Appendix E:

2015 Black Brandt Survey Memorandum

H.T. HARVEY & ASSOCIATES
Ecological Consultants

Memorandum

Project# 3225-05

23 June 2015

To: Greg Dale, Coast Seafoods Company

From: Scott Demers

Subject: Black Brant Surveys for the Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project

Introduction/Project Purpose

This memorandum summarizes surveys conducted for black brant (*Branta bernicla nigricans*) to assist Coast Seafoods Company with an environmental impact assessment associated with the Humboldt Bay Shellfish Culture Permit Renewal and Expansion Project. Surveys were conducted during high and low tides in the peak spring migration period to document brant abundance in Arcata Bay, the northern portion of Humboldt Bay where aquaculture expansion is proposed, to establish an environmental baseline associated with the California Environmental Quality Act (CEQA). The establishment of a baseline for brant abundance in Arcata Bay is of particular importance because there is anecdotal evidence that brant distribution has shifted in recent years from South Bay (i.e., the southern portion of Humboldt Bay) to Arcata Bay, and thus there is an increased potential for aquaculture practices to affect brant. Surveys were also conducted to document the number of brant occurring within existing aquaculture beds and areas that are proposed for aquaculture expansion. Additionally, camera monitoring was conducted to augment survey efforts with behavioral observations in relation to the presence of aquaculture structure, as well as to generally assess the efficacy of using cameras to monitor brant behavior for subsequent monitoring work. The survey and monitoring information will be used to assess the potential impacts on brant associated with increased aquaculture in the bay. A description of the brant surveys conducted during the 2015 spring migration period in Arcata Bay and a discussion of the results are provided below.

Methods

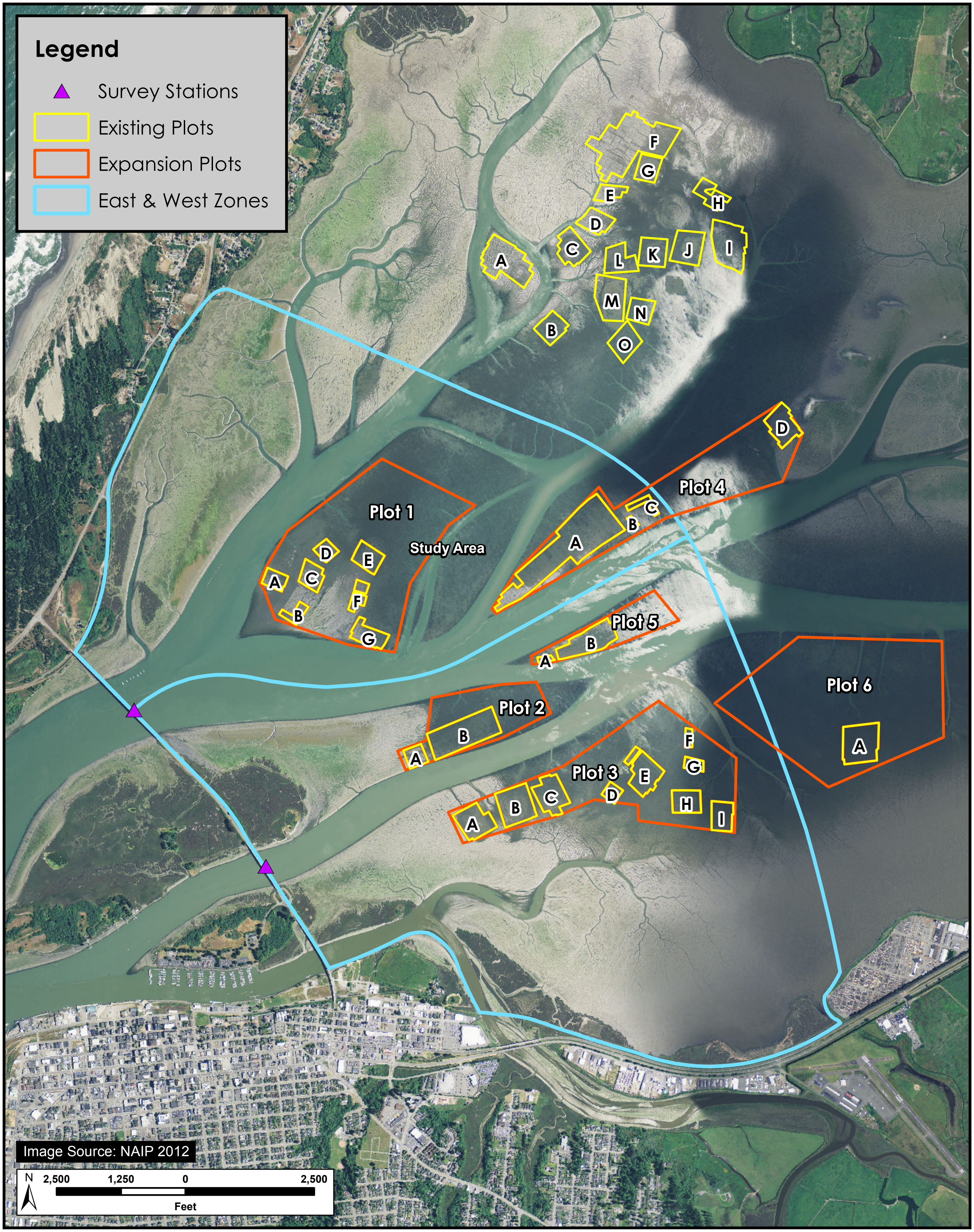
High and Low Tide Surveys

Survey Methods. Surveys for black brant were conducted in Arcata Bay during spring migration, representing the period of peak abundance for the species in the Humboldt Bay estuary. In order to become familiar with the survey area, the surveyors conducted a reconnaissance-level survey throughout Arcata Bay during low tide from a boat provided by and piloted by Coast Seafoods. During the boat survey, conspicuous structures in the bay (e.g., pilings, rafts) were identified and mapped to facilitate observer orientation during survey efforts. Surveys were conducted between 2 April and 23 April 2015 by H. T. Harvey & Associates wildlife ecologists Pia Gabriel, Betsy Elkinton, and Rob Fowler. The three surveyors have extensive experience with waterfowl identification and are familiar with the geography of Arcata Bay.

Two survey stations were established on high points of the Samoa Bridge along Highway 255 (Figure 1). A total of twenty surveys were conducted, with 10 surveys each conducted during high tides and low tides. High tide surveys were conducted between 4 feet (ft) and 2 ft Mean Lower Low Water (MLLW) on outgoing tides. Surveys were conducted during this period to capture the portion of the tidal cycle when water levels are sufficiently high enough for brant to forage by swimming in shallow water over eelgrass beds. These high tide surveys replicate the methodology used for previous and ongoing brant surveys conducted by the U.S. Fish and Wildlife Service in Humboldt Bay, which are mainly conducted in South Bay (i.e., southern Humboldt Bay) but have only been conducted sporadically in Arcata Bay. Previous brant surveys conducted in Arcata Bay were also conducted from the same two survey stations depicted in Figure 1, thus abundance estimates from the surveys described herein should be comparable to previous surveys conducted from the same locations during similar tide heights. Low tide surveys were conducted during the lowest feasible portion of diurnal tides occurring in the April survey period (i.e., the low tide "trough"). Tide heights during surveys were typically under 0.5 ft MLLW. The surveys were typically completed within approximately 1.5 hours.

During the surveys, observers recorded information on brant abundance and distribution in Arcata Bay. Surveyors recorded the total number of brant observed in the bay during each survey, counting all the birds visible in the bay from the two survey stations; the east and west portions of the bay were counted from the respective east/west survey stations on the Samoa Bridge (Figure 1). To assess brant use of existing aquaculture plots ("existing plots") and areas that are proposed for aquaculture expansion ("expansion plots"), the spatial distribution of brant in Arcata Bay was documented to the extent feasible during the surveys. For the purposes of surveys and analysis, existing plots and expansion plots were assigned plot numbers and/or letters based on their locations in the bay. For instance, all plots (both existing and expansion) within the southwestern-most aquaculture area were assigned to the larger "Plot 1", with the existing plots within Plot 1 assigned letters in addition to the overall plot number (i.e., 1A, 1B, 1C, etc.) and the remaining area within the overall plot associated with proposed expansion referred to as "Expansion 1" (Figure 1).

The numbers of brant present in existing and proposed aquaculture plots were recorded in zones (represented by the East and West zones; Figure 1) close enough to the bridge such that surveyors could accurately determine where birds were located during the survey. Areas to the north of the zones were considered too far from survey stations for surveyors to determine whether brant were in/out of existing or proposed plots; however surveyors were able to conduct counts (as described above) in all regions during most surveys. On three occasions weather conditions restricted full bay-wide counts and brant were only counted in the East and West zones depicted in Figure 1.



N:\Projects3200\3225-02\05\Reports\Fig 1 Aquaculture Plots.mxd mlagarde

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Figure 1. Existing and Proposed Aquaculture Plots
Coast Seafoods Company Black Brant Surveys (3225-05)
June 2015

Statistical Analysis. To determine whether there were differences in brant use of existing and expansion aquaculture plots, and if tide height affected brant use of either plot type, we compared brant use of plots during high and low tides. Within each plot, differences between the area (in acres) covered by existing aquaculture plots and proposed expansion plots vary considerably, but all the existing plots occupy less acreage than expansion areas. These differences in plot size make a direct comparison of observed black brant counts between existing and expansion areas statistically invalid because the expansion areas are substantially larger than existing plots, and thus would likely have higher observed counts in each survey even when densities were equal. Similar densities between existing and expansion plots would indicate similar use of these two areas, but if densities are similar then the observed counts would be quite different due to differences in acreage. To account for these differences, we calculated area-adjusted counts for expansion areas that are comparable to observed counts (i.e., the number of birds recorded) for existing beds, within a given plot (e.g., area-adjusted counts for expansion areas in Plot 1 are comparable to observed counts within existing beds in Plot 1). Although we use the observed density (i.e., the number of birds per acre) to compare brant use of existing and expansion plots, we chose not to use observed density for statistical analyses directly because density estimates did not adequately fit simple probability functions (e.g., there were an abundance of "zeros" in the data, transformations failed to achieve normality).

While these methods make area-adjusted counts in expansion areas comparable to raw counts in existing areas within a given plot, differences in acreage between plots are still unaccounted for. If brant use is similar in two plots (ignoring differences between expansion and existing areas within a plot), then densities would also be similar. If one of these plots is very small, counts would be low, and if the other is quite large, counts would be high. In this scenario brant densities are similar, and thus use is similar between plots, but counts are very different. We were most interested in differences attributable to tidal cycle and plot type (existing or expansion aquaculture plot), rather than between-plot differences. However, between-plot differences have to be accounted for before we can evaluate these two variables of interest, and thus we accounted for them in the modeling structure by including a "Plot" variable.

To investigate the effects of oyster aquaculture and tide cycle on black brant presence in existing and proposed plots, we constructed a set of negative binomial generalized linear models and used the second-order bias-adjusted Akaike's Information Criteria (AICc). The model with the lowest AICc score is considered to be "best" among the proposed models, and models with AICc scores more than 2 points greater than the "best" model are considered to have poor statistical support (Burnham and Anderson 2002). A full model that included tide cycle (Tide), aquaculture status (Status; either existing or expansion), and the interaction between Tide and Status was defined. Four additional models which excluded one or more of these variables were also defined; plot number (PlotID) was included in all models to account for differences in acreage and inherent differences in black brant use between plots. Residual plots for the top AICc-ranked model were examined for violations of model assumptions, and parameter estimates and their associated p-values were examined to make inferences about black brant use of existing and proposed aquaculture sites. Models were fit using the glm.nb() function in package MASS (Ripley et al., 2015), in the R statistical computing environment (R Core Team 2014, v 3.1.1).

Camera Deployment

Wildlife-monitoring cameras were deployed in Arcata Bay to observe brant behavior in existing aquaculture plots (as well as in non-developed areas for comparison) in relation to tide height and aquaculture infrastructure. In particular, because high and low tide brant surveys were conducted during specific portions of the tide cycle as described above, imagery collected throughout the tidal cycle may be useful in assessing brant behavior in between survey periods. To test the efficacy of using cameras to monitor brant behavior, two cameras (Browning Range OPS XR) were placed in Plot 2B (Figure 1) set to record images using the time-lapse function. Each camera was attached to a PVC pole temporarily positioned on a mudflat during low tide (Photo 1). Access to Arcata Bay was achieved via boat provided and piloted by Coast Seafoods. The camera mount was positioned such that the camera would be above the highest predicted tides and one camera was pointed towards an aquaculture plot and another towards a proposed aquaculture plot (i.e., an undeveloped plot).

Photo 1. H. T. Harvey & Associates wildlife ecologist Neil Kalson deploying wildlife monitoring cameras to record imagery of black brant in Arcata Bay.

Upon retrieving the camera, it was noted that imagery was sufficiently clear to identify avian species, including brant, and basic behavioral information could be recorded using the time-lapse function on the camera (although heavy winds during deployment altered the camera positioning). However, the time-lapse function set to 1 photo/30 seconds resulted in large temporal gaps in imagery such that the presence of brant and/or relevant brant behavior could be unrecorded that setting. Based on memory storage capacity, it was determined that time-lapse photography could be recorded for approximately 3 days (diurnal only) when set to the maximum recording setting of 1 photo/10 seconds; this duration corresponded to the maximum observed battery life of the cameras, thus this setting maximized the amount of data that could be recorded in one deployment (i.e., 3 days, daylight periods only). Two cameras were then deployed on 14 April 2015 in

Plot 4. One camera was placed in existing Plot 4A (Figure 1). This site was chosen because the plot includes longlines set at 2.5-ft row spacing with 10-ft "boat rows" every fifth row; thus this site best represented the proposed longline spacing of Coast Seafoods expansion project. The camera was deployed to record imagery from at least two boat rows, with the camera being placed at the southern extent of a boat row, facing north. The other camera was placed at the southern extent of expansion Plot 4 (Figure 1); imagery from this non-developed site was intended to serve as a control site (i.e., a close-by site without aquaculture structure). Cameras were deployed facing north to reduce the potential for sun-glare in the imagery.

Results and Discussion

High and Low Tide Surveys

Bay-wide Counts. The mean count for low-tide black brant surveys was 4164 birds (range 3120—5559) and the mean count for high-tide surveys was 3170 birds (range 2234—4340). The observed differences in low and high tide counts (i.e., lower counts during high tide) reflects observations that brant would congregate in areas such as Eureka Slough, areas south of Samoa Bridge (i.e., along Indian Island), or on the lee side of various marsh habitats during high tides, presumably because foraging opportunities were more limited during high tides in Arcata Bay (i.e., eelgrass was more likely to be inundated in portions of the bay) and brant were likely avoiding windy conditions in the open bay that were more prevalent during spring high tide surveys that mainly occurred in the afternoons during the survey period.

As discussed above, the surveys were conducted during the period of peak abundance for brant during the 2015 spring migration period, and there is indication that brant abundance in Arcata Bay has recently exceeded that of the South Bay (USFWS unpublished data) where brant and eelgrass abundance has historically been greater than Arcata Bay (Moore et al. 2004). Therefore the counts conducted in spring 2015 should be considered the best available environmental baseline information for environmental impact assessment purposes. It should be noted however that there are limitations to collecting data only during the peak migration period, as population demographics can change seasonally, with older (and more experienced) birds tending to arrive early during the migration period (Lee et al. 2007). Presumably, older and more experienced individuals are more efficient foragers and arrive on breeding grounds earlier (and have higher reproductive success) than younger, later arriving birds. However, differences in the age structure of birds occurring in the bay during the peak migration period compared to earlier in the season are unlikely to substantially affect the observed distribution relative to existing or proposed aquaculture areas.

Plot Count Summary. During low tides, black brant were consistently observed in higher densities (i.e., birds/acre) in undeveloped expansion plots (mean density=2.6 birds/acre) compared to existing plots (mean density=0.1 birds/acre). However, during high tides brant were observed in approximately the same densities in expansion plots (mean density=1.0 birds/acre) compared to the existing plots (mean density=1.3 birds/acre).

Analysis Results. As discussed above, the effects of aquaculture and tide cycle on brant presence in existing and proposed plots was tested using an AICc modeling approach. The top AICc-ranked model included plot number, tide cycle, aquaculture status, and the interaction between tide cycle and aquaculture status (Table 1). Examination of model residuals did not reveal any substantive violations of model assumptions. Parameter estimates for Plots 3 and 5 (plots are depicted on Figure 1 above) were significant at the 0.05 level of significance ($p=0.014$ and $p=0.0007$, respectively), and indicated that use was higher in Plot 3 and lower in Plot 5 as compared to use of Plot 1 (Plot 1 was chosen as a reference by the statistical program by default) (Figure 2). The parameter estimate for low tide was significant at the 0.05 level ($p<0.001$) and indicated that use was lower at low tide than at high tide in existing aquaculture areas (Figure 2). The parameter estimate for expansion areas was not significant ($p=0.93$) indicating that use was not different between existing and expansion areas at high tide.

Table 1. Modeling results for black brant use of existing and proposed aquaculture sites in Humboldt Bay, CA. A statistical interaction is denoted by ":" in the model formula; "df" denotes the number of fitted parameters in the model; ΔAICc is the difference in AICc value between each model and the model with the lowest AICc score.

Model	df	Model Likelihood	AICc	ΔAICc
Counts = PlotID + Status + Tide + Status:Tide	8	-597.3994	1211.75	0.00
Counts = PlotID + Status	6	-620.3357	1253.22	41.47
Counts = PlotID + Status + Tide	7	-619.3022	1253.34	41.59
Counts = PlotID	5	-630.3322	1271.05	59.30
Counts = PlotID + Tide	6	-629.3287	1271.21	59.45

The parameter estimate for the interaction between aquaculture status and tide cycle was also significant at the 0.05 level ($p<0.001$), which indicates that the effect of tide cycle on use depends on aquaculture status and that use is greater in expansion areas during low tide than it is in existing areas during high tide (Table 2; Figure 2). Together these results indicate that aquaculture status does not significantly affect use at high tide. Within existing plots, use is significantly lower during low tide, and that use is greater in expansion areas during low tide than it is in existing areas during high tide.

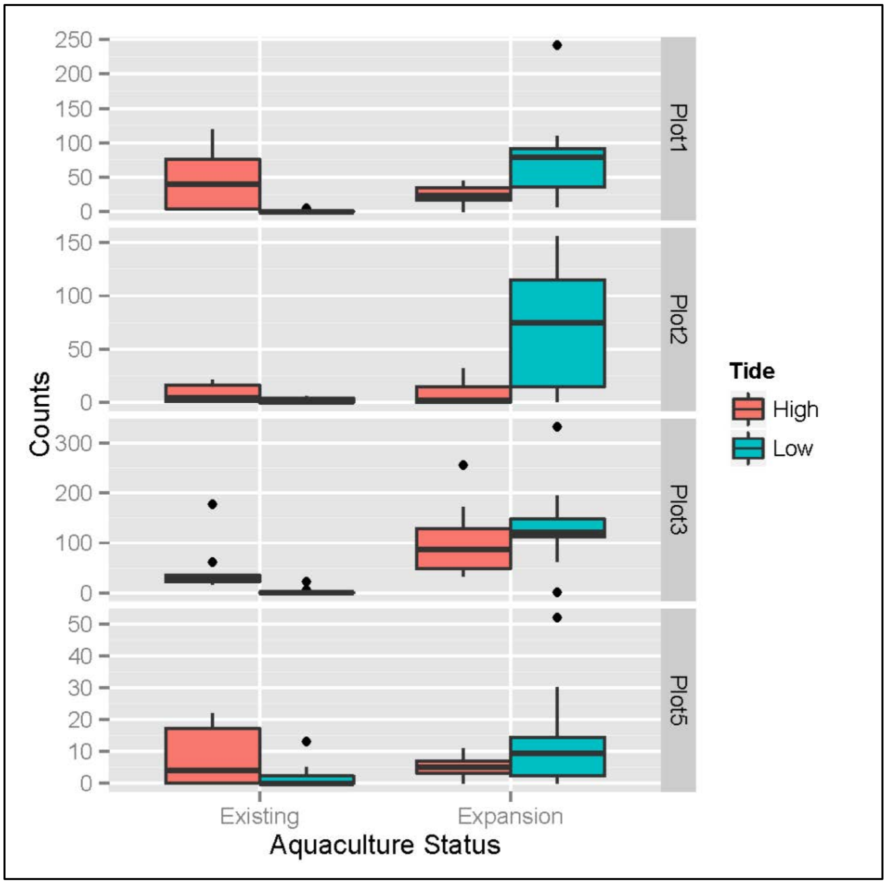


Figure 2. Area-adjusted black brant counts for existing and expansion aquaculture plots observed during high and low tide surveys in Arcata Bay, California.

Table 2. Parameter estimates, standard errors, z-statistics and p-values for the top AICc-ranked model, Counts=PlotID+Status+Tide+Status:Tide, where ":" denotes a statistical interaction. The reference case is Plot 1, existing aquaculture status, and high tide; parameter estimates represent adjustments to this reference case for the specified level(s) of each variable.

Model Parameter	Estimate	Standard Error	z value	p-value
(Intercept)	3.28	0.29	11.35	< 2e-16
PlotIDPlot2	-0.61	0.31	-1.94	0.0524
PlotIDPlot3	0.76	0.31	2.47	0.0137
PlotIDPlot5	-1.08	0.32	-3.40	0.0007
StatusExpansion	-0.03	0.31	-0.09	0.9324
TideLow	-2.37	0.33	-7.24	4.41E-13
StatusExpansion:TideLow	3.49	0.45	7.79	6.99E-15

Camera Imagery

The following is a summary of observations from reviewing imagery captured from the wildlife-monitoring cameras placed in Plot 4A and expansion Plot 4 (depicted on Figure 1) that may inform impact assessment. It should be noted that elevations of Plot 4A and expansion Plot 4 differ, as 4A appeared to have lower water levels than expansion Plot 4 when observing concurrently-collected imagery. Utilizing a digital elevation model created for Humboldt Bay (PWA 2014) to estimate elevations of aquaculture plots, the average elevations of existing 4A is approximately 0.19 ft and expansion Plot 4 is -0.08 ft. The difference in elevation between the sites is reflected in differential avian use of the site during the same portions of the tidal cycle.

- Brant were observed foraging and traversing both the existing and proposed aquaculture sites when water was sufficiently high to swim but no brant were observed walking across flats to forage at lower tides, including in the 10-ft "boat rows" in Plot 4A.
- On rising tides, brant began to access Plot 4A when the tide height was between approximately 0.5 ft and 0.8 ft MLLW (based on the predicted tide height). At those tide heights, aquaculture infrastructure was still emergent (i.e., the top of the structures were above the water line), but brant would traverse the sites under those conditions. On falling tides brant were last observed in Plot 4A between 0.8 ft and 1.5 ft MLLW. Thus, they appeared to access the site at slightly lower water levels on rising tides than on falling tides. Nonetheless, it appears that brant will readily access the aquaculture sites at tides as low as approximately 0.5 ft.
- Brant were occasionally observed to traverse the "boat rows" or 10-ft spaces between longlines at lower water levels (i.e., at approximately 0.5 ft MLLW on a rising tide), however on those occasions brant were observed traversing across the aquaculture site (not using the boat rows) at similar or just slightly higher water levels (Photo 2). Thus, based on the information collected during the period of camera deployment, the boat rows did not appear to receive higher brant use than the aquaculture site in general. .
- Plot 4A was observed to lack eelgrass compared to expansion Plot 4, likely due in part to the lower elevation of Plot 4 (and possibly coupled with shading effects associated with the longlines). Brant were however observed to occasionally forage over Plot 4A, likely pecking on floating eelgrass but also seemingly foraging on algae growing on and under the longlines (Photo 3).
- Incidental to this study, but of broader interest with respect to avian use of aquaculture sites in general, shorebirds were observed in large numbers foraging in and adjacent to Plot 4A (Photos 4 and 5). Shorebirds were observed first accessing the Plot 4A area when water levels were between 0.3 to 0.5 ft MLLW on falling tides and last using the site when water levels approached 0.1 to 0.3 ft on rising tides. Typically larger species (i.e., marbled godwits [*Limosa fedoa*]) would arrive before small species (i.e., small sandpipers [*Calidris spp.*]), as the smaller birds can only access the sites when fully exposed or in very shallow water. Because expansion Plot 4 is lower than Plot 4A water levels were relatively higher on that site during the camera monitoring, and as a result shorebirds were only observed briefly in the expansion area on one of the three days of observations when the flats were exposed.

Photo 2. Black brant traversing through a 10-ft "boat row" in Plot 4A on a falling tide on 10 April 2015. Although brant appeared to use the more open spaces more readily when infrastructure is above the water line, the boat rows did not receive substantially higher use than the aquaculture site in general.

Photo 3. Black brant apparently foraging on algae growing on longlines in Plot 4A on 12 April 2015.

Photo 4. Marbled godwits foraging within and around longlines in Plot 4A on 10 April 2015. Larger shorebirds, such as godwits, are able to forage in deeper water than smaller Calidrid sandpipers and thus accessed the site earlier on a falling tide.

Photo 5. A large mixed flock of shorebirds foraging within and around longlines on 10 April 2015 in Plot 4A. Smaller shorebirds, such as Calidrid sandpipers, are able to access the mudflats only when fully exposed or in shallow water conditions, as shown in the photo.

Conclusions

The above-described information regarding brant abundance in Arcata Bay, brant distribution relative to aquaculture at high and low tides, and behavioral information regarding brant (as well as shorebirds and other species) collected through camera monitoring will be useful for impact assessment purposes. The Arcata Bay survey information will allow for the establishment of a suitable CEQA-level baseline, which is of particular importance given most survey effort has been focused on South Bay where the majority of brant occurred historically. For purposes of impact assessment, the mean of the low-tide counts (which were higher on average than high-tide counts) represents a conservative baseline that could be used to assess the effects of aquaculture on the brant population. Based on the survey results and behavior captured with cameras, brant appear to avoid aquaculture infrastructure during low tides, apparently when water levels are approximately 0.5 ft MLLW, as predicted for the nearest tide station (note varying plot elevations will need to be considered for analytical purposes). However, brant readily access the aquaculture sites even when structure is above the waterline. Also, surveyors noted that brant were not deterred from accessing foraging sites that were directly adjacent to aquaculture structure (e.g., along channels adjacent to aquaculture plots). This suggests that impact acreages used for impact assessment should include only the boundaries of the structures and not additional buffer areas that are not directly impacted by aquaculture practices.

Literature Cited

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer, New York, New York.

Lee, D. E., J. M. Black, J. E. Moore, and J. S. Sedinger. 2007. Age-specific stopover ecology of black brant at Humboldt Bay, California. Wilson Journal of Ornithology: 119:9-22.

Moore, J.E., M.A. Colwell, R.L. Mathis, and J.M. Black. 2004. Staging of Pacific flyway brant in relation to eelgrass abundance and site isolation, with special considerations of Humboldt Bay, California. Biological Conservation 115:475-486.

Pacific Watershed Associates (PWA). 2014. Humboldt Bay Sea Level Rise DEM Development Report. Prepared for Sate Coastal Conservancy, Oakland, CA and Coastal Ecosystems Institute of Northern California, Bayside, CA.

R Core Team. 2014. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Ripley, B., B. Venables, D. M. Bates, K. Hornik, A. Gebhardt, and D. Firth. 2015. MASS: Functions and datasets to support Venables and Ripley, 'Modern Applied Statistics with S' (4th edition, 2002). R package version 7.3-40. URL http://www.stats.ox.ac.uk/pub/MASS4/.