considerably lower than the volume of water passing on either side of the raft.

Current velocities around the Alternative 1 layout of mussel rafts would be expected to increase above ambient velocities. The differential in velocities of the raft-affected water versus ambient water generates a large amount of horizontal and vertical mixing energy. The turbulent eddy and associated eddy friction create a large down-current eddy that mixes ambient water with raft-influenced water. Mathematical models of current flow indicated that rows of rafts that are further from the shoreline return to ambient conditions almost immediately of the down-current edge of the string (Figures 3-7 through 3-9). Raft-affected water (which can be envisioned as a “tail” down-current of a raft) persisted over a greater distance down-current of the raft unit, up to 230 m (755 ft) down-current, and this would also be expected from the eight raft units proposed with Alternative 1 of the North Totten Inlet mussel farm.

To make an estimate of percentage difference between Alternative 1 and Alternative 2, the surface footprint area of the three-dimensional volume of affected water can be calculated as a surrogate for the volume of water affected. A calculation for Alternative 1 (assuming these 8 tails are 10.4 m [34 ft] wide and 230 m [755 ft] long) would be 9,568 m² (2.36 acres).

The differential in current velocity creates a differential in the volume of water that is predicted to pass through the rafts. The volume of water passing inside the rafts was compared to the volume of water in the immediate vicinity (within 5 m [16 ft]) and volume passing through Totten Inlet. Volume of water passing through the arrays was calculated using the cross-sectional area of the array face and the velocity of water observed in the rafts. Based on modeling, this differential represented approximately 1.56 percent of the water passing through the immediate vicinity of the proposed North Totten Inlet rafts. Based on the EHI ADCP survey, the cross-sectional area of Totten Inlet at the North Totten Inlet site was estimated at 22,500 m² (5.56 acres). Using a depth-averaged current velocity of 15 cm/sec (5.9 in/sec), the volume of water passing through the portion of Totten Inlet represented by Transect 3 (Figure 3-2) would be 3,375 m³/sec (3,503 yd³) or 0.43 percent of the total volume of water passing through the cross sectional transect of North Totten Inlet (Newfields 2009). This effect is not likely to cause a significant adverse impact on the environment because the differences in velocity are low and such a small percentage of the water is affected.

Alternative 2 (Two-Row): With Alternative 2, water currents around and through the raft units would be similar to those of Alternative 1. For Alternative 2, there would be 10 raft units creating a “tail” of raft-affected water; however, the raft units would be arrayed in two, 5 raft-unit rows 64 m (210 ft) apart. The “tails” of raft-affected water from the up-current row of raft units would likely overlap the down-current row of raft units, thus creating five zones of raft-affected water (“tail”) approximately 343 m (1,125 ft) down-current from the up-current raft units.

If it is assumed that Alternative 2 raft units are 12.2 m (40 ft) wide and each “tail” would be a triangle 343 m (1,125 ft) down-current, that would equate to surface area of 2,090 m² (22,500 sq ft) for each pair. For five pairs of rafts, the total area of effect would be 10,450 m² (2.58 acres). The similar calculation for Alternative 1 is 9,568 m² (2.36 acres). Alternative 2 would have 9.2 percent more effect compared to Alternative 1. This difference is small, however, and, as with Alternative 1, Alternative 2 would not be likely to have a significant adverse impact on the environment.
Figure 3-7. Modeled Current Velocities in the Vicinity of the Proposed North Totten Inlet Mussel Raft Arrays Based on an Incoming Velocity of 5 cm/sec (source: Newfields 2009).

Figure 3-8. Modeled Current Velocities in the Vicinity of the Proposed North Totten Inlet Mussel Raft Arrays Based on an Incoming Velocity of 15 cm/sec (source: Newfields 2009).
Figure 3-9. Modeled Current Velocities in the Vicinity of the Proposed North Totten Inlet Mussel Raft Arrays Based on an Incoming Velocity of 25 cm/sec (source: Newfields 2009).
Alternative 3 (No Action): Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no physical presence of rafts, and no potential changes to the local water flow (ambient current velocity).

MITIGATION MEASURES

Incorporated Features

The raft arrays will be arranged parallel to the tidal currents to minimize the distance over which water will be slowed. By design, the downstream areas influenced by the rafts will not include sensitive intertidal and shallow subtidal zones for either alternative.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended for effects on water circulation because the impacts of the proposed project would be insignificant.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to water circulation as a result of the proposed project with either action alternative.

3.1.2 Water Quality

3.1.2.1 Dissolved Oxygen

Dissolved oxygen (DO) is a major area of concern to be examined with aquaculture site plans, both for the good of the environment and the good of the cultured species.

AFFECTED ENVIRONMENT

Dissolved oxygen (DO) in Totten Inlet was evaluated using direct measurements at the North Totten Inlet site, as well as long-term and transect studies at the existing Deepwater Point mussel rafts. DO concentration at the Deepwater Point site ranged from 4.5 to >10 mg/L [ppm]. DO concentrations at the site of the proposed North Totten Inlet mussel farm, as well as from Windy Point on the west side of the Inlet, ranged from 7.1 to 14.7 ppm at the surface (0.5 to 1.0 m [1.6 to 3.3 ft] depth), and 5.9 to 13.0 ppm at the maximum depth sampled. The lowest DO concentrations were generally observed during the months of August to November.

The biological stress concentration benchmark is 5.0 ppm, depending on temperature and salinity. As DO concentrations drop below about 5.0 ppm, an organism becomes increasingly more stressed, more susceptible to disease, or potentially at low values even dies from suffocation if it cannot move away to better conditions. Higher DO concentrations are good, allowing organisms to thrive.
In a report prepared for and with the U.S. Environmental Protection Agency (USEPA) Puget Sound Estuary Program, Rensel Associates and PTI Environmental Consultants (1991) calculated the percentage of time when the concentration of subsurface dissolved oxygen (at depths of 10 meters [33 ft]) was less than 5 mg/L milligrams per liter (mg/L or parts per million [ppm]), in the same time frames during the 1980s. For Totten Inlet, the result was zero percent.

A recent report by the Washington Department of Ecology (WDOE) (2008) focuses on South Puget Sound water quality. Figure 3-10 shows some of the results that demonstrate that Totten Inlet and in particular Northern Totten Inlet has the best conditions in all of South Puget Sound in terms of near-bottom DO.

**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be no risk of adverse impact to dissolved oxygen during mussel raft construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

**Potential Operational Impacts**

Alternative 1 (Preferred): Existing data and the application of predictive modeling indicates that although DO may be significantly reduced within the proposed 58-raft mussel farm, it will generally remain above the biological stress concentration of 5.0 milligrams per liter (mg/L) (parts per million [ppm]). Mathematical models predicted that DO concentrations at the proposed mussel aquaculture site would be generally reduced from 0 percent to 30 percent (70 percent maximum), as water passed through the mussel rafts. Changes in DO are likely to be tied to current velocity and seasonal fluctuations in ambient DO (Newfields 2009).

Observations from the Deepwater Point site may overestimate low DO events for the site of the proposed North Totten Inlet mussel farm due to lower ambient DO concentrations in the summer period. During periods of low ambient DO (late August and early September), dissolved oxygen concentrations below 5.0 mg/L (ppm) would be expected to persist some distance down-current from the raft edge. However, once the water exits the raft, it will likely recover to ambient DO concentrations within 70 to 200 m (230 to 656 ft) or less, due to entrainment of surrounding waters and from increased mixing caused by turbulence from the presence of the raft structure (Newfields 2009). These distances may be somewhat longer with Alternative 1 (six, 7-raft units and two 8-raft units) compared to the six, 6-raft units that were modeled from the Deepwater Point site.

Alternative 1 would create eight “zones of decreased oxygen” 70 to 200+ m (230 to 656 ft+) in length. To make an estimate of percentage difference between this alternative and Alternative 2, the surface footprint area of the three-dimensional volume of affected water can be calculated as a surrogate (since neither scenario was modeled) for the volume of water affected. If it is assumed that Alternative 1 raft units are 10.4 m (34 ft) wide and the “zone” will be a triangle ranging from 70 to 200 m (230 to 656 ft) down-current, that would equate to surface area of 2,906 to 8,288 m² (0.72 to 2.05 acres).
Figure 3-10. Near-Bottom Dissolved Oxygen Levels (mg/L) for South Puget Sound in September (WDOE 2008). Values not corrected with laboratory Winkler results.
Alternative 2 (Two-Row): Under Alternative 2, there would be 10 raft units creating “zones” of lowered DO; however, the rafts would be arrayed in two, 5 raft units 64 m (210 feet) apart. The lowered DO “zones” from the up-current row of rafts would likely overlap the down-current row of raft units, thus creating five zones of lowered DO from 183 to 313 m (600 to 1,026 ft) down-current from the up-current raft units.

To make an estimate of percentage difference between the two alternatives, it is assumed that Alternative 2 raft units will be 12.2 m (40 ft) wide and the “zone” will be a triangle ranging from 183 to 313 m (600 to 1,026 ft) down-current, that would equate to surface area of 5,574 to 9,532 m^2 (1.38 to 2.36 acres). From the calculation for Alternative 1 above, the surface area would range between 2,906 to 8,288 m^2 (0.72 to 2.05 acres).

If 70 m (230 ft) “zones” to DO recovery are assumed for Alternative 1, Alternative 2 would have 91.8 percent more effect compared to Alternative 1. If 200 m (656 ft) “zones” are assumed for Alternative 1, Alternative 2 would have 15.0 percent more effect compared to Alternative 1.

This difference is small, however, and as with Alternative 1, Alternative 2 would not be likely to have a significant adverse impact on the environment, because it will generally remain above the biological stress concentration of 5.0 mg/L (ppm).

Alternative 3 (No Action): Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no effects on DO from the proposed project. Existing mussel rafts in Totten Inlet would continue to operate: the Gallagher Cove 21-raft farm, and the Deepwater Point 48-raft farm operated by Taylor Shellfish, and the floating long-line system operated in the Deepwater Point area by Kamilche Sea Farms.

MITIGATION MEASURES

Incorporated Features

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The Taylor Shellfish Farms Environmental Code of Practice (April 2010), included in Draft EIS Appendix A lists primary BMPs on pages A-6 through A-8 that will be utilized in operating the proposed North Totten Inlet mussel farm.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No other mitigation measures are proposed for effects on dissolved oxygen because the impacts of the proposed project would be insignificant.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to dissolved oxygen as a result of the proposed project with either action alternative.
3.1.2.2 Nutrients

AFFECTED ENVIRONMENT

The key nutrients of concern related to mussel raft culture impacts to nutrients in the water column include silicate (SiOH$_4$), phosphorus (as PO$_4$), and dissolved inorganic nitrogen (DIN), which is the sum of all three nitrogen species (NO$_2$+ NO$_3$+ NH$_4$). Site-specific parameters for nutrients were measured at water quality sampling stations monitored by WDOE (as a part of its Marine Water Quality Monitoring Program); measurements taken at the site of the proposed North Totten Inlet mussel farm location by Brooks (2005); and measurements taken at an existing mussel raft in Totten Inlet by the Pacific Shellfish Institute (Cheney et al., unpublished data). Methods and technical details of results are presented in Newfields (2009).

Silicate. The primary sources of dissolved silicates in marine waters are river input and rock weathering. Silicates are used by diatoms and a few invertebrates with silicified structures. A general seasonal pattern for silicates in South Puget Sound is characterized by peaks in the winter followed by regional depletion in the spring, most likely due to diatom blooms. Regeneration (silicates being released as the diatom blooms fade and the organisms are broken down by bacteria) occurs during the summer, with silicate concentrations nearing peak values in the fall. This pattern was observed at all three sites monitored in Totten Inlet, and silicate concentrations at 10 m (33 ft) depth were similar to those measured at the surface (see Newfields [2009] Figures 19 and 20). It is important to evaluate potential silica limitation as it can become a limiting factor in eutrophic areas where human sources of nitrogen and phosphorus are abundant. This can lead to long-term domination of the phytoplankton by dinoflagellates and microflagellates that may include harmful or toxic species.

Several studies have measured silicate (SiOH$_4$) fluxes through suspended cultures of bivalves; however, the results from these studies vary. Based on data collected by WDOE (2003c), Brooks (2005), and PSI (Cheney et al. unpublished data), however, silicate concentrations remain at least three times greater than the designated “low” silicate level of 3 M$\mu$ (Newton et al. 2002) throughout the year, indicating that even during spring diatom blooms, silicate concentrations are not limiting diatom growth.

Phosphorus. Phosphorus is an essential plant and animal nutrient necessary for many cellular reactions. It enters the marine environment through a variety of mechanisms, including rock weathering, input from rivers and streams, agricultural practices, and sewage effluent. Phosphorus is an essential nutrient for phytoplankton, though at much lower concentrations than nitrogen. The nitrogen:phosphorus ratio required by phytoplankton is approximately 16:1. Bacteria also require phosphorus, which is acquired from the breakdown of organic detritus. Regeneration of phosphorus incorporated in phytoplankton occurs through excretion by animals and bacterial action on dead and decaying organisms.

Phosphorus concentration in Totten Inlet varies seasonally. Concentrations of inorganic phosphate are relatively high in the winter, but are quickly depleted during the spring, presumably as a result of phytoplankton consumption. During the summer months, phosphorus is available primarily in a dissolved organic form. Concentrations tend to increase throughout the summer as phytoplankton cells die and zooplankton and fish release phosphorus through urea and feces production. During the fall, phosphorus continues to be regenerated into inorganic phosphorus from the organic matter in the water. Phosphorus concentrations collected in the 10 m (33 ft) samples were similar to those measured at the surface (see Newfields [2009] Figures 22 and 23).

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3 See Glossary for explanation of $\mu$M (micromolar units).
Dissolved Inorganic Nitrogen (DIN). Nitrogen inputs to coastal environments are primarily from human generated sources, including agricultural run-off into rivers and streams, sewage entering either from sewage treatment facilities or leaching into ground water from septic systems and atmospheric deposition from burning fossil fuels. There are also modest influxes from adjacent marine systems. There are several estimates of nitrogen input available for Totten Inlet. The stream/watershed input of DIN to Totten Inlet is estimated at 47,450 kg (52.3 tons) N/yr (WDOE 2003a), while sewage from septic tanks is estimated to contribute between 10,393 to 25,524 kg (11.5 to 28.1 tons) N/yr (Golder and Associates 2003; US Census Bureau 2000). Atmospheric nitrogen is predicted to enter South Puget Sound at a rate of 1,100 kg (1.2 tons) N/yr or 0.015 g N/m2/day (0.00049 ounce [oz] N/sq ft/day) (WDOE 2003a). Jennifer Ruesink’s recent work on productivity and nutrient sources in Totten Inlet has suggested a high level of N coming from human-generated sources, with concentrations increasing with distance further inside Totten Inlet from its mouth (Ruesink 2009).

Seasonal fluctuations of DIN at Windy Point and at the site of the proposed mussel rafts in North Totten Inlet site fluctuate with relatively high concentrations during late winter, followed by a rapid decrease during the spring (see Newfields [2009] Figures 25 and 26), presumably as phytoplankton production seasonally increases in response to increased sunlight and rising water temperature. A low level of nitrogen at the surface is maintained throughout the summer, most likely a result of excretion by animals, and concurrent uptake by phytoplankton. A reduction in phytoplankton populations combined with wind disturbance and terrestrial input of nitrogen from flooding during late fall and winter results in an increase of the dissolved nitrogen portion of the total nitrogen pool. Dissolved nitrogen appears to be distributed “evenly” throughout the upper 10 m of the water column. There is also a large interannual variance in median and peak values. Inner Totten Inlet appears to have a similar seasonal pattern of DIN, nitrite/nitrate (NO₂ + NO₃) and ammonium (NH₄) as observed at Windy Point (see Newfields [2009] Figures 27 and 28). For most of the year, DIN is primarily composed of nitrates and nitrites; however, ammonium becomes an important component during the summer months.

In a report prepared for and with the U. S. Environmental Protection Agency (USEPA) Puget Sound Estuary Program, Rensel Associates and PTI Environmental Consultants (1991) compiled the percentage of time during the 1980s when DIN was depleted (defined as any concentration less than 7μM DIN in surface waters from monthly observations April through October, 1981 through 1985 with Windy Point sampling data. They found it comprised 62 percent of the data and resulted in a mean DIN concentration of 2.46 μM. Of the 40 sub-areas of Puget Sound evaluated, Totten Inlet placed as the eighth most nutrient-sensitive in this tentative ranking.

Potential Impacts

Suspended mussel culture can influence nutrients in the water column in several ways. These include removal of organic and inorganic nutrients in the water column through filtration and tissue storage (Bayne et al 1987; Prins and Smaal 1989), transformation and regeneration of nutrients through excretion of ammonium and biodeposits (Foster-Smith 1975; Bayne and Scullard 1977; Kautsky and Evans 1987; Prins and Smaal 1989; and Jaramillo et al. 1992), settlement and decomposition of biodeposits (Cromeley et al. 2002; Christensen et al. 2003; and Hartstein and Stevens 2005), and development of a community of biofouling organisms (Mazoumi et al. 2001; Brooks 2003; and LeBlanc et al. 2003).

Potential Impacts during Construction

There would be no risk of adverse impact to silicate, phosphorus, or dissolved inorganic nitrogen (water column nutrients) during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.
Potential Operational Impacts

Alternative 1 (Preferred): The sections below characterize the potential impacts of the Preferred Alternative of the proposed project on the key nutrients in the water column: silicate, phosphorus, and dissolved inorganic nitrogen.

Silicate. The effects of the proposed 58-raft mussel farm on silicate were evaluated using data collected by the Pacific Shellfish Institute (PSI) in the vicinity of the existing Deepwater Point mussel rafts during the summer and fall months of 2002. Silicate concentrations appear to remain relatively constant as water passes through the mussel raft. The concentrations of silicate measured in the Deepwater Point mussel raft array were consistent with the ambient concentrations measured at Windy Point and at the proposed North Totten Inlet mussel farm site during the corresponding months.

Due to high existing concentrations of silicates in Totten Inlet, such that silicate concentrations are not limiting diatom growth (WDOE 2003c, Brooks 2005, and PSI (Cheney et al. unpublished data)), combined with the minor influence mussels appear to exert on local silicate fluxes, the addition of the proposed North Totten Inlet mussel farm will not significantly alter the silicate cycle in Totten Inlet.

Phosphorous. Effects of mussel rafts on phosphorus were evaluated using data PSI collected in the vicinity of the Deepwater Point mussel rafts during the summer and fall months of 2002. While there were some minor changes in phosphorus concentrations as water passed through the Deepwater Point raft array, there did not appear to be a significant change in phosphorus levels as a result of the array (Newfields 2009). In addition, the effect of increased phosphorus concentrations on phytoplankton populations is expected to be minimal because nitrogen is considered the limiting nutrient during the summer season (WDOE 2003b). For these reasons, the addition of the proposed North Totten Inlet mussel raft would not significantly alter phosphorus levels in Totten Inlet compared to existing conditions.

Dissolved Inorganic Nitrogen. The potential effects of the proposed new mussel rafts on nitrogen were inferred from using PSI data collected in the vicinity of the existing Deepwater Point mussel rafts during the summer and fall months of 2002. PSI measured ammonium (NH$_4$), nitrate (NO$_3$), and nitrite (NO$_2$) on select dates during June through October 2002. For this analysis, these forms of nitrogen will be referred to as DIN. Samples were collected 2.5 m below the surface (Cheney et al., unpublished data). DIN concentrations for each date and location with the mussel raft are presented in Newfields (2009) Figure 29. For all sample dates, ammonium was the principal inorganic form of nitrogen present within the mussel raft, except on October 18 where nitrates and ammonium concentrations were similar. Within a typical Deepwater Point raft, ammonium peaks occurred within the center of the raft or 3 m (10 ft) down-current with concentrations ranging from 0.53 to 5.3 µM NH$_4$ greater than reference (up-current) concentrations.

In general, the PSI data suggest that operation of a mussel culture system results in elevated concentrations of DIN (primarily NH$_4$) within its boundaries. This is in agreement with numerous studies, which have also reported mussel rafts as a source of DIN to the surrounding water column (Amus and Amus 1991, Prins et al 1995, LeBlanc et al 2003, Richards et al 2006). However, approximately 70 m (230 ft) down-current of the raft array, DIN concentrations appear to return to ambient DIN conditions. It is likely that the amount of DIN observed at the raft center is diluted by mixing with ambient water down-current of the raft.

To make an estimate of the area of effect of Alternative 1, the surface foot print area of the three-dimensional volume of affected water can be calculated as a surrogate for the volume of water affected by elevated ammonium. If it is assumed that Alternative 1 raft units are 10.4 m (34 ft) wide and the elevated ammonium “plume” was a triangle 70 m (230 ft) long down-current, the area of effect would be would be
2,906 m² (31,280 sq ft) for the eight raft units. (This will be used later to compare areas of effect between Alternatives 1 and 2.)

Seasonally, because of higher feeding by, and metabolism of mussels in warmer water, the estimated increase in ammonium excretion from the proposed mussel rafts are two to ten times greater in the summer compared to winter. Based on the field measurements and seasonal model (Newfields 2009), the proposed mussel rafts would not be expected to increase water column ammonium concentrations exceeding 5 µM, except in the late spring and early summer. Field measurements indicate that the ammonium increase is a localized event, and as such would not be expected to trigger eutrophic conditions in North Totten Inlet. It is important to note that mussels are feeding on phytoplankton growing on ambient nutrients present in South Puget Sound. This means that nutrient excretion from the cultured mussels is not a source of new nutrient inputs but is simply recycling existing nutrients. Ammonium values within the vicinity of the raft approach WDOE criteria for high concentrations of ammonium (>5 µM, Newton et al. 2002); however, as noted previously, the amount of ammonium appears to return to ambient conditions approximately 70 m (230 ft) down-current from the rafts.

Nitrogen “regeneration” is the remobilization of nitrogen from feces and pseudofeces that have deposited in sediments. Unlike excretion, not all of the deposited feces and pseudofeces are in a biologically available form of nitrogen. A portion of these materials settle in the sediments below the mussel raft, where it is broken down by either aerobic or anaerobic processes or lost to burial within and beneath sediments. The settled materials are referred to as “biodeposits.” “Remineralization” of nitrogen is the process of transforming organic to inorganic nitrogen. This is an important part of recycling nutrients from mussel raft deposits. Nitrogen released back into the environment from mussel biodeposits is a significant source of the total nitrogen flow in a system with mussel culture. Several studies have found that the degradation of biodeposits from suspended mussel culture resulted in a significant localized increase of ammonium in the water column above the sediment (Asmus et al. 1990; Hatcher et al. 1994; LaRosa et al. 2002; and Christensen et al. 2003). When viewed from the perspective of the entire Totten Inlet, however, it does not mean that more nitrogen is being regenerated; rather it means that the location of such recycling is being more focused in the region of the mussel rafts. Although the significance of nitrogen remineralization in Totten Inlet is difficult to predict it could allow for an extension of phytoplankton growth during periods of times of nitrogen limitation. The remineralization of nitrogen associated with mussel rafts appears to occur close to the sediment surface, with the signal disappearing 50 cm (20 in) above the sediment surface.

An important consideration of the effects of the proposed 58-raft mussel farm on Totten Inlet is the removal of nitrogen (N) through mussel assimilation and removal via harvest. This can be considered a beneficial remediation effect because all coastal waters, including South Puget Sound are exhibiting adverse ecological changes associated with over-enrichment by human derived nitrogen and phosphorus inputs (Cloern 2001).

Based on the percentage of nitrogen entering the raft system, approximately 27 percent would be transferred into harvested biomass. The amount of nitrogen removed by harvest is estimated to be 4,549 kg (5.01 tons) N/yr, based on the total estimated harvest of 398,169 kg (438.98 tons) whole body wet weight and a total nitrogen content of 1.14 percent (includes both soft tissue and nitrogen sequestered in the shell; Haamer 1996). The estimate for nitrogen removal associated with the fouling community is based on observations by Brooks (2005), and indicates anemones comprise 90 percent of the fouling community and other species, including bivalves comprise 10 percent of the total. The estimated biomass associated with anemones at harvest is 11,961 kg (13.19 tons) dry weight (dw) and for other species is 2,953 kg (3.26 tons) dw. If the “other species” are assumed to be soft-body tissues of bivalves, the

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4 See Glossary for explanation of µM (micromolar units).
predicted whole body weight (assuming 7.7 percent of whole body wet weight is shell-free dry weight – (Newfields [2009] Table 1)), the whole body wet weight of fouling bivalves is 38,350 kg (42.28 tons) wet weight. Based on a nitrogen content of 8 percent for the soft-bodied anemones and 1.14 percent of wet weight for bivalves, the total nitrogen removal associated with the fouling community is estimated at 1,393 kg (3,071 lb) N or 1,044 kg (2,302 lb) N/yr. This is similar to the estimate generated using the Rodhouse model, which predicts that 13 percent of the total or 1,083 kg (2,388 lb) N/yr will be removed with the associated fouling community (presuming that the fouling community is removed from the Inlet during harvest).

Nitrogen removal by the Alternative 1 configuration of the North Totten Inlet mussel farm would represent approximately 23 percent to 54 percent of the nitrogen introduced to Totten Inlet by human activities. An estimated 10,939 to 25,524 kg (12.06 to 28.14 tons) N per year is predicted to enter Totten Inlet from human sewage-related sources based on the formula used in the Hood Canal Dissolved Oxygen Study and Year 2000 Census data (Golder and Associates 2003; US Census Bureau 2000). Much of the ammonia-nitrogen that passes through an on-site septic system is oxidized to NO₂ and NO₃, with 30 percent to 70 percent of nitrogen entering the groundwater, based on an EPA study of on-site septic systems (PSAT/HCCC 2004). Once in the groundwater, the nitrates and nitrites eventually move down-gradient into the receiving marine waters. Ruesink (2009) showed that N from human-caused sources is assimilated into marine organisms.

**Summary of Potential Operational Impacts to Nutrients:** The proposed North Totten Inlet mussel farm is not expected to significantly alter silicates in or near the rafts. Silicate concentrations in Totten Inlet remain at least three times greater than the designated “low” silicate level of 3 μM throughout the year. This indicates that even during spring diatom blooms, silicate concentrations are not limiting diatom growth.

While there were some minor increases observed in phosphorus concentrations as water passed through the Deepwater Point mussel raft array, there does not appear to be a significant change in phosphorus levels as a result of the array.

Inorganic nitrogen concentrations are expected to increase in the immediate vicinity of the proposed mussel farm during warmer months with longer periods of daylight (June through September), with ammonium as the principal form present within the mussel raft. Both data collected within the Deepwater Point mussel farm and predicted concentrations for North Totten Inlet mussel farm approach WDOE criteria for high concentrations of ammonium (>5 μM). Once the water passes 70 m (230 ft) beyond the raft system, however, the change in ammonium concentration was no longer detectable. Remineralization of nitrogen associated with sediments below and down-current of mussel rafts may represent a source of DIN during periods of nitrogen limitation. The magnitude of this effect is unknown as it is site specific and varies depending on how much is permanently buried in sediments and the nature of the sediments and overlying water column. Based on the percentage of nitrogen entering the raft system, approximately 27 percent would be transferred into harvested biomass. The amount of nitrogen removed by harvest is estimated to be 4,549 kg (5.01 tons) N/yr. The total nitrogen removal associated with the fouling community is estimated at 1,393 kg N or 1,044 kg N/yr. Nitrogen removal by harvesting mussels from the North Totten Inlet rafts would represent approximately 23 percent to 54 percent of the estimated anthropogenic nitrogen introduced to Totten Inlet.

**Alternative 2 (Two-Row):** The sections below characterize the potential impacts of Alternative 2 on key nutrients in the water column: silicate, phosphorus, and dissolved inorganic nitrogen.

**Silicate.** Because of high existing concentrations of silicates in Totten Inlet, and the minor influence mussels appear to exert on local silicate fluxes, there is no reason to believe the addition of the proposed
North Totten Inlet mussel farm will significantly alter the silicate cycle in Totten Inlet. The impacts of Alternative 2 of the proposed project would be the same as those described above for Alternative 1.

**Phosphorous.** The impacts of Alternative 2 would be the same as for Alternative 1 because only minor changes in phosphorus concentrations were observed as water passed through the Deepwater Point mussel raft array, such that there did not appear to be a significant change in phosphorus levels as a result of the rafts (Newfields 2009).

**Dissolved Inorganic Nitrogen.** To make an estimate of percentage difference between Alternatives 1 and 2, the surface foot print area of the three-dimensional volume of affected water can be calculated as a surrogate for the volume of water affected by elevated ammonium. If it is assumed that Alternative 2 raft units are 12.2 m (40 ft) wide and the elevated ammonium “plume” was a triangle 70 m (230 ft) long down-current, the area of effect would be 4,600 sq ft for each. Because the raft-unit rows in Alternative 2 would be 210 ft apart, there would be an overlap of the elevated ammonium “plume” with the down-current raft units by 20 feet, which would have an area of 50 sq ft. For the five up-current rafts, the coverage would be 2,578 m² (27,750 sq ft), and the down-current raft-unit plumes of elevated ammonium would cover 2,137 m² (23,000 sq ft), for a total of 4,250 m² (45,750 sq ft). Assuming the footprint for Alternative 1 (as estimated in the Alternative 1 section) would be 2,906 m² (31,280 sq ft), Alternative 2 could have 46 percent more effect than Alternative 1. Neither of these is expected to result in a significant adverse impact to the natural environment because of the narrow band of the effect, rapid mixing of the water.

The same amount of N per year would be removed with mussel harvest and the associated fouling community in the Alternative 2 raft configuration as that calculated for Alternative 1. Nitrogen removal by operation of the North Totten Inlet rafts in the Alternative 2 configuration would represent the same approximate percentage (23 to 54 percent) as Alternative 1, of the estimated anthropogenic nitrogen introduced to Totten Inlet.

**Alternative 3 (No Action):** Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no physical presence of rafts, and no potential changes to the amount of the primary nutrients (silicate, phosphorous or DIN) in North Totten Inlet. Because the net effect of the project is to reduce nutrient loading, the no action alternative would result in higher concentration and flux of nitrogen throughout the system with the related increased risks of eutrophication.

**MITIGATION MEASURES**

**Incorporated Features**

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality.

**Applicable Regulations and Commitments**

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.
Other Recommended Mitigation Measures

No additional mitigation measures are recommended for effects on silicate, phosphorus or dissolved inorganic nitrogen because the impacts of the proposed project would be insignificant.

**Significant Unavoidable Adverse Impacts**

There would no significant unavoidable adverse impacts to silicate, phosphorus or dissolved inorganic nitrogen as a result of the proposed project with either action alternative.

### 3.2 Marine Plants

#### 3.2.1 Phytoplankton

**Affected Environment**

Phytoplankton are microscopic plants and unicellular plant/animals (protists) that form the foundation of the marine water-column food web. Species composition at any given time, and abundance of each species, depends on a complex interaction between environmental (e.g., light, temperature, inorganic nutrient availability) determinants of productivity, biological influences (e.g., intensity of grazing) and rates of settlement. These processes contribute, determine the rate and amount of energy available to pelagic and benthic ecosystems, and result in a seasonal pattern of abundance and distribution of the invertebrate predators and the food chain that they support.

Characterization of the phytoplankton in Totten Inlet was determined in two ways. First, species composition and abundance were based on a study performed by the Pacific Shellfish Institute (PSI; Cheney et al., unpublished data) in 2002 and 2003. Second, the amount of phytoplankton, was based on chlorophyll $a$ (chl $a$) measurements. Chlorophyll $a$ values were extracted from datasets collected by a WDOE water quality monitoring program, Brooks (2005), and PSI.

The phytoplankton species composition observed in Totten Inlet was dominated by diatoms and dinoflagellates. During the fall and winter months, the diatoms *Thallassiosira* sp., *Skeletonema costatum*, and *Chaetoceros* spp. were the dominant phytoplankton species. *Chaetoceros* spp. increased in abundance prior to the spring bloom event, comprising from 10 percent of the assemblage in March to 90 percent of the assemblage in May. Following the spring bloom, *Chaetoceros* became less abundant and the assemblage became more diverse including centric (*Thallassiosira* sp.) and pennate diatoms (*Thallassionema* sp. and *Eucampia zodiaca*) and dinoflagellates (*Ceratium* sp., *Gyrodinium* sp. and unidentified dinoflagellates). The fall bloom started with *E. zodiaca* (2002) and *Chaetoceros* sp. (2003) and was followed by a dinoflagellate bloom of *Gymnodinium* spp., *Ceratium* spp. *Heterocapsa triquetra*, and unidentified dinoflagellates.

Phytoplankton abundance in Totten Inlet in 2002 and 2003 was characterized by relatively low abundance in late fall and winter (<100,000 cells/L) (378,500 cells/gal), a short, large diatom bloom in early spring (3,156,000 to 4,123,000 cells/L) (11,945,460 to 15,605,555 cells/gal) of primarily *Chaetoceros* spp., followed by more modest abundance in late May through July, and a second bloom (220,000 to nearly 1 million cells/L) (832,700 to nearly 3,785,000 cells/gal) of diatoms and dinoflagellates in late summer early fall. For the purposes of food web modeling, a fall/winter and spring/summer profile was used for phytoplankton standing stock.
Plankton biomass in Totten Inlet was estimated using chlorophyll $a$ measurements collected by WDOE (WDOE 2006) and Brooks (2005). Average monthly chlorophyll $a$ concentrations at the site of the proposed North Totten Inlet mussel farm ranged from 1.0 to 10.8 μg/L (or parts per billion [ppb]), with concentrations exceeding 20 μg/L (ppb) during the spring and late summer blooms. Chlorophyll $a$ concentrations were lowest between November and March, ranging from 1.0 to 2.9 μg/L (ppb). Higher chlorophyll $a$ concentrations were observed between April and October, ranging from 6.7 to 11.7 μg/L (ppb). Peak concentrations occurred during the spring bloom in April/May and the late summer bloom between August and October.

**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be no impact to phytoplankton during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

**Potential Operational Impacts**

*Alternative 1 (Preferred)*: In order to evaluate the phytoplankton reduction as water passes through the mussel rafts, computer simulations developed by Blue Hill Hydraulics were conducted at three different velocities that represent the typical depth-averaged velocities recorded at the site of the proposed North Totten Inlet mussel farm (5 cm/sec, 15 cm/sec, and 25 cm/sec (2 in/sec, 6 in/sec, and 10 in/sec)). These simulations were run for ambient chlorophyll $a$ concentrations of 18 μg/L (ppb). In general, the size of the affected area (depleted chlorophyll $a$ concentrations) was inversely proportional to the current velocity. At higher current velocities, the volume of water at ambient conditions flowing between and under the rafts quickly mixed with the slower water moving through the rafts, shortening the length of the affected area down-current and decreasing the amount of lateral mixing of water from neighboring rafts. If there is decreased phytoplankton abundance following this initial zone of mixing, it would require about one day to reach ambient conditions based on cell division rates of about one division per day. This estimate incorporates the effects of predation, light availability, and nutrient availability.

In order to understand the removal of phytoplankton by the proposed mussel farm from the northern portion of the main basin of Totten Inlet, an approach developed by Environment Waikato (EW) to evaluate potential effects related to marine farming in New Zealand was used. This approach allows the effect of phytoplankton consumption around the proposed mussel farm to be compared to overall phytoplankton production in the surrounding waters. This quantitative comparison revealed that for the spring/summer period, the North Totten Inlet mussel farm may remove approximately 0.3 to 0.9 percent of the primary production over 50 percent of the area of Totten Inlet (representing the Northern Totten Inlet basin). For the fall/winter period, the North Totten Inlet mussel farm may remove approximately 0.5 to 1.4 percent of the primary production over 50 percent of Totten Inlet. These comparisons can be considered a conservative estimate (Newfields 2009).

*Alternative 2 (Two-Row):* Under Alternative 2, the potential effects to phytoplankton would be the same as those described for Alternative 1 because production under either alternative would be similar. Any difference would be undetectable within the variability of the estimated seasonal production removals.

*Alternative 3 (No Action):* Under the No Action Alternative, no additional mussel farm would be developed in North Totten Inlet, and there would be no additional removal of primary production above existing conditions.
MITIGATION MEASURES

Incorporated Features

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended to address the insignificant removal of primary production from North Totten Inlet.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to phytoplankton as a result of the proposed project with either action alternative.

3.2.2 Macroalgae

AFFECTED ENVIRONMENT

Sea lettuce (Ulva sp.) is the dominant species of intertidal algae of Totten Inlet, with some patches of kelp (Laminaria sp.) and red macroalgae that occur in the nearshore zone, predominantly on the western shore (WDNR 2003 and Brooks 2002). The marine algae normally utilized for spawning substrate by herring are sparse in this area (Stick 2005). The area immediately beneath the proposed North Totten Inlet mussel farm site has some amount of sea lettuce (Ulva sp.) and brown kelp (Laminaria sp.) (Goodwin, 1997).

During the summer of 2009, a new survey was performed by BioAquatics International (2009) that quantified attached macroalgae within the area of the proposed project. The survey showed that attached (fixed) Laminaria and Ulva were present only to depths of -30 ft MLLW and shoreward (Figure 3-11). This covers an estimated 7 percent of the immediate area where the raft-units will be located. Within this small area, the bottom coverage of fixed macroalgae was very sparse, mostly 10 percent or less (Figure 3-12).

POTENTIAL IMPACTS

Potential Impacts during Construction

There would be little risk of adverse impact to macroalgae during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site. During a site inspection conducted March 19, 2009, there was no marine vegetation on the beach where the mussel rafts will be assembled for deployment.
Figure 3-11. Contour Map of the Estimated Areal Coverage of Predominately Fixed and Unattached or Drift Macroalgae within the Proposed North Totten Inlet Mussel Farm Site (source: BioAquatics International, 2009).

Notes:
Depth contours relative to 0.0 feet MLLW.
Coordinates are from the Universal Transverse Mercator (UTM) coordinate system, Zone 10T.
Figure 3-12. Classed Map of Percent Total Macroalgae Coverage within the Proposed North Totten Inlet Mussel Farm Site (source: BioAquatics International, 2009).
Potential Operational Impacts

**Alternative 1 (Preferred):** Under the Alternative 1, there is a potential for the two shoreward raft units to shade the sparse coverage of fixed macroalgae. The footprint of these two raft-units would be approximately 16,230 square ft compared to 18,000 square ft for Alternative 2 during the first three years. Because the raft units are not fixed structures (like a pier), they and their shadows will move constantly (because of tidal currents and wind) over the bottom substrate upon which the macroalgae grows. This will allow light to reach the bottom around the periphery of each unit. The units are also not covered (again like a solid pier), and this will allow some light to penetrate to the bottom, especially after harvest and when the seed lines are newly placed.

**Alternative 2 (Two-Row):** Under Alternative 2 there is a potential for 3 of the 10 five-raft units (the two shallow raft units in the northeast row, and the most shallow in the southwest row) to shade the sparse coverage of fixed macroalgae. These three raft units would cover approximately 18,000 square ft compared to 16,230 square ft with Alternative 1. Alternative 2 includes an alternative mussel farm management strategy in which the raft units would be relocated every 3 years into the adjacent offshore gap between rafts. During this relocation period, only two of the raft units would be located above the sparse density of attached macroalgae. This would reduce the potential shading by 6,000 square feet, and would cover approximately 4,230 square ft less than Alternative 1 during that three-year period.

An extra set of anchors would be required mid-way between the initially-installed rows of raft units to facilitate this periodic raft relocation. The effect of the anchors on fixed macroalgae would be negligible.

**Alternative 3 (No Action):** Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet, and there would be no change in effects to macroalgae at the site.

**MITIGATION MEASURES**

**Incorporated Features**

The proposed location of raft units is mostly in water depths below which attached macroalgae is not present. Raft units in either alternative configuration would be separated by several feet, which will allow light to penetrate between the units. The rafts will not be covered or fixed in one location, so they will move with currents and wind, allowing light to reach the substrate.

The alternative mussel farm management strategy in Alternative 2, in which these rafts would be relocated every 3 years into the adjacent gap between rafts, would allow any build-up beneath the rafts to assimilate at a faster rate. An extra set of anchors would be required mid-way between the initially-installed rows to facilitate this periodic raft relocation.

**Applicable Regulations and Commitments**

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

**Other Recommended Mitigation Measures**

No additional mitigation measures are recommended to address the effects on macroalgae in North Totten Inlet as a result of developing the proposed mussel farm.
SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to macroalgae as a result of the proposed project with either action alternative.

3.3 ANIMALS

Totten Inlet, and its inner bays, Inner Totten Inlet and Little Skookum Inlet, are rich in invertebrate and fish resources, with intertidal and subtidal clams and oysters, crab, and four species of salmon. In addition, this area is a highly productive shellfish growing area. It is estimated that Totten-Little Skookum and the neighboring Eld inlets produce approximately 10 percent of Washington State shellfish and a large portion of the State’s Manila clams (WDFW 2003a).

3.3.1 Invertebrates

3.3.1.1 Zooplankton

AFFECTED ENVIRONMENT

Zooplankton are a remarkably diverse assemblage of small organisms that live in the water column. They include not only animals that are planktonic throughout their entire life (holoplankton), but also animals that are planktonic only in their larval form (meroplankton). The two important categories of zooplankton are microzooplankton and gelatinous zooplankton (jellyfish). Zooplankton provide a crucial link between the photosynthetic phytoplankton and the fish and shellfish resources in Puget Sound. Although there is a substantial amount of information on zooplankton population structure and abundance in Puget Sound, there is considerably less data on zooplankton in Totten Inlet. Data on population structure and seasonal population size was collected in Totten Inlet by PSI, and in Budd Inlet by Giles and Cordell (1998).

As with phytoplankton, zooplankton populations cycle throughout the year, both in abundance and in species composition. *Heleocostamella* and other tintinnids were the most common microzooplankton, occurring most frequently and comprising 60 percent to >90 percent of the zooplankton observed in samples. Other dominant groups were copepods, barnacle and crab nauplii, and *Tiarina* (a prostomatid ciliate). In August/September, unidentified species were numerically dominant. Based on Giles and Cordell (1998), these may be larval or cladocerans (Newfields 2009 Appendix D).

Microzooplankton are a critical link between phytoplankton and zooplankton and bivalves. During periods of low primary productivity, microzooplankton support the food chain. They are often the more numerically important class of zooplankton since their abundance appears to be less affected by algal boom-bust cycles. In Totten Inlet, tintinnids are the dominant microzooplankton species, with abundance ranging from $3.0 \times 10^6$ individuals/m$^3$ ($2.3 \times 10^6$ individuals/cubic yard) in winter, to $7.7 \times 10^6$ individuals/m$^3$ ($5.9 \times 10^6$ individuals/cu yd) in late summer (Cheney et al., unpublished data). Tintinnids are ciliates, unicellular organisms featuring cilia as food-catching and locomotor organs. Microzooplankton biomass in Totten Inlet was estimated at 10 g wet wt/m$^3$ (7.6 g wet wt/yd$^3$), based on Cheney et al. (unpublished data).

Although numerically not dominant, euphausiids and mysids are an important link between zooplankton and fish. Euphausiids and mysids are shrimp-like crustaceans that consume both zooplankton and phytoplankton. Because of their larger size, they are a preferred component of juvenile salmonids diets and are second only to copepods in herring diets. Much larger than copepods, euphausiids grow to about 20 mm in length. Generally, euphausiids cluster in schools, migrating to deeper waters in the daytime and
feeding at the surface during the nighttime. Euphausiids feed on both phytoplankton and zooplankton, including copepod adults and nauplii. There is little quantitative data on the abundance or biomass of euphausiids in South Puget Sound.

Larval forms of benthic invertebrates and fish are a critical seasonal component of the zooplankton community. Based on the findings of Giles and Cordell (1998), barnacle and crab larvae comprise 30 percent to 40 percent of the zooplankton abundance in Budd Inlet during migrations. A number of phyla have swimming larval forms, including echinoderms, annelids, crustaceans, molluscs, and fish. Just as there are a variety of larval forms, there are a variety of feeding strategies, including omnivores, carnivores, and larvae that do not feed or use lipid stores during their swimming phase. For the purposes of this evaluation, larval forms are included with zooplankton.

Jellyfish (gelatinous) zooplankton includes medusae, siphonophores, and ctenophores, collectively referred to as ‘pelagic coelenterates.’ Their presence in Totten Inlet is not well documented. Available data have been collected visually or with non-closing nets; however, there is a lack of true quantitative data for gelatinous zooplankton in South Puget Sound (Erik Thuesen, The Evergreen State College, personal communication, as cited in Newfields [2009], Appendix D). Determination of baseline population or biomass for gelatinous zooplankton is problematic because of extremely high variability between years. Details of the various species and what is known in Southern Puget Sound are presented in Newfields (2009, Appendix D).

Although dietary composition for jellyfish largely depends on the availability of prey, primary food sources include ichthyoplankton and zooplankton. There is little information available on the importance of the interaction between pelagic coelenterate populations and fish. This relationship, however, has received increasing attention due to potential impacts to commercial fisheries from predatory interactions between jellyfish, ichthyoplankton, and fish. In relation to fish, jellyfish are predators, competitors, and prey. Through consumption of zooplankton such as copepods, jellyfish impact the availability of similar food sources to bivalves and fish. This leads to an imbalance in local fisheries during periods of large blooms. Jellyfish also impact fish abundance by feeding on the eggs and larvae of fish. Conversely, jellyfish are also preyed upon by fish (Newfields 2009).

**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be little risk of adverse impact to zooplankton during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

**Potential Operational Impacts**

Alternative 1 (Preferred): Impacts of operation of the proposed 58-raft mussel farm on zooplankton include indirect effects of removal of zooplankton food organisms (phytoplankton), as well as direct effects in the form of removal of some zooplankton by the feeding mussels. Using data collected within Totten Inlet over the past seven years, as well as a number of mathematical models, it appears, however, that the influence of the mussel raft array designed for North Totten Inlet would create small areas of raft-affected water. The proposed mussel farm would be unlikely to create irreversible impacts to the hydrologic or biological health of this subbasin of Puget Sound due to characteristics of the proposed site and regional-specific physical and biological factors discussed in Newfields (2009).
Alternative 2 (Two-Row): Under Alternative 2, the effects on zooplankton would be the same as Alternative 1 because mussel production under either alternative would be similar. Any difference in effect would be undetectable.

Alternative 3 (No Action): Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet, and there would be no change in the characteristics of the zooplankton populations in Totten Inlet.

MITIGATION MEASURES

No mitigation measures are recommended to address the insignificant effects of the proposed mussel farm on zooplankton in North Totten Inlet.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to zooplankton as a result of the proposed project with either action alternative.

3.3.1.2 Macroinvertebrates (Benthos)

AFFECTED ENVIRONMENT

A baseline survey of Totten Inlet found sediments to be significantly organically enriched with total volatile solids (TVS) concentrations above the upper 90th percentile reported for Puget Sound Reference areas. Common infauna within the inlet, including Nephtys cornuta, Paraprionospio pinnata, Macoma nasuta, Alvania compacta and Sigambra tentaculata, have previously been shown to be tolerant of naturally-enriched conditions.

The area immediately beneath the site of the proposed North Totten Inlet mussel farm was surveyed for the presence of benthic organisms by Brooks (2005b). A total of 131 taxa and 4,840 animals were identified in each of the 23 0.1 m² (about one square foot) Van Veen 5 grab samples collected at the North Totten site. Overall, the community was dominated by annelids (38 percent of total number of animals collected) and mollusks (36 percent of total animals) with fewer arthropods (12 percent of total animals). The mean abundance of macrofauna at this site was 218/0.1 m² (1 sq ft), and was lower (464.2 to 491.4/m² [1 sq ft]) than documented at Puget Sound Reference Locations sharing similar water depths and proportion fines. Species richness was also generally lower at North Totten (32 ± 3) than reported for Puget Sound reference stations containing 20 to 50 percent fines (Mean = 64.4; coefficient of variation (CV) = 31.4). The macrobenthic community’s diversity, as measured by Shannon’s Index, was higher than reported for WDOE reference locations.

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5 This lightweight metal grab that takes samples of soft bottom substrate. Its long lever arms and sharp cutting edges on the bottom of the scoops allow it to cut deep into softer bottoms. The closing mechanism is a self-releasing pinch-pin attached to the two closing arms which holds the grab open before it hits the bottom. Upon impact, the tension on the chains is released, which releases the pinch-pin. The chain pulls the closing arms together to close the scoops when the cable is lifted. The top of each scoop is covered with a stainless steel screen for water to flow through during descent. The screen is covered with a neoprene rubber flap to prevent sample washout during retrieval.
More annelids were observed in fine-grained sediments to the south and west in deeper water of the proposed mussel raft site, and more mollusks were found in the coarser sediments of nearshore (northeast and southeast) quadrants. Many of the dominant taxa found at the site are characteristic of enriched sediments. These included polychetes (segmented worms) such as *Leitoscoloplos pugettensis*, *Lumbrineris luti*, *Nephys cornuta*, *Parapriornospi pinnata* and *Sigambra tentaculata*. Dominant mollusks included species tolerant of naturally-enriched conditions (e.g., the snails *Alia gausapata*, *Alvania compacta*, and *Nassarium perpising*, the bent-nose clam (*Macoma nasuta*) and the Lord dwarf-venus clam (*Psephidia lordi*). However, the macrobenthic community also included taxa that are intolerant of excessive enrichment resulting in high sulfide concentrations. These include brittle stars (*Ophiuroidea sp.* and *Amphiodia urtica*); arthropods like *Photis brevipes*; and mollusks such as the clams *Axinopsida serricata*, *Lucina tenuisculpta*, *Nuttall’s cockle* (*Clinocardium nuttallii*), and the white-sand macoma clam (*Macoma secta*). The physicochemical data and macrobenthic community inventory were consistent in describing the area as organically enriched but not yet so eutrophic as to exclude many sulfide-intolerant taxa.

Benthic organisms such as barnacles, mussels, and sea anemones, naturally occur on hard surfaces and structures on the bottom, and/or where tidally exposed. When humans introduce artificial hard structures (like pilings), benthic organisms colonize the new surfaces. This is known as the “fouling community” because it can “foul” the bottoms of boats or anchor lines, for example, and it frequently has to be scraped off. The fouling community biomass in Totten Inlet is dominated by anemones, comprising 90 percent of the wet weight biomass. Anemone production is estimated to range from 15.7 g carbon (C)/m²/yr to 520 gC/m²/yr (0.46 oz to 15.34 oz C/sq yd/yr). However, anemones are selective, secondary consumers and are not expected to directly affect phytoplankton standing stock. Fouling bivalves were predicted to consume 0.7 to 25 gC/m²/yr (0.02 to 0.74 oz C/sq yd/yr).

A colonial species of tunicate in the genus *Didemnum* is a recent non-native species that has invaded Puget Sound. “*Didemnum sp. A*” was first discovered in Washington in 2004. Locally it has been found growing on Taylor Shellfish mussel lines in Totten Inlet. Taxonomists have not yet decided which species is in Puget Sound, so for now it is being called *Didemnum* sp. A. This species can grow in harbors on boat hulls, ropes, docks and other structures where it forms irregular lobes and hanging sheets up to a meter long. It can also form extensive encrusting mats over gravelly bottoms, smothering other marine organisms. It can spread in several ways: by dispersing motile larvae, by overgrowing surrounding areas, or, when fragments break off a colony, they can be carried about by currents to settle and grow in a new location. The tendency of this species to break up into fragments makes eradication difficult, if not improbable. Because it disperses so easily and overgrows surfaces in its environment so rapidly, *Didemnum* sp. A is considered a serious threat in Puget Sound (D’Amore 2006).

**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be little risk of adverse impact to macroinvertebrates during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site. The assembled rafts will be towed to the proposed mussel farm site for anchoring. While a small amount 40.32 m² (434 sq ft) of benthic habitat may be displaced by the concrete wedge anchors, the anchor ropes will provide more than an equal amount of substrate for other marine organisms to attach.
Potential Operational Impacts

Alternative 1 (Preferred): The environmental response of benthic organisms to intensive aquaculture, such as the proposed additional mussel farm in North Totten Inlet, depends on numerous factors such as the depth of water, local currents (direction and speed), sediment grain size, dissolved oxygen concentrations in the benthic boundary layer, and other currently recognized factors. Aquaculture biodeposits can result in significant long-term enhancement of local benthic communities (Brooks 1995; Tenore and Dunstan 1973). They can also result in adverse effects in the benthic community when situated in poorly-flushed environments. For example, at a site in Sweden, Mattsson and Linden (1983) noted a shift in the infaunal community from echinoderms and mollusks to opportunistic polychaetes and the amphipod (*Corophium insidiosum*) following several years of suspended mussel culture. Remediation was slow at this site because average currents were weak at only ~3 cm/sec (1 in/sec). Despite the presence of anaerobic sediments, the authors observed only a small decrease of 3 to 7 percent saturation in oxygen concentration in the water 10 cm (3.9 in) above the mussel farm sediments when compared with a reference area. It has been well documented- (Mattson and Linden 1983 and references cited therein) that fish appear to flourish around mussel culture sites.

To characterize likely effects on the underlying sediments from the proposed mussel culture rafts, a sampling program was designed and implemented at existing Taylor Shellfish mussel farms at Deepwater Point and Gallagher Cove (Brooks 2005a). Sediment samples were collected at distances of 0.0, 15, 30, 45, 60, 80, 100 and 125 meters (0, 49, 98, 148, 197, 262, 328, and 410 ft) on a down-current (northern) transect at Deepwater Point in March, April, May, July and October of 2002 to assess sediment physicochemical conditions as a function of season and cultured mussel biomass. Microfauna were sampled with Van Veen grab sampler. Sediment trap canisters were deployed to quantify rates of particle deposition. Traps were positioned at six stations located beneath the center of the line of rafts (one on the perimeter of the northernmost raft at the Deepwater Point mussel farm and other ones at distances of 30, 60 and 120 m (98, 197, and 394 ft) down-current from the farm). A sixth canister was deployed at the Deepwater Point reference station, and a seventh at the buoy marking the center of the proposed North Totten Inlet mussel farm. Details of the materials and methods used are described in *Benthic Response at the Deepwater Point Mussel Farm in Totten Inlet, Puget Sound, Washington* by Brooks (2005b).

The detailed results of the sampling program are summarized as follows. Approximately 138,000 kg (152.1 tons) of mussels were cultured on the inner row of six rafts at Deepwater Point in 2002. The following results demonstrate minor benthic effects associated with the intensive culture of these mussels. The term “minor” is used in consideration of the observations of total volatile solids (TVS) deposition rates of 105 g/m²/day (3.1 oz/sq yd/day), and sulfide concentrations as high as 7,400 µM⁶ associated with the naturally occurring epifaunal community (dominated by mussels) resident on creosote-treated piling in Sooke Basin, British Columbia (Goyette and Brooks, 1998 and 2000). If sediments under the mussel rafts had contained higher concentrations of fine material (silts and clays), the moderately high sulfide concentrations observed in July 2002 would have excluded sensitive infauna, and the very high sulfide concentrations observed in November 2002 would have excluded all but a few opportunistic annelids. However, sediments under the rafts were dominated by gravel and sand – an environment not conducive to surface and subsurface deposit-feeding annelids common in Totten Inlet’s enriched sediments. Instead, the benthic community under the Deepwater Point rafts was dominated by surface-living megafauna including starfish, crabs, anemones and predatory gastropods.

The megafaunal community was likely enhanced by the residual organic material present in the particulate waste released from the overlying mussel cultures and their symbiotic community. This community was diverse and abundant when the July 17, 2002 video recordings were made at the

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⁶ See Glossary for explanation of µM (micromole or micrograms atoms per liter units).
Deepwater Point site. Sediments from the northern perimeter of the raft to the reference location contained significant quantities of silt and clay, representing an environmentally homogeneous environment. Elevated concentrations of free sediment sulfides were observed to 45 m (148 ft) from the perimeter of the raft in July 2002 and 60 m (197 ft) from the perimeter in late November 2002.

The biological results presented in Brooks (2005b) indicated subtle infaunal community effects extending to a distance of between 45 m (148 ft) and 75 m (246 ft) down-current from the existing Deepwater Point mussel farm, but not beyond that distance. For the proposed mussel raft configuration in Alternative 1, each row of eight, 34-foot wide raft units could be envisioned as resulting in triangular “zones” of infaunal community effects, both up-current and down-current (because current direction changes twice each day), on areas ranging between 0.92 acre to 1.54 acres. The rafts in the Brooks (2005b) study were reseeded approximately 3 months following harvest of the last crop. The low sulfide and TVS concentrations observed during the first sample period in March 22, 2002 indicate that natural attenuation of substrate chemistry toward baseline conditions occurred very quickly at this site with no evidence of cumulative effects. This suggests there would not be an adverse long-term effect arising from the proposed raft culture of mussels in North Totten Inlet.

Alternative 2 (Two-Row): The effects on the infaunal community would differ with Alternative 2 compared to Alternative 1. Each row of 5 raft units in Alternative 2 would leave five “tails” of infaunal community effects from 45 m (148 ft) to 75 m (246 ft) down-current. If it is assumed these tails are triangles trailing from each 40 ft-wide raft unit, the effects of the 10 raft units would equal areas of 1.36 to 2.24 acres. Compared to similar calculations for the raft-units in Alternative 1, Alternative 2 could have up to 45 percent to 48 percent greater effects on benthic organisms than Alternative 1.

An off-setting feature of Alternative 2 to relocate raft units every 2 to 3 years would allow the infaunal community to be restored down-current from the former raft unit locations. This procedure, however, will still result in a similar amount of effect; the effect would, however, be temporary and occur at different locations and times.

Alternative 3 (No Action): Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet, and there would be no additional effect on the benthic substrate or the benthic community of animals that live there.

MITIGATION MEASURES

Incorporated Features

The rafts have been planned and configured to minimize effects on benthic organisms by placing them in optimum locations for waste particle dispersion, resuspension and assimilation.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6. Specifically, an Individual Section 10 Permit will be required from the U.S. Army Corps of Engineers, and will address measures to minimize disturbance of inter-tidally spawned forage fish eggs when accessing culture sites.
Other Recommended Mitigation Measures

No additional mitigation measures are recommended to address the insignificant effects of the proposed mussel farm on macroinvertebrates (benthic organisms) in North Totten Inlet.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no permanent significant unavoidable adverse impacts to macroinvertebrates (benthic organisms) as a result of the proposed project with either action alternative.

3.3.1.3 Native Mussel Species

AFFECTED ENVIRONMENT

In Puget Sound, the “blue” mussel (*Mytilus edulis trossulus*) is the native mussel species. It is common along the west coast from California north. Other common names for *M. e. trossulus* are the bay mussel, foolish mussel, and edible mussel. The “Mediterranean” mussel (*Mytilus edulis galloprovincialis*) is the most commonly cultured mussel in Washington (usually on off-bottom racks or nets), as it is more disease-resistant than the native mussel (Brooks 1991, and Wonham 2001). Both species are found naturally on rocky shores and also commonly as “fouling organisms” on pilings and other man-made structures in any protected to exposed habitat. They can live in the intertidal or shallow subtidal zone to about 5 meters (16.4 ft) or sometimes deeper. While these species are genetically distinct (McDonald et al. 1991; Rawson and Hilbish 1995), genetic variation within each species and natural hybridization is common among mussels in the *Mytilus edulis* species complex (Riginos et al. 2006).

North Totten Inlet is one of the few places in Puget Sound where “Mediterranean” (*M. e. galloprovincialis*) mussels grow particularly well; better even than nearby Oakland Bay. Stable salinity and high productivity in North Totten Inlet are thought to contribute to this success (personal communication with Gordon King, Mussel Department Manager, Taylor Shellfish Company, Inc., April 6, 2009).

The literature suggests that the taxonomic status and origin of *M. e. galloprovincialis* in the Northeast Pacific is uncertain. Other than the observation of similar morphologies and genetic allele frequencies at 8 loci along certain genes, McDonald and Koehn (1988) did not present evidence supporting their assertion that *M. e. galloprovincialis* was an “invading” mussel introduced from Europe. In contrast, the findings of Kenchington *et al.* (1995) suggest that *M. e. galloprovincialis* mussels in the Atlantic and Pacific Oceans diverged millions of years ago. Gérard *et al.* (2008) suggest that *M. e. galloprovincialis* has been in New Zealand for over 500,000 years. The work of Kenchington *et al.* (1995) and Gérard *et al.* (2008) does not contradict the potential for additional recent introductions of *M.e. galloprovincialis* in ballast water or as fouling organisms on the hulls of ships from the Mediterranean Sea. However, it does indicate that the sample of Washington State *M. e. galloprovincialis* collected from a population of cultured mussels was not genetically similar to the Mediterranean variety of mussel carrying the same name. Kenchington *et al.* (1995) found that cultured mussels resembling *M. e. galloprovincialis* in Washington State were genetically more distant from Mediterranean *M. e. galloprovincialis* than was *M. e. trossulus*.

The fact is that at the present time, the origin of *M. e. galloprovincialis* is unknown for mussels such as those found in California and cultured in Washington State. It appears as likely that Pacific and Atlantic populations of blue mussels originated in the Pacific and migrated into the Atlantic millions of years ago. What is known in Washington State is that when the ability to genetically distinguish these siblings in Puget Sound was developed, Brooks (1991) reported *M. e. galloprovincialis* during a 1988 survey of raft cultures that were initiated in 1985 and in a feral population containing up to 6-year old *M. e.*
galloprovincialis from Dyes Inlet, Washington. Additional specimens were found in Sequim Bay on the Strait of Juan de Fuca. These six-year old M. e. galloprovincialis from Dyes Inlet set prior to any known aquaculture efforts with this species in Washington State. The larvae may have originated in bilge water discharged at the Bremerton shipyard or from the fouling community resident on commercial or recreational boat hulls. This leads to the conclusion that M. e. galloprovincialis was resident in Puget Sound waters prior to its culture here (Brooks 2008).

**POTENTIAL IMPACTS**

The native mussel impact analysis in this EIS examines the potential genetic effects that could be caused by escapement and propagation of mussels used in the proposed mussel raft operations. The primary question is to determine the potential for M. e. galloprovincialis to displace or “genetically pollute” M. e. trossulus stocks in Puget Sound.

From a physiological point of view, Brooks (1991) concluded that M. e. trossulus is adapted to cold water having reduced salinity, whereas M. e. galloprovincialis is adapted to areas having fairly high and constant salinity and warmer water temperatures. Brooks (1991) also suggests that populations of M. e. trossulus suffer nearly 100 percent mortality at temperatures above 20°C (68°F) in Puget Sound, and that sustained populations would be unlikely in the waters of Southern California, for example, where the warm water and constantly high salinity-adapted M. e. galloprovincialis currently thrives. In contrast, the relatively cold waters of Puget Sound experience large reductions in salinity – particularly during the winter peak spawning period of M. e. galloprovincialis – which would likely inhibit, but not extinguish, successful recruitment of this species. See Brooks (2007) for details on distribution of the two mussel species in Puget Sound.

In 2002, Brooks (2008) surveyed the species composition of non-cultured, naturally occurring mussel populations in Totten Inlet. Between zero and three percent of the mussels collected by Brooks (2008) were indentified as M. e. galloprovincialis, and three to ten percent were hybrids between the two species (Table 3.3-1a). Thus it appears that in Totten Inlet, where intensive M. e. galloprovincialis culture has been practiced for 20 years, that M. e. trossulus is still the dominant species in the naturally recruiting population and there is little evidence that this natural mussel population may contain M. e. galloprovincialis genes. Tables 3.3-1a and 3.3-1b summarize these results.

The environmental niches preferred by these two species are quite different. Brooks (2008) suggests it is reasonable to assume that M. e. galloprovincialis will continue to dominate mussel populations in more southerly latitudes, and that M. e. trossulus will dominate in more northerly latitudes. This hypothesis is supported by the existing population structures of these mussels along the Pacific Coast, including those found in San Francisco and Humboldt Bay in California.

**Table 3.3-1a.** Genotypes observed in non-random samples of Mytilus collected in Totten Inlet: Non-random samples with M. galloprovincialis shell morphology (Brooks 2008). The percent frequency of M. galloprovincialis in the sampled population is provided in parentheses.

<table>
<thead>
<tr>
<th>Location</th>
<th>No.</th>
<th>M. e. trossulus</th>
<th>M. e. galloprovincialis</th>
<th>Hybrid</th>
<th>Apparent Back-cross hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deepwater Point</td>
<td>30</td>
<td>12 (40)</td>
<td>2 (7)</td>
<td>15 (50)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>North Totten</td>
<td>30</td>
<td>16 (53)</td>
<td>9 (30)</td>
<td>1 (3)</td>
<td>4 (13)</td>
</tr>
<tr>
<td>Little Skookum Inlet</td>
<td>30</td>
<td>2 (7)</td>
<td>5 (17)</td>
<td>20 (67)</td>
<td>3 (10)</td>
</tr>
</tbody>
</table>
Table 3.3-1b. Summary of species and hybrid identification based on genetic markers (Brooks 2008) of numbers of randomly collected mussels from two locations near raft cultures of *M. galloprovincialis* and at Little Skookum Inlet, a control station in Totten Inlet, Washington. The percent frequency of each species in the sample is provided in parentheses.

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th><em>M. trossulus</em></th>
<th><em>M. galloprovincialis</em></th>
<th>Hybrid</th>
<th>Apparent Back-cross hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deepwater Point</td>
<td>34</td>
<td>32 (94)</td>
<td>1 (3)</td>
<td>1 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>North Totten</td>
<td>30</td>
<td>28 (93)</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Little Skookum Inlet</td>
<td>30</td>
<td>27 (90)</td>
<td>0 (0)</td>
<td>3 (10)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Potential Impacts during Construction

There would be little risk of adverse impact to native mussel species during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

Potential Operational Impacts

**Alternative 1 (Preferred):** Based on the studies described above, the risk of *M. e. galloprovincialis* to displace or “genetically pollute” *M. e. trossulus* stocks in Puget Sound is low, and it is unlikely that the proposed project will have a significant adverse effect.

**Alternative 2 (Two-Row):** Alternative 2 would have the same potential (or lack of potential) to affect native mussel populations as the 58-raft Preferred Alternative.

**Alternative 3 (No Action):** Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet, and there would be no additional effect on the genetic composition of existing mussel populations. There were three operating mussel farms in Totten Inlet at the time of this writing, all of which cultivate *M. e. galloprovincialis* and have for more than 15 years.\(^7\)

**MITIGATION MEASURES**

No specific mitigation is proposed for addressing genetic interaction as an impact resulting from the proposed project.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

**SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS**

There would be no significant unavoidable adverse impacts to the genetic make-up of native mussel populations in North Totten Inlet as a result of the proposed project with either action alternative.

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\(^7\) The Taylor Shellfish mussel farms at Gallagher Cove and Deepwater Point began operation in 1992 and 1994, respectively.
3.3.2 Fish

AFFECTED ENVIRONMENT

According to the Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) Database (WDFW 2009), surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) are documented to spawn on intertidal beaches adjacent to the site of the proposed North Totten Inlet mussel farm. There is also documented spawning of Pacific herring (*Clupea harengus pallasi*) along both shores of the mouth of Gallagher Cove, but none at the proposed project site. All of these forage fish are important species in Washington. As the name implies, the significance of forage fish is related to the critical part they play as the prey base for a large variety of other marine organisms, their popularity as recreational fishing bait, and their significance to commercial and subsistence fisheries. Forage fish are harvested by recreational and commercial fisheries, and continue to be utilized for Tribal subsistence. The condition of the stocks that comprise each forage fish population are vitally important to the marine species and Native American people that use them as a food source. The vitality of the aggregate forage fish resource in Washington, including Totten Inlet, is also a valuable indicator of the health and productivity of the marine environment.

The Squaxin Pass herring population, which includes those that spawn in Totten Inlet, is the southernmost stock within the Puget Sound basin, and it exhibits unusual spawning behavior. The marine algae normally utilized for spawning substrate by herring are sparse in this area. Therefore, spawn deposition often occurs on rocks and gravel, occasionally quite deep. Such behavior does not lend itself well to assessment from the spawn deposition survey methods, which may explain the large differences between the spawn deposition and acoustic/trawl survey estimates for this stock. Undocumented spawning grounds are probable for this stock. The Squaxin Pass stock has the slowest known herring growth rate in Washington. It has been at a high level of abundance in recent years. Spawning occurs from mid-January through mid-April and averaged 1,474 mt (1,625 tons) of adults between 1999 and 2004 (Stick 2005). Adult herring feed primarily on planktonic crustaceans throughout their life cycle (ADFG 1986). Stomach contents analysis of herring in central and South Puget Sound indicated that juvenile herring in sublittoral habitats feed on calanoid copepods (45 percent), decapod larvae (23 percent), and chaetognaths (10 percent) (Fresh et al. 1981). In neritic habitats, prey items are dominated by calanoid and harpacticoid copepods and euphausiids.

Both surf smelt and sand lance populations are considered to be present in Totten Inlet throughout the year; however, their distribution and seasonal abundance are poorly understood. Based on Priekshot and Beattie (2001), the estimated biomass for forage fish (excluding herring) in Totten Inlet is 1,419 mt (1,564 tons). Based on stomach contents analysis, surf smelt and sand lance feed primarily on copepods and other zooplankton. Surf smelt and sand lance consume primarily pelagic prey; however, smelt are also epibenthic feeders (Fresh et al. 1981).

Another important, but less common Puget Sound forage fish species is the northern anchovy (*Engraulis mordax*). It has appeared recently in Totten Inlet (Fagergren 2005). Their spawning is temperature-dependent, requiring 10 to 23.3 degrees C (50° to 74° F), which falls within the temperature range of Totten Inlet. Anchovies feed similarly to sardines, randomly filtering the water with gill covers extended. Over the past six years, this species has appeared during the late summer and fall in increasing numbers, mostly visible in the early life stages as 25 to 100 mm (1/10th to 2/5th in) fish. Dense schools of juvenile fish have attracted seals, large flocks of double-crested cormorants and other birds such as gulls, loons, eagles and osprey from September to as late as February the following year. The sighting of young post-larval anchovies, combined with a short egg developmental stage of 2 to 4 days, provide evidence that the species reproduces in South Puget Sound and likely spawns at multiple times beginning in the early
summer. Anchovies are known to be a preferred forage fish with high oil content. Their increasing abundance make it a likely food source for other fish such as immature Chinook salmon (*Oncorhynchus tshawytscha*), and coho salmon (*O. kisutch*), searun cutthroat trout (*O. clarki clarki*), spiny dogfish (*Squalus acanthias*), and many marine birds and mammals (Fagergren 2005).

Chum salmon (*O. keta*) are common in Totten Inlet. One of the most productive chum salmon streams in Puget Sound is Kennedy Creek at the head of the Inlet. Runs of more than 40,000 adults are not uncommon, ranging from 6,000 to 85,000. Kennedy Creek chum are a fall-run stock, generally returning to the stream between mid-October and mid-December (WDFW 2009). Returning chum feed primarily on forage fish (~75 percent), with a small proportion of the diet from large zooplankton, such as euphausiids or mysid shrimp (~25 percent). In the early spring, juvenile chum salmon out-migrants swim along the shorelines, feeding as they make their way through Puget Sound and out to the Pacific Ocean.

Other salmonids that likely occur in the Inlet, but do not have significant spawning in its tributaries include Chinook and coho salmon, winter steelhead (*O. mykiss*), and searun cutthroat trout. Salmon smolts (young salmon that have just made the transition from freshwater to marine water) feed primarily on zooplankton (~65 percent) and other fish (16 percent), as well as amphipods, and insects. The steelhead diet is dominated by fish and gammarid amphipods, whereas coastal cutthroat feed primarily on fishes, as well as euphausiids and decapod larvae (Pearcy 1997).

Other groundfish species expected to be found in Totten Inlet include rock sole (*Lepidopsetta bilineata*), English sole (*Parophrys vetulus*), Pacific staghorn sculpin (*Leptocottus armatus*), spiny dogfish, big skate (*Raja binoculata*), longnose skate (*Raja rhina*), and Pacific tomcod (*Microgadus proximus*). All of these species are common to shallow mud/sandy bottom habitats (Washington Department of Fisheries 1992), and feed mainly on benthic organisms (worms, small clams, and crabs). Surfperches are also common in Totten Inlet, and include shiner perch (*Cymatogaster aggregata*), pile perch (*Rhacochilus vacca*), and striped perch (*Embiotoca lateralis*). These feed mainly on encrusting organisms that grow on pilings and other hard structures off the bottom.

Fish species listed as threatened or endangered under the Federal Endangered Species Act are discussed in Draft EIS Section 3.3.5 below.

The proposed new mussel farm float frames will be assembled and launched from the Taylor Shellfish “Old Plant” site at the end of Hargis Road, near the entrance to Gallagher Cove (see Figure 3-3). For this reason, existing conditions of the beach at this location are described here, based on a field report prepared by Mark Pedersen, co-author of the EIS (Margenex International, April 7, 2009). The beach at the Old Plant site is characterized as moderate slope, semi-protected at the base of a steep bluff. Substrate consists of large gravel with a few cobbles in the mid-tidal zone with smaller gravel, sand, and heavy oyster shell hash in the upper intertidal to the toe of the embankment. Four cement anchors are embedded in the substrate at approximately 100-foot intervals, at about the +9.5 ft MLLW elevation. These are used for mooring new rafts under construction. The only substantive work occurs just below these anchors when constructing new raft frames and above the +1.0 MLLW level, below which the substrate is too soft to work. Frame assembly begins at lower low tides and the completed frames are floated off the beach and then towed to the chosen location. The site is a long-standing point of entry and egress to the beach. There is a gravel ramp where trucks can back down to the beach. The site is used several times/week (even several times/day) by Taylor's Oyster Department and Clam Department (personal communication with Gordon King, Mussel Department Manager, Taylor Shellfish Company, Inc., April 6, 2009). The beach is not documented for rock sole, surf smelt, or Pacific sandlance spawning, nor as potential spawning habitat for these species (WDFW 2009).
**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be no risk of adverse impact to fish during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site (described above). Because only hand tools will be used for assembly, there is no risk of pollutants entering the water that could affect water quality or fish habitat.

**Potential Operational Impacts**

The following three paragraphs are excerpts from the *Endangered Species Act – Section 7 Programmatic Consultation Biological and Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Nationwide Permit 48 Washington: Assessment of the effects of shellfish aquaculture activities associated with existing commercial shellfish growing farms in Washington State* (NMFS 2009). While the Opinion focused on Federally-listed species (discussed below in Section 3.3.5), it is applicable to other fish species in Totten Inlet. These three paragraphs relate to mussel culture as currently practiced by Taylor at its existing farms in Totten Inlet and as proposed by Taylor at the North Totten Inlet mussel farm. Mussel culture does not have the types of effects that other types of shellfish aquaculture have where direct contact with the bottom is involved. (Even these other types of aquaculture are not likely to adversely affect listed fish species in Puget Sound.)

“The primary issue for listed fish caused by benthic disturbance is whether or not bottom interactions from any source change conditions affecting the function of the benthic food web. The effects of those interactions on benthic function to produce forage for listed fish are variously reported. Straus et al. (2008) reported increased benthic species at mussel culture sites.

Furthermore, the complex surface area provided by oysters and mussels offers habitat for over 100 different benthic species (as reviewed in CRMC 2008). The CRMC review also found that large biomasses of cultured mussels or oysters and fouling organisms suspended from lines attached to buoys or rafts have a major beneficial effect on phytoplankton, benthic, and hydrographic conditions within the immediate area of culture activities. For example, suspended rope culture in high current waters does not disrupt nutrient balance that would, in turn, create a hypoxic environment diminishing benthic food productivity for listed salmon, steelhead.

In summary, intertidal and nearshore shellfish aquaculture activities cause some disturbance of benthic habitat affecting the availability of benthic food resources for listed fish for a short period of time following disturbance. As stated above, benthic affects are reasonably certain to be irrelevant to listed fish in places with already low benthic diversity. In places with normal benthic diversity, with regular flows and normal nutrient balance, benthic items rapidly recolonize after disturbance, making food available again at the disturbed site. The consultation process revealed no evidence to support the argument that forage productivity is limited in and around managed sites. In fact, based on the currently available evidence, the level of benthic disturbance from existing shellfish aquaculture in Washington State is well within the range of normal benthic processes and effects on productivity are likely to be so limited in space (the footprint of the shellfish bed plus some down drift area to account for current) and duration (from a few hours to days, and certainly less than a year), that they are not likely to adversely affect listed salmon, steelhead, or sturgeon. Therefore, the effects of management activities on benthic communities are unlikely to impact forage productivity to a degree that would impair or even influence normal feeding and rearing behavioral patterns in the action area.”

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*North Totten Inlet Mussel Farm*  
*Draft EIS Chapter 3: May 2010*
Those segments of the Squaxin Pass herring population in Totten Inlet deposit spawn mostly on rocks and gravel, and no spawning has been documented at the proposed project site. Because the shifting raft units will minimally shade sparse attached vegetation on the substrate, it is unlikely the proposed project would have any significant physical effect on successful herring spawning.

To evaluate potential effects of the proposed mussel farm on forage and other fish higher in the food chain, it is important to establish a benchmark for the lower levels of the food chain that can relate to forage fish.

As reported in Newfields (2009), in order to consider the effects of consumption by mussel rafts and the associated fouling community, a carbon-flow model developed for the NTI rafts based on a model developed by Rodhouse et al. (1985). An estimated 13.7 percent of the carbon consumed by cultivated mussels was used in production, which included soft tissue growth as well as shell and byssal fiber growth. The remaining carbon was distributed as gametes (2.7 percent), respiration (57.5 percent), feces (18.8 percent), and scavengers and decomposers.

The average production rate predicted for the NTI site mussel rafts was 1,723 g C/m²/yr (5.6 oz C/ft²/yr). Seasonal production rates for winter ranged from 179 to 1,048 g C/m²/yr (0.6 to 3.4 oz C/ft²/yr), with a fall/winter mean of 629 g C/m²/yr (2.1 oz C/ft²/yr). Spring/summer production was consistently higher, with rates ranging from 1,201 to 2,810 g C/m²/yr (3.9 to 9.2 oz C/ft²/yr) and a seasonal average of 2,192 g C/m²/yr (7.2 oz C/ft²/yr). Peaks in mussel production coincided with patterns in phytoplankton blooms, with the highest rates of growth occurring in late spring and August to September. Annual carbon sequestration into shell and soft body tissues, based on seasonal production rates was predicted to be 14,557 kg C/yr (16 t C/yr). This is similar to an estimate based on the estimated annual harvest of 13,568 kg C (15 t C/yr).

According to Newfields (2009), primary production by phytoplankton in Totten Inlet was estimated to be 40,614 mt C/yr (44,769 tons C/year) during the spring/summer period. Of this total production, 70 percent is consumed by primary consumers (e.g., zooplankton and other small organisms). The proposed mussel raft facility was predicted to consume <1 percent of the primary production during the spring/summer period. Primary production by phytoplankton in Totten Inlet was estimated to be 3,066 mt C/yr (3,380 tons C/year) during the fall/winter period. Of this total production, 42 percent was estimated to be consumed by primary consumers. The proposed mussel raft was predicted to consume <1 percent of the production during the fall/winter period. No significant changes to carbon flow in the water-column food web were predicted to occur as a result of the consumption associated to the proposed North Totten Inlet mussel farm during the spring/summer or fall/winter period (Newfields 2009).

**Alternative 1 (Preferred):** Effects on fish that would result from the Alternative 1 configuration of the North Totten Inlet mussel farm would be linked to the magnitude of effect on their prey, which in turn would be linked to project effects on production of phytoplankton and zooplankton, and environmental parameters related to primary production and the benthos. Based on the analyses described above, it is unlikely that there would be any significant adverse impact to fish or their prey organisms caused by the 58-raft proposal for the North Totten Inlet mussel farm.

There could be positive effects for fish, because the encrusting organisms that will form on the raft structures and anchor cables will supply food for several species of fish, including surf perches. The rafts and the mussels ropes also forms protective habitat for some species of fish.

**Alternative 2 (Two-Row):** Effects on fish that would be attributable to Alternative 2 would be very similar to those described for Alternative 1. There would be more anchor lines and structure surface in
Alternative 2 upon which fouling organisms could grow. This could generate an increased food source for some fish species.

Alternative 3 (No Action): Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no additional physical presence of rafts, and no potential changes to fish, their habitats, or their prey organisms.

MITIGATION MEASURES

Incorporated Features

The NMFS Biological Opinion on Nationwide Permit (NWP) 48 recommends the following measures for existing mussel culture activities. Taylor proposes to employ these same measures at the North Totten Inlet site:

• Growers should strictly adhere to their code of practice to ensure minimized effects to listed species.
• Growers should continue to minimize disturbance of inter-tidally spawned forage fish eggs when accessing their culture sites.

Because the proposed mussel farm will be located over a subtidal area, the only potential interaction with inter-tidally spawned forage fish is related to access. Taylor’s intertidal shellfish farming operations in the upper intertidal area of the North Totten Inlet site are covered under NWP 48 for existing shellfish cultivation activities, and therefore are required to comply with the bullet items listed above.

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality (see Appendix A, pages A-6 through A-8). The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no adverse effect on water quality, and therefore no adverse impact on fish habitat.

Applicable Regulations and Commitments

An Individual Section 10 Permit from the U.S. Army Corps of Engineers will address measures to minimize disturbance of intertidally spawned forage fish eggs when accessing the mussel culture site.

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended for the proposed North Totten Inlet mussel farm relative to fish or fish habitat.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to fish or fish habitat as a result of the proposed project under either action alternative.
3.3.3  Birds

**AFFECTED ENVIRONMENT**

Many species of birds inhabit Totten Inlet. It is a significant stop along the flyway for migrating bird species. According to WDFW PHS Database (WDFW 2009), the nearest colonies of seabirds are two populations that occur on Steamboat Island about 2.3 miles northeast of the project site near the mouth of the inlet.

Totten Inlet is home to the largest over-wintering population of dunlins (*Calidris alpina*) in South Puget Sound (Seattle Times 2002). Dunlins, a type of sandpiper, begin their migration to Totten in late October. Dunlins comprise 95 percent of the over-wintering shorebird population of Puget Sound. They can be found in flocks of more than 4,000 in Totten Inlet where they will remain until May. When the birds are close to shore, they follow the tideline to feed on small crustaceans, worms, and other organisms that live in the mudflats. Dunlins have vision keen enough to forage in the middle of the night, if they must, to take advantage of low tide. Dunlins are among the smallest birds feeding on the extensive mud flats in the Inlet, and are preyed upon by peregrine falcons (*Falco peregrinus pealei*).

The black-bellied plover (*Pluvialis squatarol*) is also a common shore bird feeding along the tideflats of Totten Inlet. The plovers are strategic, visual foragers that watch the mud for worm bubbles (an indication of preferred food organisms). Western sandpipers (*Calidris mauri*), killdeers (*Charadrius vociferous*), and long-billed dowitchers (*Limnodromus griseus*) are also common tide flat feeders, and willets (*Catoptrophorus semipalmatus*) are sometimes also observed (Buchanan 2004). Other birds that feed in the Inlet include great blue heron (*Ardea herodias*) along the shoreline, pigeon guillemot (*Ceppus columa*), and scoters (*Melanitta* spp.)

Large flocks of double-crested cormorants (*Phalacrocorax auritus*) and other birds such as glaucous-winged gulls (*Larus glaeucens*) and western gulls (*L. occidentalis*), common loon (*Gavia immer*), western grebe (*Aechmophorus occidentalis*) and osprey (*Pandion haliaetus*) are known to feed on forage fish species and northern anchovy, which form schools in Totten Inlet from September to as late as February (Fagergren 2005).

**POTENTIAL IMPACTS**

Potential Impacts during Construction

There would be little risk of adverse impact to birds during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site. Noise from hand tools and disturbance from human activity is expected to be temporary, occasional, and minor. While local bird species may leave the area temporarily, they would be expected to return when the noise-generating activities are completed.

Potential Operational Impacts

**Alternative 1 (Preferred):** There would be low risk for the proposed mussel farm to have an adverse impact on birds. The raft structures will provide perching and resting areas for local birds (especially cormorants and gulls) when not occupied by staff performing mussel culture duties. Because the rafts will displace a very small amount of the surface area of Totten Inlet and the activity will not result in noise levels much different from existing conditions, the proposed project is unlikely to have a significant adverse effect on birds. This is confirmed in the U.S. Fish and Wildlife
Services (USFWS) Biological Opinion for Nationwide Permit 48 for shellfish aquaculture in Washington (USFWS 2009), where existing mussel raft culture activities (removing tubes and transfer to shore using a boat) are listed as those with the potential effects that are expected to be insignificant (immeasurable) or discountable (extremely unlikely to occur) for marbled murrelets, which are typical of the types of birds that may feed on organisms that could be affected by the proposed project.

**Alternative 2 (Two-Row):** The effects of Alternative 2 would be the same as Alternative 1 in relation to birds, except there would be two more raft units upon which to perch.

**Alternative 3 (No Action):** Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no additional physical presence of rafts, or minor effects on the local ecosystem that would affect birds.

**MITIGATION MEASURES**

**Incorporated Features**

Predator nets around the rafts will have small mesh and will be kept taunt and without loose edges that could trap diving birds or herons.

**Applicable Regulations and Commitments**

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

**Other Recommended Mitigation Measures**

No additional mitigation measures are recommended for the proposed project relative to birds.

**SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS**

There would be no significant unavoidable adverse impacts to birds as a result of the proposed project with either action alternative.

**3.3.4 Mammals**

**AFFECTED ENVIRONMENT**

According to WDFW PHS Database (WDFW 2009), harbor seals (*Phoca vitulina richardsi*) are known to haul out on rafts and log booms on the east side of Totten Inlet. Harbor seals are opportunistic feeders, taking a variety of fish. California sea lions (*Zalophus californianus*) may also occur in Totten Inlet, as well as the northern river otter (*Lontra Canadensis*). These species are also opportunistic feeders, targeting mainly fish. Otters are very adept at catching small fish, and especially target flatfish.

**POTENTIAL IMPACTS**

**Potential Impacts during Construction**

There would be little risk of adverse impact to mammals during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site. Noise from hand tools and disturbance from human activity is expected to be temporary, occasional,
and minor. While local species may leave the area temporarily, they would be expected to return when brief construction activities are completed.

**Potential Operational Impacts**

Alternative 1 (Preferred): Noise generated by marine vessels, hand tools and disturbance associated with human maintenance and harvesting activities is expected to be similar to baseline activities at existing mussel farms in Totten Inlet at Gallagher Cove and Deepwater Point. Harbor seals congregate on the rafts and will haul out a few rafts away while workers are present. While some marine mammals may avoid the area temporarily, they would be expected to return when human disturbances cease. California sea lions are sometimes attracted to aquaculture facilities, probably seeking fish that may congregate around such structures. Northern river otters are known to haul out on mussel raft units in Totten Inlet (personal communication with Gordon King, Mussel Department Manager, Taylor Shellfish Company, Inc., February 17, 2009), and would be expected to do so on the proposed raft facilities, once installed. Significant adverse impacts are not likely to occur to marine mammals as a result of implementation of the proposed project.

Alternative 2 (Two-Row): Potential effects to marine mammals that could result from implementation of Alternative 2 would be the same as those described for Alternative 1, except there would be two more raft units upon which otters or seals may haul out.

Alternative 3 (No Action): Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no additional physical presence of rafts for marine mammals to haul out on, and no changes to the local ecosystem that could potentially affect marine mammals.

**MITIGATION MEASURES**

**Incorporated Features**

The rafts will be sited and configured to minimize effects on marine mammals. During maintenance and harvest operations, due care will taken to minimize disturbance of marine mammals, particularly seals and sea lions, in compliance with the Federal Marine Mammal Protection Act.

**Applicable Regulations and Commitments**

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6. Specifically, the MMPA will afford protection for marine mammals by prohibiting “take.” Under the MMPA take is defined as “harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect.”

**Other Recommended Mitigation Measures**

No additional mitigation measures are recommended for the proposed project relative to marine mammals.

**SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS**

There would be no significant unavoidable adverse impacts to marine mammals as a result of the proposed project with either action alternative.
3.3.5 Protected, Endangered, and Threatened Species

The Endangered Species Act (ESA) prohibits unauthorized “take” of listed species (16 USC 1531 et seq.). “Take” means to harm, harass, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct. Habitat modification that actually injures or kills a listed species through impairment of essential behavior is considered a “take.” Where otherwise lawful activity will result in a “take” of a listed species, an incidental take permit must be obtained. The application for an incidental take permit must be accompanied by a conservation plan, often referred to as a Habitat Conservation Plan (HCP).

On April 27, 2010, the National Marine Fisheries Service (NMFS) announced that three species of rockfish in Puget Sound will be listed under the ESA, effective July 27, 2010 (Federal Register 2010). These include Georgia Basin Distinct Population Segments (DPSs) of yelloweye rockfish (Sebastes ruberrimus) and canary rockfish (Sebastes pinniger) to be listed as threatened, and bocaccio rockfish (Sebastes paucispinis) to be listed as endangered. Because no habitat for these deep-water species—associated with rocky reefs (or extensive kelp beds for juveniles)—exists at or near the proposed North Totten Inlet Mussel Farm site (personal communication with Greg Bargmann, Research Scientist, Washington Department of Fish and Wildlife, May 4, 2010; and Dan Tonnes, Biologist, National Marine Fisheries Service, May 4, 2010), the proposed project will have no effect on these species. Therefore, they will not be discussed further under this section.

3.3.5.1 Bald Eagles (now down-listed from threatened to sensitive under the Endangered Species Act)

AFFECTED ENVIRONMENT

Bald eagles (Haliaeetus leucocephalus) are known to forage and perch along the shorelines of Totten Inlet. According to the WDFW PHS Database (WDFW 2009), the nearest bald eagle nest to the proposed project site is on the west shore of Eld Inlet, more than 1.8 miles from the project site, and not within line of sight.

Few birds eat as wide a variety of foods as do bald eagles. Fish are usually the most common prey taken by breeding bald eagles throughout North America, but bald eagles also capture a variety of birds. Bald eagles are capable predators and regularly kill prey using various hunting behaviors. In Puget Sound, bald eagles often raid gull and seabird roosts or nesting colonies to prey on adults, nestlings, or eggs, and occasionally prey on eggs, nestlings, or fledglings at great blue heron colonies. Subadult eagles have been observed walking through a seabird colony, stopping to pierce an egg with a talon, and carefully lapping out the contents. Diving ducks are taken by circling above and diving upon the duck, sometimes an eagle pair will alternate attacks. Bald eagles also feed on the carcasses of whales, seals (probably Phoca vitulina), sea lions, sea otters, and other marine mammals that wash up on marine shores. Thus, bald eagles are also effective scavengers, willing at times to feed on well-decayed flesh or garbage. In winter, spawned salmon on banks and bars of tributaries to Totten Inlet become the most important food for much of the local wintering population of eagles (Stinson et al. 2007).

POTENTIAL IMPACTS

Potential Impacts during Construction

There would be little risk of adverse impact to bald eagles during construction because fabrication of mussel raft parts will occur on land at the more-distant Taylor Shellfish Lynch Road plant in Mason County, and assembly of the rafts will occur on the beach at the Taylor Shellfish Old Plant site. Noise from hand tools and disturbance from human activity is expected to be temporary, occasional, and minor.
While foraging eagles may leave the area temporarily, they would be expected to return when brief
er construction activities are completed.

**Potential Operational Impacts**

Operation of the proposed new mussel rafts under either action alternative may affect but are
unlikely to adversely affect bald eagles because the closest known nest tree is more than 1.8 miles from
the project area, and disturbance associated with the new mussel farm will not be noticeably different
compared to baseline conditions.

Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet.
There would be no additional physical presence of rafts, and no minor effects on the local ecosystem that
could potentially affect bald eagles.

**MITIGATION MEASURES**

**Incorporated Features**

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration)
will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber
(Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation
devices), which will have no negative effect on water quality that could affect bald eagle prey species.

**Applicable Regulations and Commitments**

Local, State, and Federal regulations and commitments that will apply to the project are described in
Draft EIS Chapter 2, Section 2.4.6. It should be noted that the U.S. Fish and Wildlife Service removed the
bald eagle from the Federal list of threatened and endangered species in 2007. Bald eagles and their nests
are still protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The
Bald and Golden Eagle Protection Act also prohibits disturbance or molesting of eagles.

**Other Recommended Mitigation Measures**

No additional mitigation measures are recommended for the proposed North Totten Inlet mussel farm
relative to bald eagles.

**SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS**

There would be no significant unavoidable adverse impacts to bald eagles as a result of the proposed
project with either action alternative.

**3.3.5.2 Marbled Murrelet**

**AFFECTED ENVIRONMENT**

According to the WDFW PHS Database (WDFW 2009), no marbled murrelet occupancy sites occur
within the project area. Based on information in the USFWS Biological Opinion for Nationwide Permit
48 for shellfish aquaculture in Washington (USFWS 2009), it is unlikely that murrelets occur in Totten
Inlet: “Murrelets are observed in small numbers at various seasons as far south as the Nisqually Reach
and Budd Inlet.” Murrelets theoretically could feed in the area and would not be disturbed by presence of
existing mussel farm rafts.
POTENTIAL IMPACTS

Potential Impacts during Construction

There would be little risk of adverse impact to marbled murrelets during construction of mussel rafts because they likely do not occur in Totten Inlet.

Potential Operational Impacts

Operation of the proposed new mussel farm under either action alternative would be unlikely to adversely affect marbled murrelets because they likely do not occur in Totten Inlet. In the rare event that they did, marbled murrelet are unlikely to be significantly affected during mussel harvest. This is confirmed in the USFWS Biological Opinion for Nationwide Permit 48 for shellfish aquaculture in Washington (USFWS 2009), where existing mussel raft culture activities (removing tubes and transfer to shore using a boat) are listed as those with potential effects that are expected to be insignificant (immeasurable) or discountable (extremely unlikely to occur) for marbled murrelets.

Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no additional physical presence of rafts, and no minor effects on the local ecosystem that would affect marbled murrelets.

MITIGATION MEASURES

Incorporated Features

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality that could affect marbled murrelet prey species.

Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6. It should be noted, however, that a Section 401 Water Quality Certification is not needed because these are not required for Section 10 permits issued by the U.S. Army Corps of Engineers.

The USFWS Biological Opinion for Nationwide Permit 48 for shellfish aquaculture in Washington (USFWS 2009) lists existing mussel raft culture activities (removing tubes and transfer to shore using a boat) as those with potential effects that are expected to be insignificant (immeasurable) or discountable (extremely unlikely to occur) for marbled murrelets.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended to address potential effects of the proposed project on marbled murrelets.
SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to marbled murrelets as a result of the proposed project with either action alternative.

3.3.5.3 Bull Trout and Critical Habitat

AFFECTED ENVIRONMENT

Bull trout were Federally-listed under the Endangered Species Act (ESA) in 1999 (Federal Register 1999). In South Puget Sound, bull trout have only been detected as far south as the Nisqually River, which was probably a historical natal basin. The Puyallup River is currently a natal basin, although the population is much depressed. It is unknown whether a remnant bull trout population continues to persist in the lower Nisqually River drainage. Since it is the southernmost population, it is suspected that even if bull trout are using south Puget Sound, they are not very abundant (U. S. Fish and Wildlife Service 2009).

The project action area is not within designated bull trout critical habitat (Federal Register 2005), and there are no known runs of bull trout to tributaries of Totten Inlet (WDFW 2009). The Squaxin Island Tribe Natural Resources Department confirms that there have been no recorded occurrences of bull trout in the Skookum Watershed or any other watershed in this part of south Puget Sound (February 27, 2007).

POTENTIAL IMPACTS

Potential Impacts during Construction

There would be little risk of adverse impact to bull trout during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

Potential Operational Impacts

There would be no measurable risk of significant adverse operational impacts to bull trout under either action alternative because this species rarely (if ever) occurs in Totten Inlet. This is confirmed in the USFWS Biological Opinion for Nationwide Permit 48 for shellfish aquaculture in Washington (USFWS 2009), where existing mussel raft culture activities (removing tubes and transfer to shore using a boat) are listed as those with potential effects that are expected to be insignificant (immeasurable) or discountable (extremely unlikely to occur) for bull trout.

Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no potential changes to the local water chemistry, flow (ambient current velocity), or minor effects on the local ecosystem that could affect bull trout.

MITIGATION MEASURES

Incorporated Features

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality that could affect bull trout or their prey species.
Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended to address potential effects of the proposed project on bull trout.

Significant Unavoidable Adverse Impacts

There would be no significant unavoidable adverse impacts to bull trout as a result of the proposed project with either action alternative.

3.3.5.4 Chinook Salmon and Critical Habitat

Affected Environment

According to the WDFW PHS Database (WDFW 2009), there are no runs of Federally-listed Puget Sound Chinook salmon to tributaries of Totten Inlet. Juvenile Chinook may stray into Totten Inlet to feed.

Potential Impacts

Potential Impacts during Construction

There would be no risk of adverse impact to Puget Sound Chinook salmon or their critical habitat during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site during lower low tides.

Potential Operational Impacts

There would be no measurable risk of significant adverse operational impacts to Chinook salmon with either action alternative because their occurrence in Totten Inlet would be rare. See Section 3.3.2 for discussion of the impact of mussel aquaculture on non-listed fish species.

Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no potential changes to the local water chemistry, flow (ambient current velocity), or minor effects on the local ecosystem that could potentially affect Chinook salmon.

Mitigation Measures

Incorporated Features

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality that could affect Chinook salmon or their prey species.
Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended to address potential effects of the proposed project on Puget Sound Chinook salmon.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to Chinook salmon as a result of the proposed project with either action alternative.

3.3.5.5 Steelhead and Critical Habitat

AFFECTED ENVIRONMENT

According to the WDFW PHS Database (WDFW 2009), there are no runs of steelhead to tributaries of Totten Inlet. Juvenile steelhead may stray into Totten Inlet to feed.

POTENTIAL IMPACTS

Potential Impacts during Construction

There would be no risk of adverse impact to steelhead during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

Potential Operational Impacts

There would be no risk of significant adverse operational impacts to steelhead with either action alternative because their occurrence in Totten Inlet is uncommon. See Section 3.3.2 for discussion of the impact of mussel aquaculture on non-listed fish species.

Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet, and there would be no potential changes to the local water chemistry, flow (ambient current velocity), or minor effects on the local ecosystem that could affect steelhead.

MITIGATION MEASURES

Incorporated Features

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality that could affect steelhead or their prey species.
Applicable Regulations and Commitments

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

Other Recommended Mitigation Measures

No additional mitigation measures are recommended to address potential effects of the proposed project on steelhead.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There would be no significant unavoidable adverse impacts to steelhead as a result of the proposed project with either action alternative.

3.3.5.6 Southern Resident Killer Whales and Critical Habitat

AFFECTED ENVIRONMENT

From 1990 through 2003, the Whale Museum (2003) recorded between one and five sightings of Southern Resident killer whales in Totten Inlet. An internet search was also conducted to gather information on the occurrence of Southern Resident killer whales. From the Orca Network site, one result was found: on December 21, 2002, there was a “report of two male orcas swimming off Carlyon Beach (northern tip of the peninsula between Eld Inlet and Totten Inlet, near Olympia) in Squaxin Passage, between the mainland and Hope Island. They were swimming fast and heading north. In addition, three male orcas were sighted cruising the entrance to Eld Inlet that morning (8:25 a.m.). They continued to circle the southeast shoreline and the area off Cooper Point spit (just NW of Olympia) at the very southern tip of Puget Sound) for more than one hour.”

While the proposed North Totten Inlet mussel farm site is considered within the designated critical habitat for Southern Resident killer whale, the occurrence rate is very low compared to most all other areas of Puget Sound. The known occurrences coincide with the late fall chum salmon spawning run into Kennedy Creek, a small lowland stream that flows into the head of Totten Inlet. It is one of the most productive chum salmon streams in Washington State.

POTENTIAL IMPACTS

Potential Impacts during Construction

There would be little risk of adverse impact to Southern Resident killer whales during construction because fabrication of mussel raft parts will occur on land, and assembly of the rafts will occur on the beach at the Old Plant site.

Potential Operational Impacts

Alternative 1 (Preferred): Operation of the proposed 58-raft mussel farm would have little or no significant effect on Southern Resident killer whales because of their low level of occurrence in Totten Inlet, and the fact that whales would move away from any human activity disturbance in the immediate vicinity of the mussel rafts. Whales would be more likely to travel in the deeper parts of Totten Inlet.

8 URL: http://www.orcanetwork.org/sightings/archives.html
rather than the shallow areas close to shore where the rafts will be located. Because of their ability to echo-locate underwater objects, Southern Resident killer whales could easily avoid the rafts and predator netting beneath the mussel raft arrays. Mussel rafts and fish farms have existed for up to 40 years in marine waters of Western Washington without a single adverse interaction of whale and the facilities. Rafts in the Alternative 1 configuration would extend waterward a distance of approximately 539 feet offshore.

**Alternative 2 (Two-Row):** Most aspects of Alternative 2 would be very similar to Alternative 1, except that rafts would extend approximately 2,056 feet offshore, compared to the estimated 2,188 feet offshore for the rafts in Alternative 1. Whales could have slightly less distance to swim with this alternative to avoid the mussel rafts; however, this difference is expected to be insignificant.

**Alternative 3 (No Action):** Under the No Action Alternative, no additional mussel farm would be created in North Totten Inlet. There would be no additional physical presence of rafts, and no potential changes to the local water chemistry, flow (ambient current velocity), or minor effects on the local ecosystem that could affect Southern Resident killer whales.

**MITIGATION MEASURES**

**Incorporated Features**

Best Management Practices (BMPs) for mussel raft culture (including siting and raft configuration) will be employed to maintain water quality. The rafts will be constructed of natural, untreated lumber (Douglas fir), welded aluminum cross beams, and 55-gallon recycled food product barrels (for floatation devices), which will have no negative effect on water quality that could affect Southern Resident killer whales or their prey species.

**Applicable Regulations and Commitments**

Local, State, and Federal regulations and commitments that will apply to the project are described in Draft EIS Chapter 2, Section 2.4.6.

**Other Recommended Mitigation Measures**

No additional mitigation measures are recommended to address potential effects of the proposed project on Southern Resident killer whales.

**SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS**

There would be no significant unavoidable adverse impacts to Southern Resident killer whales as a result of the proposed project with either action alternative.
3.4 Navigation

AFFECTED ENVIRONMENT

There is no designated or maintained “navigation channel” within Totten Inlet. This waterway is currently used by small, private boats and vessels tending aquaculture sites. The Coast Guard is unaware of existing mussel rafts creating conflicts with vessels using the waterway (personal communication with Timothy Westcott, Private Aids to Navigation Manager, USCG, May 28, 2009).

POTENTIAL IMPACTS

Potential Impacts during Construction

There would be no potential impacts to navigation during the fabrication and assembly of rafts to create the North Totten Inlet mussel farm, as these activities would occur on land. There could be a temporary safety hazard when the rafts are floated into place, before navigation lights or other markers are installed.

Potential Operational Impacts

No safety hazards to vessel navigation within Totten Inlet would be anticipated in the developed and operational condition of the North Totten Inlet mussel farm, as the structure would be equipped with all private aids to navigation required by the U.S. Coast Guard. There is no precedent indication that mussel rafts so-equipped cause a safety hazard to navigation within Totten Inlet. The U.S. Coast Guard plotted the proposed position of the mussel farm using latitude and longitude coordinates and concludes that – at this location – minimal vessel conflicts could be assumed (personal communication with Timothy Westcott, Private Aids to Navigation Manager, USCG, July 7, 2009).

MITIGATION MEASURES

Incorporated Features

Taylor routinely installs two solar-powered navigation lights to identify the width of the raft structure, and as a back-up in case one of the lights burns out. These and/or temporary visual markers would be installed concurrent with floating the first rafts into place within the North Totten Inlet mussel farm, and would be maintained throughout operation of the farm.

Applicable Regulations and Commitments

The mussel raft installation will comply with U.S. Coast Guard private aids to navigation requirements set forth in 33 CFR, Parts 62 and 66. Marine marker lights on buoys will be required to mark the boundary of the proposed mussel raft, and/or lights on the ends of each raft to identify the obstruction on the water surface. Navigation charts will be revised to apply a symbol to indicate the presence of the mussel raft and any buoys, lights, or “dayshapes” installed to mark the raft location in the waterway. Once the rafts are deployed and the private aids to navigation are installed, the Coast Guard will immediately make a public notice announcement by marine radio broadcast, followed by inclusion of

9 The latitude and longitude coordinates of the center of the proposed North Totten Inlet mussel farm site are 47 09.527, and 122 57.771, respectively.
10 Dayshapes = signs of a particular shape and color that denote the type of obstruction in a waterway.
information regarding the new structure their printed weekly public notice (personal communication with Timothy Westcott, Private Aids to Navigation Manager, USCG, May 28, 2009).

Other Recommended Mitigation Measures

Additional ways to better mark obstructions in a waterway could be considered to ensure that the boating public is aware of the existence of the new mussel raft. Buoys, lights, and dayshapes could be used to mark the mussel raft. These would need to be permitted by the U.S. Coast Guard. The use of brightly-colored flags on cane sticks attached to the rafts could also be used to help make the rafts more visible. These would not need to be permitted; however, the Coast Guard would like to be involved in the determination of what color flags should be used (personal communication with Timothy Westcott, Private Aids to Navigation Manager, USCG, May 28, 2009). If deemed necessary or appropriate, Taylor could also issue public notice of the location of the new mussel raft in Totten Inlet via the local newspaper, radio or television; in the form of public notices posted at boat ramps or in marine supply stores; and/or on the Taylor website.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

Given that there is no record of conflicts between vessel traffic in Totten Inlet and existing mussel rafts in the Inlet, and given that the new North Totten Inlet mussel raft would be equipped with required private aids to navigation, no significant unavoidable adverse impacts to the navigable waterway would be anticipated as a result of either action alternative to implement the proposal.