Appendix F:

Brant Foraging Technical Memorandum

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Memorandum

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To: Jessica Anderson, Plauché & Carr

From: Ken Lindke, Quantitative Ecologist, and Scott Terrill, Principal Wildlife Ecologist

Subject: Reduction in foraging opportunity for black brant

Introduction

This appendix is intended to provide a detailed description of the methods used to estimate the reduction in eelgrass biomass available to brant as the result of brant avoidance of aquaculture structures and the project's impact on eelgrass density. The analysis is based on the previous project description, which was presented in the Draft Environmental Impact Report for Coast Seafoods Company's Humboldt Bay Shellfish Aquaculture: Permit Renewal and Expansion Project published in October 2015 (October 2015 DEIR). The October 2015 DEIR analysis provides a valid basis for evaluating the potential impacts of the revised project (Project) covered in this recirculated DEIR (R-DEIR) because it overestimates the reduction in eelgrass biomass available to brant compared to the R-DEIR. The October 2015 DEIR analysis predicted a 4.8% net decrease in eelgrass biomass; the Project proposed in this R-DEIR is predicted to result in no net loss of biomass. Moreover, the Project has been substantially revised such that less project acreage occurs in continuous eelgrass habitat relative to patchy eelgrass compared to project presented in the October 2015 DEIR. Assuming the revised Project results in the projected net zero loss of eelgrass biomass, the reduction in eelgrass biomass available to brant is attributable only to physical exclusion due to the presence of aquaculture infrastructure.

Below, we provide a detailed description of an existing model of brant energetics in Humboldt Bay (Stillman et al. 2015), which was used as a basis of comparison to model the impact of reduced foraging on brant in the Bay as a function of the October 2015 DEIR project design. We then describe the project-specific modeling conducted for the October 2015 DEIR and present the modeling results.

Conclusions and CEQA determinations regarding the Project presented in this R-DEIR, which are based on the modeling conducted for the October 2015 DEIR project, are provided in Section 6.5.4 of the main text of the R-DEIR.

Summary of the Stillman et al. Model

Stillman et al. (2015) present an individual-based model that predicts changes in daily mass gain, stopover duration, and survival of black brant in Humboldt Bay in response to sea level rise, changes in eelgrass abundance, and increases in anthropogenic disturbance (e.g., boat traffic). The model takes advantage of the best available data on eelgrass density, distribution, and biomass in Humboldt Bay based on surveys conducted in December and January 2001/02 and 2002/03 as part of a California Sea Grant study (as described in Stillman et al. 2015). Population parameters of black brant, including population abundance, energetics, and thresholds for behavioral shifts, are derived from Humboldt Bay-specific data whenever possible (e.g., population abundance, arrival date of first brant, and maximum feeding depth), and from data that most closely approximates the Humboldt Bay population otherwise (e.g., brant mass on arrival, brant target mass on departure, and energy expenditure while foraging or resting). The model follows a population of brant over a 183-day spring season in which brant arrive, forage and move throughout the Bay to optimize individual mass gain, and emigrate once a target mass threshold of 1,580 grams is reached. Model predictions were within 35% of observed values in Humboldt Bay for 11 properties of the modeled brant population; however, model predictions were sensitive to 10% changes in some model parameters, notably eelgrass energy content and metabolizability.

The model predicts that the total biomass of eelgrass in Humboldt Bay could support up to five times the number of brant observed to use the Bay in recent years; however, the authors are careful to point out that this result is somewhat misleading because brant are limited in their ability to fully capitalize on the resource. Eelgrass is only available during a limited window of tidal height, which imposes a temporal limitation on the amount of total eelgrass available for foraging. When this temporal limitation is accounted for, the model predicts that as little as a 10% decrease in eelgrass biomass or increase in human disturbance could result in a decrease in daily mass gain, which in turn results in an increase in stopover duration (i.e., delayed migration toward the breeding grounds). A decrease in the number of birds emigrating from Humboldt Bay was not predicted until eelgrass biomass was reduced or human disturbance was increased by at least 30%.

While the Stillman et al. (2015) model is based on the best available data, it should be noted that the model approach uses a conservative estimate of the total eelgrass biomass available in Humboldt Bay. Eelgrass biomass at the beginning of the model simulation is calculated only for the three youngest shoots of the turion occurring within "dense eelgrass beds" (aka "continuous eelgrass beds," based on NOAA Coastal Services mapping 2009), and thus does not include biomass for older shoots or eelgrass occurring throughout the Bay in "patchy" eelgrass habitat (defined as >10% to <85% cover). Brant preferentially feed on the three youngest shoots because they are the most energetically dense (Moore 2002), and tend to choose areas of higher biomass and nutritional quality (Moore and Black 2006). However, they also forage in areas of lower biomass and nutritional quality due to tide-height restrictions to high-quality foraging areas (Moore and Black 2006), and brant consume some (although a smaller proportion) of the older leaves (Moore 2002). Underestimating total biomass in this way, and calculating the amount of floating eelgrass as a percentage of the total biomass, underestimates the available floating eelgrass biomass as well. Although feeding on older eelgrass shoots and in patchy eelgrass beds would provide fewer calories per energy expended compared to feeding on young shoots in dense beds, there is caloric value associated with the biomass that is unaccounted for in the model. Nonetheless, Stillman et al. (2015) predict a very reasonable result: reduction in food availability can result in slower growth and longer residency time in order to achieve sufficient energy stores for migration and reproduction.

It should be noted that model predictions are based on simulations in which many parameters are held constant. If model parameters are close to the true values for Humboldt Bay eelgrass and brant populations, predictions should be accurate, but ignoring uncertainty in model parameters makes the standard deviations of those predictions smaller than they should be (i.e., overestimating precision). Also, error bars presented in Stillman et al. (2015) represent 1 standard deviation, which equates to approximately 68% confidence intervals rather than the more commonly used 90% or 95% confidence intervals. If 90% or 95% confidence intervals were used, the confidence bounds would be larger and a 10% change in eelgrass availability might not be significantly different than existing conditions.

Project-Specific Modeling for October 2015 DEIR

To assess whether the October 2015 DEIR project could reduce eelgrass biomass availability to the extent that stopover duration for brant would increase significantly, we estimated the percent reduction in bay-wide eelgrass biomass that would be effectively available to brant as the result of the project footprint . The GIS shapefiles containing eelgrass biomass and shoot length data were the same as those used in Stillman et al. (2015), and were derived from Sea Grant December/January biometric data collected in 2001/2002 and 2002/2003 (S. Schlosser, unpublished data). First, eelgrass data consisting of above-ground biomass and average shoot length of all continuous eelgrass habitat in Humboldt Bay were incorporated with eelgrass depth-range data (0.3 to -1.3 m MLLW in North Bay and 0.4 to -2.1 m MLLW in South Bay; Shaughnessy et al. 2012) and the Humboldt Bay DEM (Gilkerson 2008) using ArcGIS 10.1 (ESRI, Redlands, CA). Model grids were developed at 25 m^2 spatial resolution for both North and South Bays and attributed with cell center coordinates (WGS84 UTM zone 10 North in meters), eelgrass above-ground biomass (grams dry weight per square meter), eelgrass shoot length (meters), and cell depth (meters relative to MLLW).

Map algebra expressions were generated from functions described in Stillman et al. (2015) (Table 1) to relate eelgrass above-ground biomass and shoot length to depth relative to MLLW. This was done within the depth range capable of supporting continuous eelgrass habitat in North and South Bays using the Humboldt Bay DEM. Taking into consideration the spatial resolution of the DEM (25 m^2 grid cells), depth-specific biomass and shoot length projections were generated at 25 m^2 resolution for all areas deemed capable of supporting continuous eelgrass habitat in North and South Bays. To determine the proportion of rooted eelgrass habitat potentially available to foraging brant, winter tidal water level observations[1] and day length predictions (civil twilight)[2] were incorporated with depth-specific eelgrass biomass, shoot length projections, and the maximum depth brant reach below the water surface (0.4 m; Clausen 2000). All modeled continuous eelgrass habitat

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[1] Information derived from: http://tidesandcurrents.noaa.gov/inventory.html?id=9418767.

[2] Information derived from: see http://aa.usno.navy.mil/data/docs/RS_OneYear.php.

determined to be within the reaching depth of foraging brant at the lowest tidal height during winter daylight hours was considered to be available to brant. In doing so, we eliminate all eelgrass (in all areas, Bay-wide) that occurs below a depth that brant would never be able to access during winter daylight hours. It should be noted that because eelgrass biomass and associated shoot lengths were modeled from the late winter/early spring when they are at a minimum, the biomass estimates are conservative (because they likely increase throughout the season of brant occurrence in the Bay).

Table 1. Expressions Describing Eelgrass Biomass and Shoot Length as a Function of Depth for Arcata Bay and South Bay (Stillman et al. 2015)

Basin	Biomass Function	Shoot Length Function
North Bay	$y = -33.83x^2 - 21.28x + 31.30$	$y = -0.423x + 0.590$
South Bay	$y = -31.13x^2 - 41.92x + 47.61$	$y = -0.095x + 0.349$

Shapefiles depicting existing aquaculture and proposed aquaculture expansion areas within modeled continuous eelgrass habitat were then used to assess total eelgrass biomass that may have been affected by the October 2015 DEIR project, as well as the proportion of that habitat that could be rendered unavailable to foraging brant due to their propensity to avoid oyster longlines during periods of low tide exposure. This portion of the modeling process differed from that presented in Stillman et al. (2015) in that the existing aquaculture was not excluded (either partially or wholly) from brant availability in their model. Thus, the resulting biomass estimates presented below likely reflect a more conservative estimate of eelgrass that remains available to brant (and includes existing conditions, i.e., existing aquaculture infrastructure, rather than only proposed project effects in the prediction).

To estimate the potential reduction in eelgrass biomass effectively available to brant due to existing and proposed aquaculture operations (from the October 2015 DEIR), the following metrics were incorporated into the analysis. First, information describing reduction in eelgrass density associated with long-line oyster aquaculture (4.8% reduction in density due to shading) was used as a surrogate for biomass and applied to all areas of existing and proposed aquaculture areas.[3] It should be noted that using an estimate of reduced density to infer reduced biomass without additional information may result in an underestimate of reduced biomass because density is a function of surface area, whereas biomass is a function of volume. Next, to estimate the proportion of eelgrass biomass that would be rendered unavailable to brant as a result of longline infrastructure, behavioral observations from survey efforts and time-lapse videos of brant utilizing existing lease sites were used to determine the relative water elevation at which brant became excluded from the areas. For Coast's existing operations, brant were observed in time-lapse videos to depart when longlines became exposed at the water surface. For expansion areas proposed in the October 2015 DEIR, longlines were proposed to be a height of 1' (0.3 m) for cultch-on-longlines and 40" (1.02 m) for basket-on-longlines. This depth of exclusion was

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[3] Based on further analysis after the model was run, the projected loss in eelgrass density was revised to project a 5.0% reduction in density. This small increase in the projected eelgrass density reduction did not affect the overall estimates or conclusions of this analysis.

incorporated with depth-specific shoot length estimates to determine the proportion of the eelgrass canopy occurring below the longlines, and therefore unavailable to brant. Eelgrass biomass, which was assumed to be evenly distributed vertically from the substrate surface to the tip of the longest leaf, was then multiplied by the proportion of the canopy occurring below the height of the longlines to estimate the reduction in rooted eelgrass biomass potentially available to brant across both existing and proposed aquaculture areas. Because survey results indicate brant do not avoid the edges of existing aquaculture sites, no additional buffer areas of exclusion (i.e., around the project footprint) were included in this analysis.

Without accounting for the effects of aquaculture on eelgrass availability to brant, eelgrass biomass within the October 2015 DEIR project expansion area was estimated to be approximately 9% of the total biomass in Humboldt Bay (or 18% of the eelgrass biomass in North Bay), and biomass in Coast's existing aquaculture areas was estimated to be approximately 3% of the total Bay-wide biomass. Thus biomass within both existing and proposed areas was estimated to be approximately 12% of the total biomass in Humboldt Bay. The Bay-wide eelgrass biomass reduction (i.e., the impact to brant foraging) as a result of October 2015 DEIR Project activities was estimated to be approximately 3%. This estimated relied on the following assumptions: 1) aquaculture proposed in the October 2015 DEIR would have reduced overall eelgrass biomass by 4.8% within the project footprint; 2) brant will forage on shoots taller than the longlines and other structures (when tide height allows); and 3) there is no buffer around project footprints (i.e., where brant are excluded).

A direct comparison to the results of the Stillman et al. (2015) model is not possible because they did not account for biomass reduction or temporal loss of availability associated with brant avoidance of exposed longline infrastructure within existing aquaculture areas (i.e., existing conditions under CEQA), whereas this analysis includes these effects at Coast's existing and proposed aquaculture sites. However, we do not expect the differences between biomass estimates used in Stillman et al. (2015) and those presented here to be substantially different other than the reduction in biomass associated with existing aquaculture areas.

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