California Department of Fish and Wildlife Report on Accepted Practices Guidelines for Groundfish Stock Assessments Meeting

The California Department of Fish and Wildlife (CDFW) provides the following report in response to the Groundfish Subcommittee of the Scientific and Statistical Committee (GFSC) report (Agenda Item H.4.a, SSC Groundfish Subcommittee Report 2, March 2025) which recommended additional review and analysis of Remotely Operated Vehicle (ROV) data to be presented at the March 2025 Council meeting.

CDFW appreciates the GFSC's endorsement of use of ROV indices in stock assessments at the discretion of the STAT. Appendix 1and 2 adds to the progressive work completed to date to address concerns raised at the 2024 workshop. CDFW anticipates an additional workshop may be needed for continued advancement of this important and innovative work. CDFW supports adding a general statement to the Accepted Practices Guideline document articulating the GFSC consensus that ROV indices can be used in stock assessments at the discretion of the STAT team.

In recognition of more than 20 years of large-scale Rockfish Conservation Area closures combined with California's Marine Protected Area Network, CDFW has been working on incorporating ROV data collected inside and outside closed areas into stock assessments since 2018. The integration of ROV data to develop indices of relative abundance using Generalized Linear Mixed Models (GLMM) and estimates of absolute abundance using design-based and model-based methods in combination with seafloor mapping are a testament to the advancement of fishery population assessment modeling work that directly considers large closed areas in a real and objective way.

CDFW appreciates Pacific Fishery Management Council support for hosting public workshops and looks forward to input from the SSC and continued collaboration with STAT science partners. The immediate goal of integrating this work into the full benchmark assessment for quillback rockfish remains a priority, while recognizing the application of these methods may be just as important for other groundfish species assessed in future cycles.

Appendix 1

Appendix 1 follows the format laid out in SSC GFSC Meeting Report Dec 2-3, 2024 (March 2024, H.4.a SSC Groundfish Subcommittee Report 2). Suggestions and requests from the GFSC are laid out in the body of the report and also specifically numbered under each section. CDFW denotes these in each section as a "Request" followed by our "Response".

C. California ROV: Overview of survey methodologies

C.1. 2020 methodology review report and recommendations

Follow-up analyses from the methodology review regarding indices of abundance and design-based estimates of abundance were presented to the GFSC at the December 2024 meeting. Additional requests regarding the model-based estimates of abundance remain to be addressed at a future workshop regarding feedback received by California and Oregon proponents at the methodology review.

C.2. Ongoing research and methodological improvements

Request i: CDFW reported the development of a data user manual for the ROV survey. The GFSC recommends making this manual publicly available.

Response: The Department of Fish and Wildlife has Data Sharing Agreements with parties that have requested the data and they can be provided to them at that time or independently if requested. The current ROV data user manual is included here as Appendix 2.

C.3. 10-m segment indices of abundance and MPA applications

The GFSC provided useful feedback on the indices developed by Nick Perkins of the University of Tasmania using the 10 m resolution data set to examine variation in distribution at finer spatial scales, as well as analyses conducted by CDFW to compare the results at this resolution to the transect level analyses preferred for use in stock assessments. These 10 m resolution methods are not pursued for the 2025 quillback rockfish stock assessment thus the focus of following efforts were placed elsewhere.

C.4. Transect level indices for the Quillback Rockfish Assessment

Request i: Future model configurations should consider including along coast distance as a spline or latitude and longitude as a bivariate term in place of average latitude as the spatial covariate.

Response: Along coast distance was derived by measuring the distance along the 50 m bathymetric depth contour from Point Conception to the latitude of the centroid were each ROV transect intersecting with the 50 m contour line. This depth was chosen over other shallower depths given the greater degree of convolution of the line in shallower depths with more variable relief. The along coast distance was used in place of the average latitude of the transect with the remaining variables identified in the preferred model presented at the December GFSC. The results of the Generalized Linear Mixed Model (GLMM) output are provided in Figure 1, which indicates a lower AIC score (2209.7) than the model with latitude (2214.1). That said, the diagnostics for the KS test indicated a significant value and significant patterns were in the model residuals with depth from the R package Dharma for the distance along coast, which indicate that latitude may be preferred (Figure 2). As with the model using latitude instead of distance along coast, the measure of dispersion from a non-parametric dispersion test using the standard deviation of residuals for fitted vs. simulated data was significant with a p-value of 0.024, while the dispersion itself was only 0.01953, which is very low. The outlier test was not significant, as was also the case for latitude (Figure 2).

Given the consistent northwesterly direction of the coast starting at Point Conception from south to north, latitude captures the increasing density of quillback rockfish in more northern latitudes toward the center of its range sufficiently well. Comparing the percent deviation between the preferred model with average latitude and distance along the coast resulted in around 11% being captured with either model (Table 1). Thus the percent deviance did not indicate a substantive improvement from using distance along the coast vs. average latitude.

A significant residual pattern was observed in the residuals of the model with model predictions, though it was not visually evident apart from the fitting of the model (Figure 3). No significant pattern was observed in the residual of the model with variables for proportion hard and mixed substrate Figure 4 or depth squared Figure 5. Though statistically significant correlations of residuals with depth were observed in Figure 6 (which did not occur when latitude was used Figure 7) and distance along coast, though the pattern observed in the fit to the residuals is not clear in visual inspection of the residuals. A similar residual pattern to that observed for the distance along coast was observed for the same model using latitude (Figure 8). Tests for zero inflation were not significant (P-value = 0.352). Tests for homogeneity of variance between areas with (1) and without (0) protection in MPAs were not significant (Figure 9).

Regarding including latitude and longitude as a bivariate framework, including both as separate terms in a GLMM may present issues with collinearity due to the nature of the coastline as higher latitudes also have higher longitudes. Also, longitude is confounded with depth as it is a measure of how far offshore a location is, but this changes with latitude. Moving to a Generalized Additive Model (GAM), Latitude and Longitude can be included as a two-dimensional “smooth” term as a random effect. This is somewhat analogous to modelling spatial autocorrelation as you model a 2D surface that captures spatial variability not captured by fixed effects. There was not sufficient time to explore these options and given considerations presented, this may not be a fruitful exercise.

```
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: Negative Binomial(2.4805)  ( log )
Formula: Quillback.Rockfish ~ (1 | site) + SuperYear * Protection + PropHardMixed + distance +
avg_depth + DepthSquared, Data: sc.dat, Offset: log(usable_area_fish)

AIC              BIC       logLik     deviance            df.resid
2209.7    2258.1    -1094.8    2189.7      925
Scaled residuals:
Min          1Q             Median          3Q          Max
-1.4010    -0.4978          -0.1685          -0.0295     11.0961

         Fixed effects:
                              Estimate   Std. Error   z value   Pr(>|z|)
(Intercept)                  -7.88595     0.34267   -23.013    < 2e-16 ***
SuperYear2020                 0.26424     0.14054     1.880    0.06008 .
Protection1                  -0.07015     0.43881    -0.160    0.87299
PropHardMixed                 0.61826     0.07162     8.633    < 2e-16 ***
distance                      1.77671     0.24428     7.273    3.51e-13 ***
avg_depth                     0.63423     0.10288     6.165    7.07e-10 ***
DepthSquared                 -0.57834     0.07650    -7.560    4.03e-14 ***
SuperYear2020:Protection 0.55992     0.18737     2.988     0.00281 **
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) SpY2020 Prtct1 PrpHrM distnc avg_dp DpthSq
SuperYr2020 -0.213
Protection1 -0.661  0.172
PropHardMxd -0.066 -0.087  -0.001
distance   -0.410  0.049   0.213 -0.002
avg_depth   -0.016 -0.005  -0.012  0.488 -0.030
DepthSquard -0.206  0.035   0.034  0.131  0.023  0.107
SprY2020:P1  0.156 -0.747  -0.261  0.054 -0.031  0.013 -0.005
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Figure 1. Results of a GLMM for preferred model with distance along coast in place of latitude.

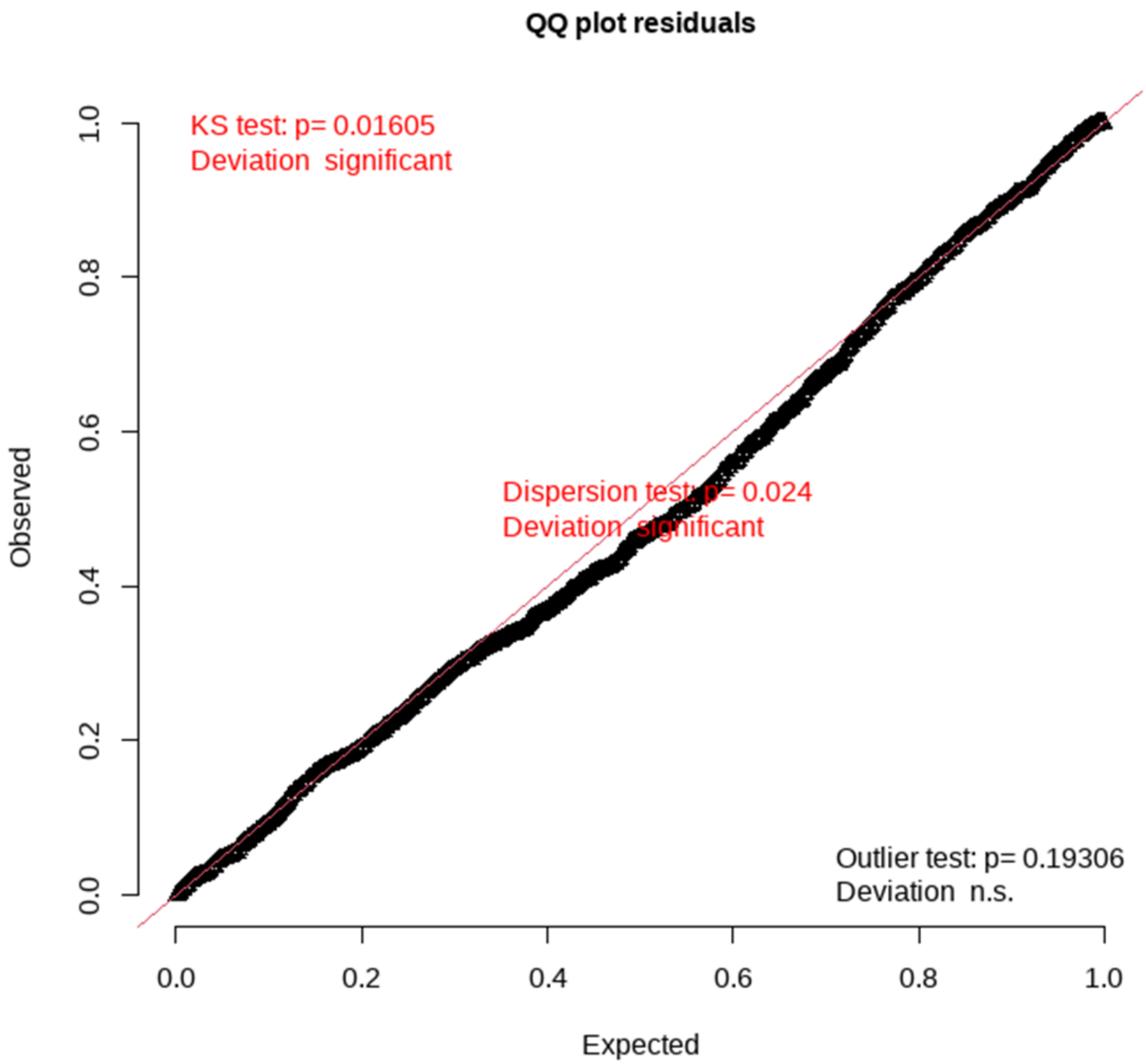

Figure 2. QQ Plot from Dharma using the negative binomial distribution employed in the model, showing results of KS tests, dispersion tests and outlier tests.

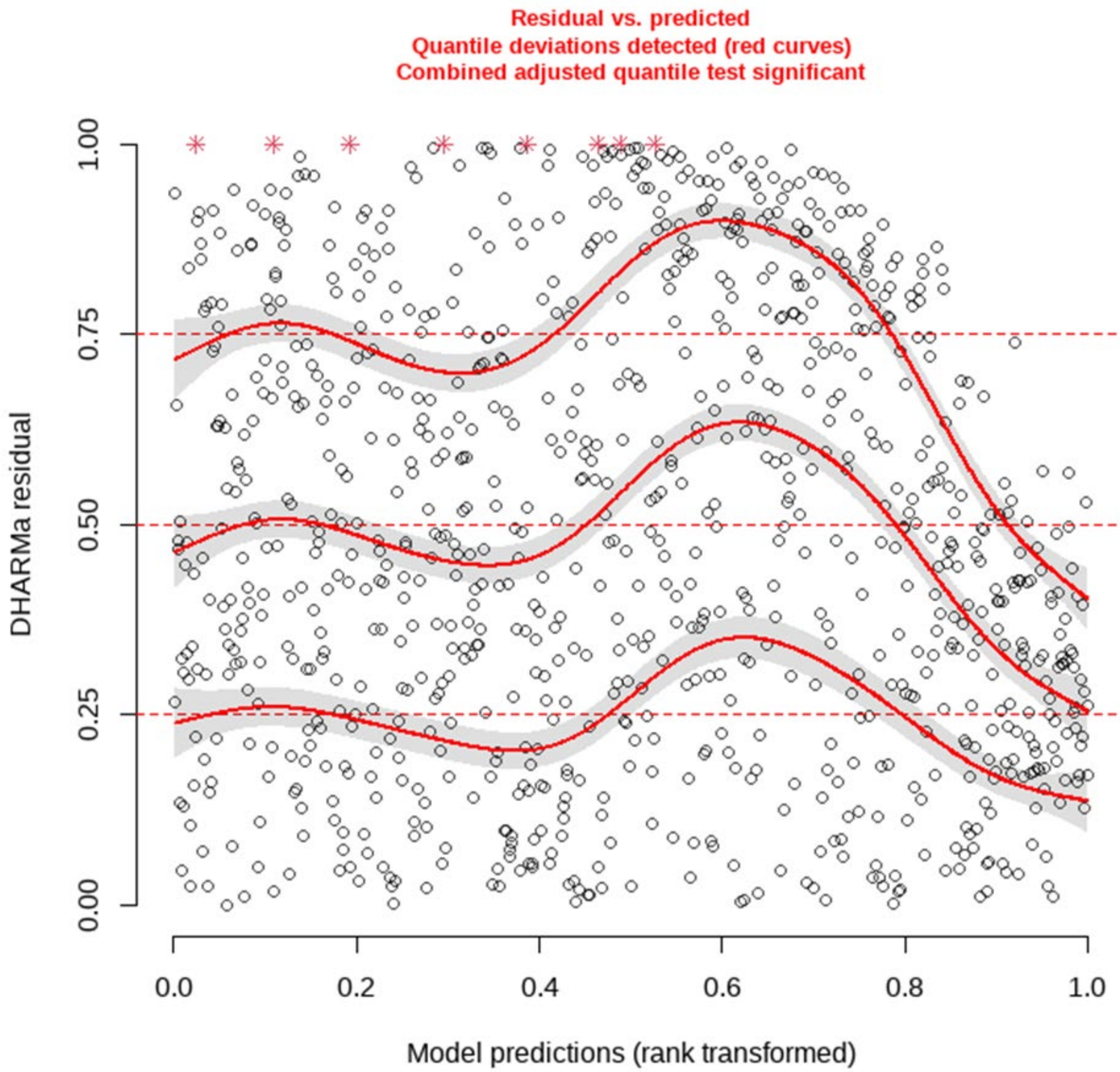

Figure 3. Dharma output of residuals with rank transformed model predictions.

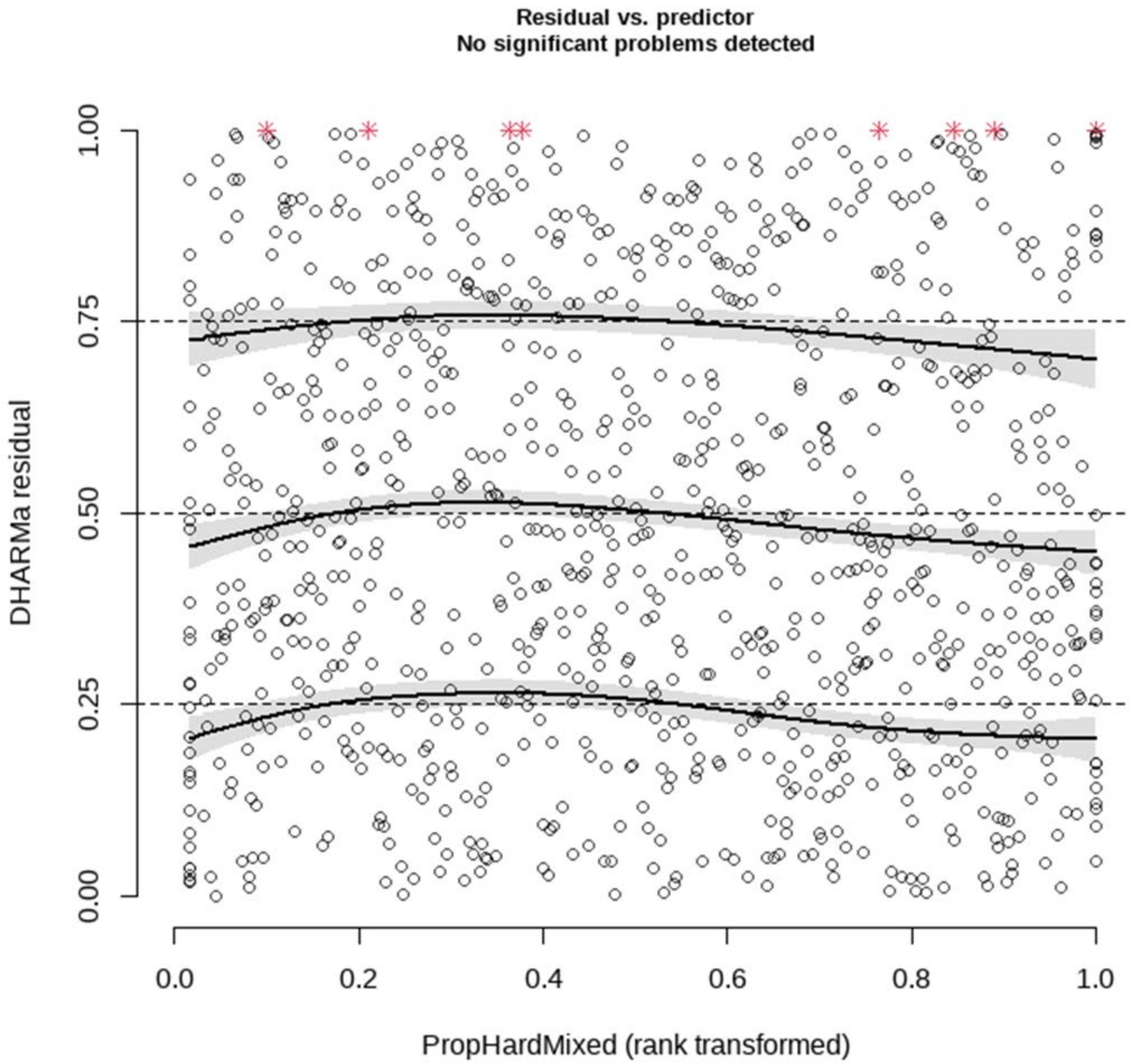

Figure 4. Dharma output of residuals with rank transformed proportion of hard and mixed substrate.

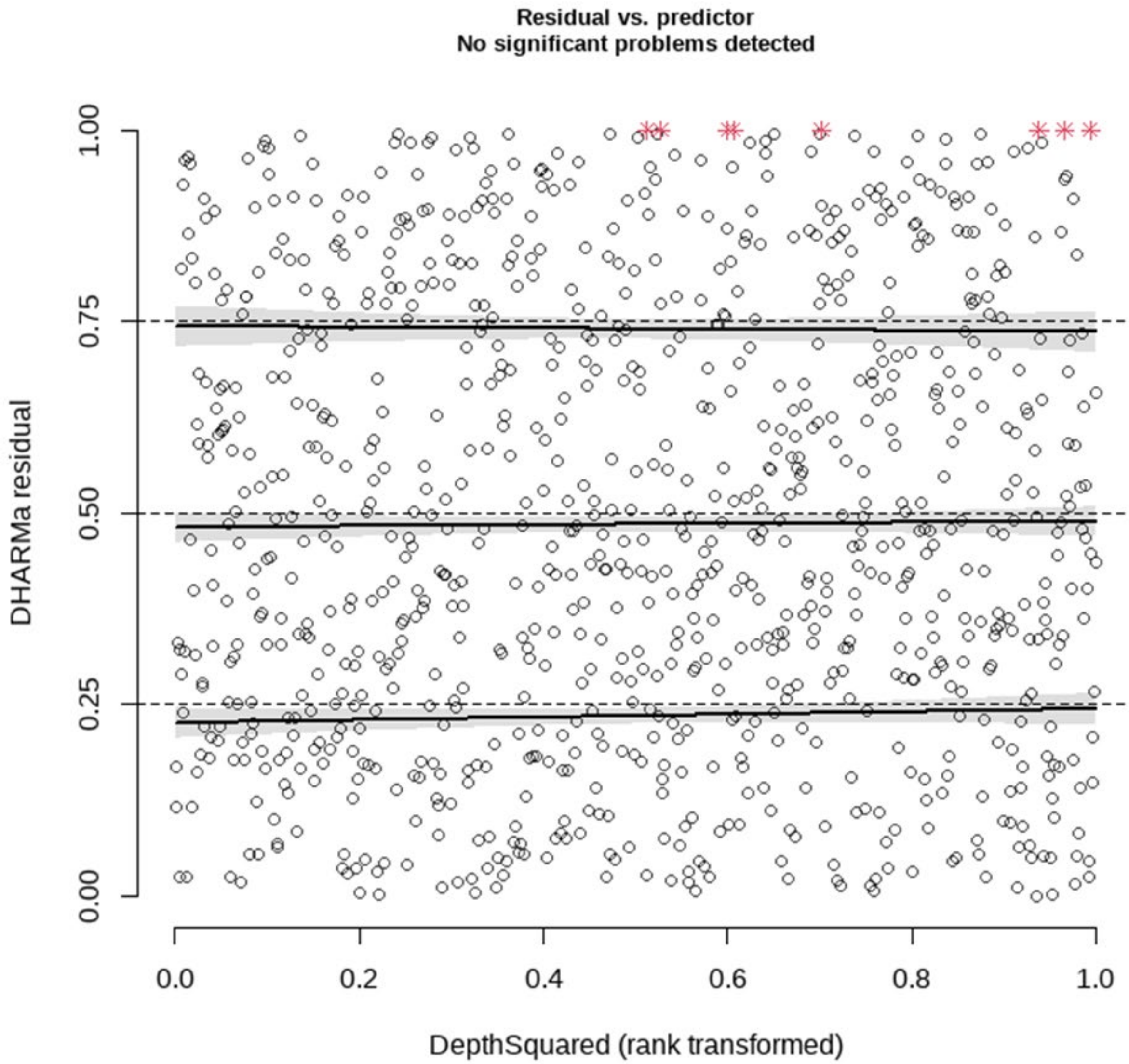

Figure 5. Dharma output of residuals with rank transformed depth squared.

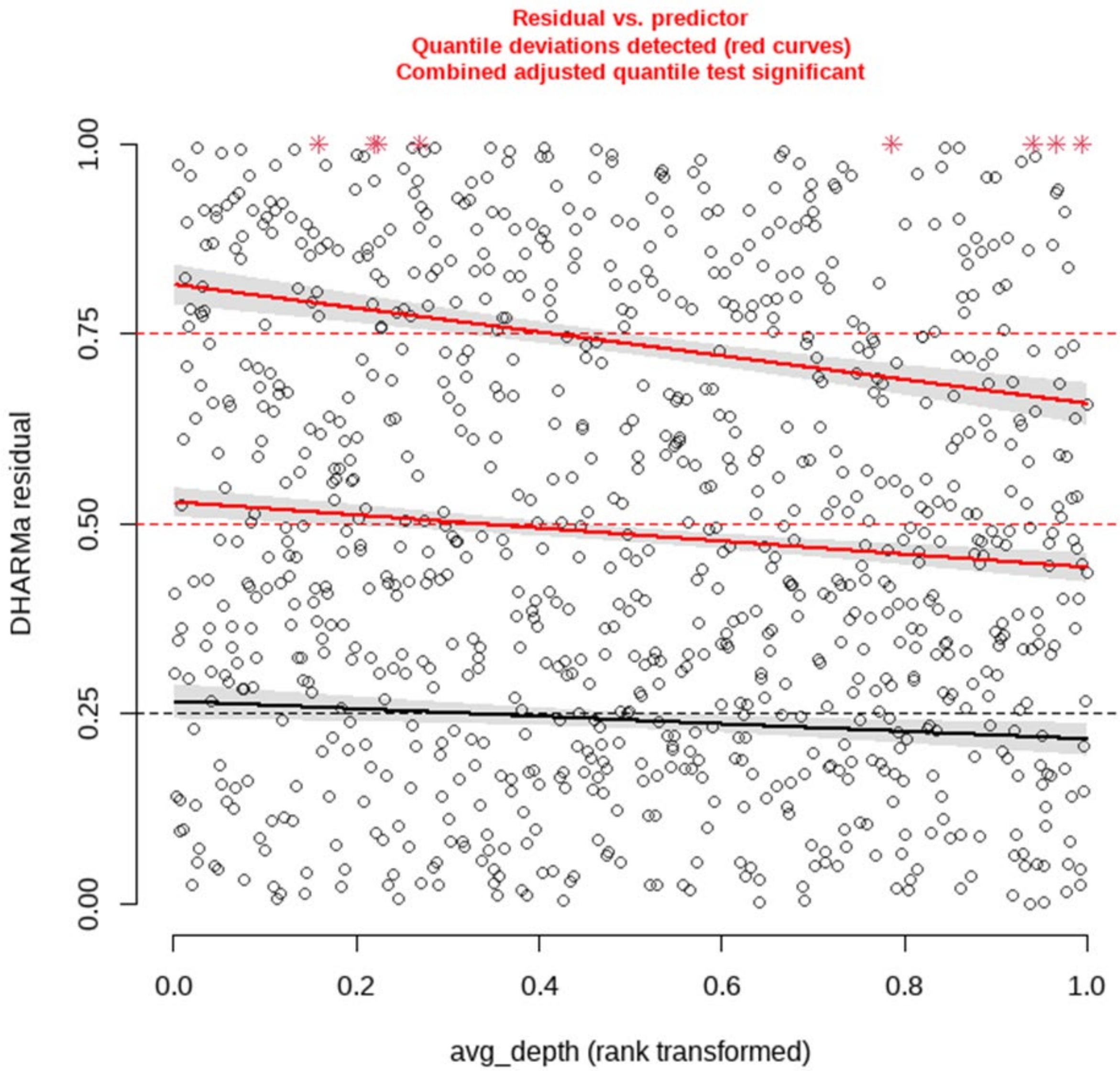

Figure 6. Dharma output of residuals with rank transformed depth.

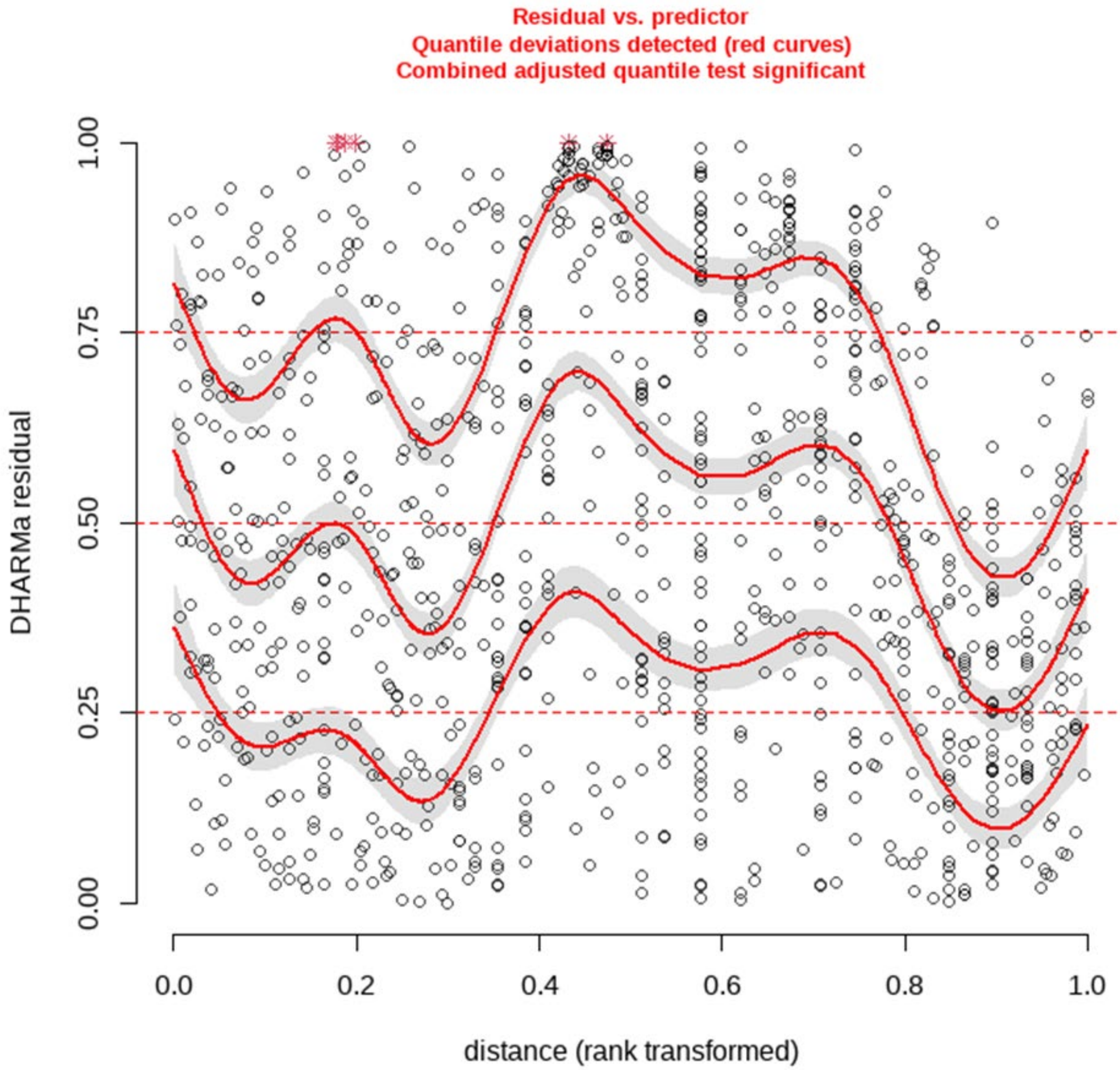

Figure 7. Dharma output of residuals with rank transformed distance along the coast.

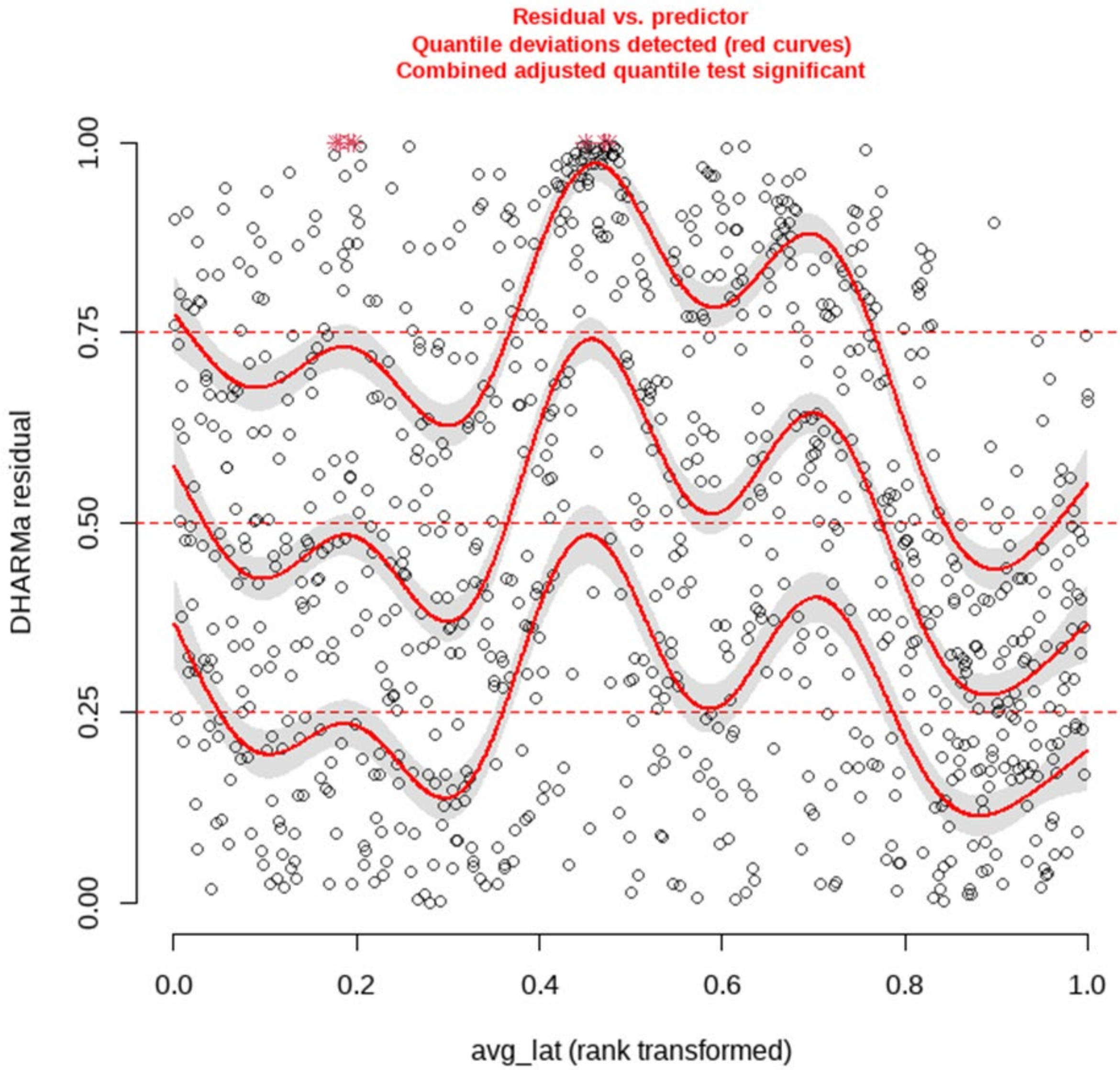

Figure 8. Dharma output of residuals with rank transformed average latitude.

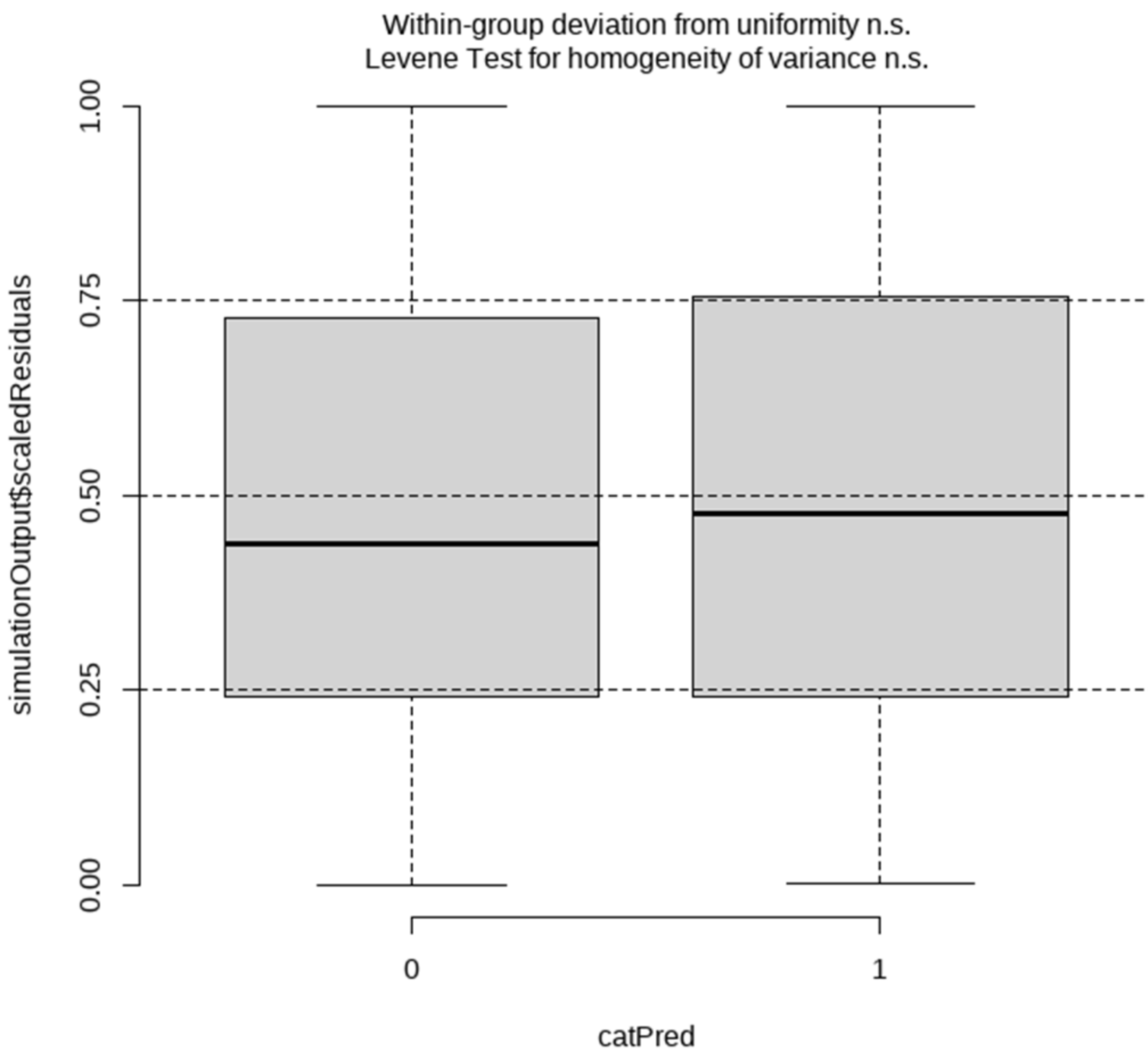

Figure 9. Tests for homogeneity of variance between areas with (1) and without (0) protection in MPAs.

Table 1. The percent deviance for the preferred model with average latitude vs.distance along the coast.

Model	Selected Model Deviance	Null Model Deviance	Percent Deviance
Negative Binomial Avg_Lat	2194.1	2458.8	10.77%
Negative Binomial Distance	2189.7	2458.8	10.94%

Request ii: The GFSC recommends that CDFW check to make sure that Q-Q plots present correct information regarding the fit of the model and consider examining alternative measures of fit.

Response: The QQ-norm plot is frequently used to plot theoretical and observed values assuming a normal distribution of errors, though a negative binomial distribution is being used and thus the qq norm plot may not provide the ideal comparison. The package Dharma was applied to the preferred model presented at the December 2024 GFSC meeting, which used latitude to capture the increase in density of quillback rockfish moving northward toward the center of it's range from the edge in Point Sur, California. The results from the along coast distance provided in the response to request C.4.i. above can be compared to those provided here for the average latitude along the transect, with each run along with the remaining variables identified previously.

The results of the GLMM model output using latitude are in Figure 10. Dispersion from a non-parametric dispersion test using the standard deviation of residuals for fitted vs. simulated data was significant with a p-value of 0.024, while the dispersion itself was only 0.010375, which is very low. The QQ plot using the negative binomial error distribution from the model rather than assuming a normal distribution as is the case with the QQ norm plot, also indicated a reasonable fit to the 1 to 1 line (Figure 11). The KS test and outlier test were not significant.

A significant residual pattern was observed per the residuals of the model with model predictions, though it was not visually evident apart from the fitting of the model (Figure 12). No significant pattern was observed in the residual of the model with variables for proportion hard and mixed substrate (Figure 13), depth squared (Figure 14) or average depth (Figure 15). The pattern observed in the fit to the residuals with latitude was found to be significant, there was no clear pattern with visual inspection of the residuals (Figure 16). Tests for zero inflation were not significant (P-value = 0.312). Tests for homogeneity of variance between areas with (1) and without (0) protection in MPAs were not significant (Figure 17). Tests for homogeneity of variance between areas between 2015 and 2020 were significant (Figure 18).

In an effort to address the residual pattern observed with latitude, a second variable of latitude squared was added in an effort to address the non-linear relationship apparent in the residuals with and without data south of Point Sur. The residual pattern with latitude and the new variable remained. As noted, the variation in the residual pattern was observed with distance along the coast or average latitude. The random site variable was anticipated to account for some of the variation along the coast, but the fit to the residuals is indicative of either overfitting to the residuals given the undulating pattern of the fit and the lack of strong visible pattern in the residuals themselves to the eye, or an unaccounted for variable may still be needed to resolve the latent variability in the model. Based on additional examinations of the QQ plots and examining alternative measures of fit CDFW thinks the lack of a clear residual pattern to the eye may indicate overfitting to the model residuals, though they will pursue efforts to resolve them in indices proposed for use in the upcoming quillback stock assessment.

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Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: Negative Binomial(2.4866)  ( log )
Formula: Quillback.Rockfish ~ (1 | site) + SuperYear * Protection + PropHardMixed +  avg_lat +
avg_depth + DepthSquared, Data: sc.dat
 Offset: log(usable_area_fish)
 AIC      BIC   logLik deviance df.resid
  2214.1   2262.5  -1097.0   2194.1      925
Scaled residuals:
Min       1Q        Median     3Q        Max
-1.4038 -0.4996 -0.1692   -0.0318 11.1463
Random effects:
 Groups Name         Variance Std.Dev.
 site   (Intercept) 1.947            1.395
Number of obs: 935, groups:  site, 60
Fixed effects:
                         Estimate Std. Error z value Pr(>|z|)
(Intercept)              -7.91685  0.35878 -22.066  < 2e-16 ***
SuperYear2020              0.26365 0.14069   1.874  0.06093 .
Protection1              -0.04960  0.46153  -0.107  0.91442
PropHardMixed              0.61822 0.07174   8.617  < 2e-16 ***
avg_lat                   1.74217   0.25290   6.889 5.63e-12 ***
avg_depth                 0.62884   0.10348   6.077 1.22e-09 ***
DepthSquared             -0.58254  0.07689  -7.576 3.56e-14 ***
SuperYear2020:Protection1  0.55911    0.18748   2.982  0.00286 **
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
 Correlation of Fixed Effects:
              (Intr) SpY2020 Prtct1 PrpHrM avg_lt avg_dp DpthSq
SuperYr2020 -0.204
Protection1 -0.663  0.165
PropHardMxd -0.062 -0.087  -0.001
avg_lat     -0.400  0.050   0.220 -0.004
avg_depth   -0.016 -0.004  -0.010  0.489 -0.030
DepthSquard -0.199  0.035   0.033  0.133  0.023  0.113
SprY2020:P1  0.149 -0.747  -0.249  0.054 -0.032  0.012 -0.006
```

Figure 10. Results of a GLMM for preferred model with latitude.

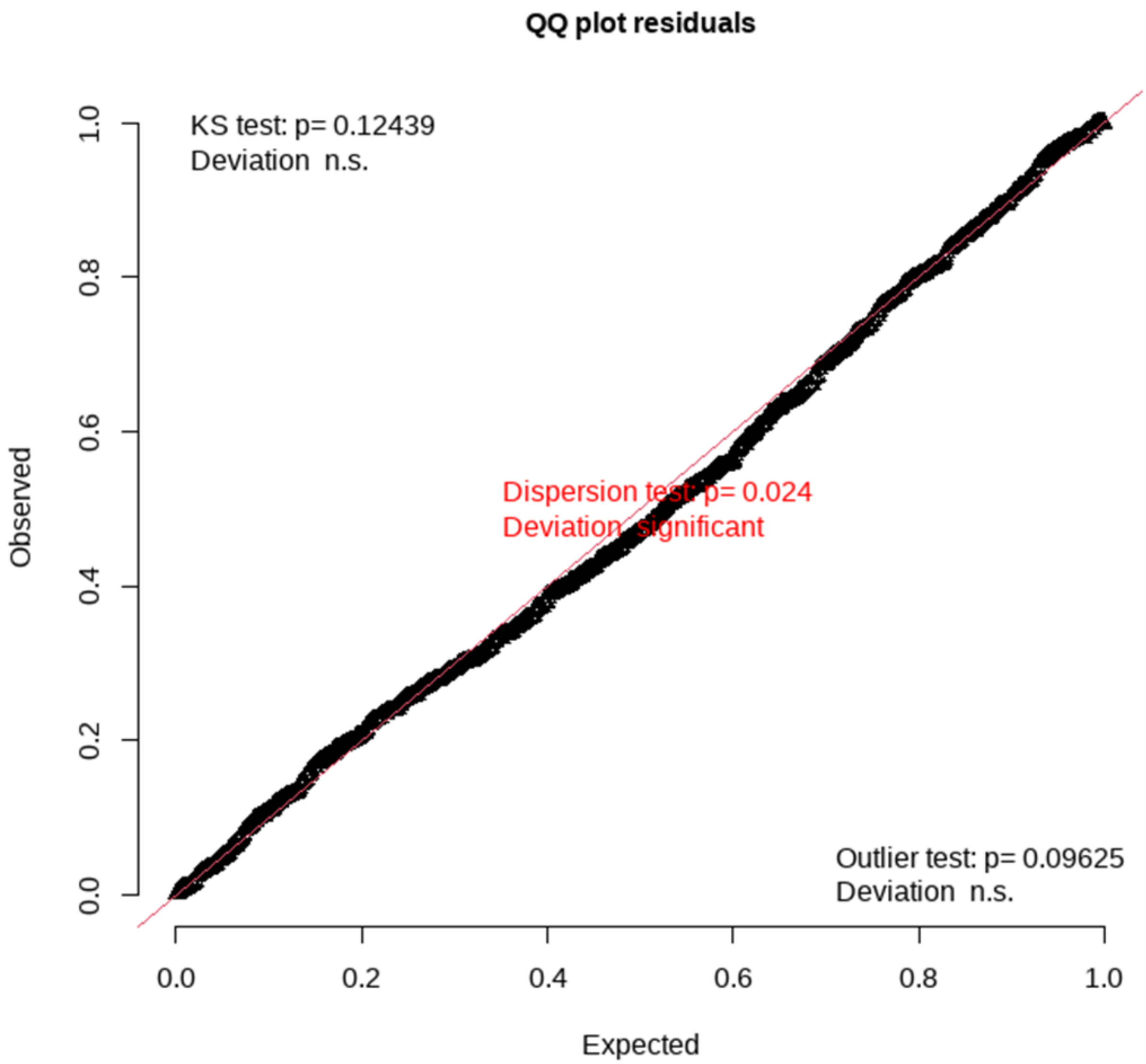

Figure 11. QQ Plot from Dharma using the negative binomial distribution employed in the model, showing results of KS test, dispersion test and outlier test.

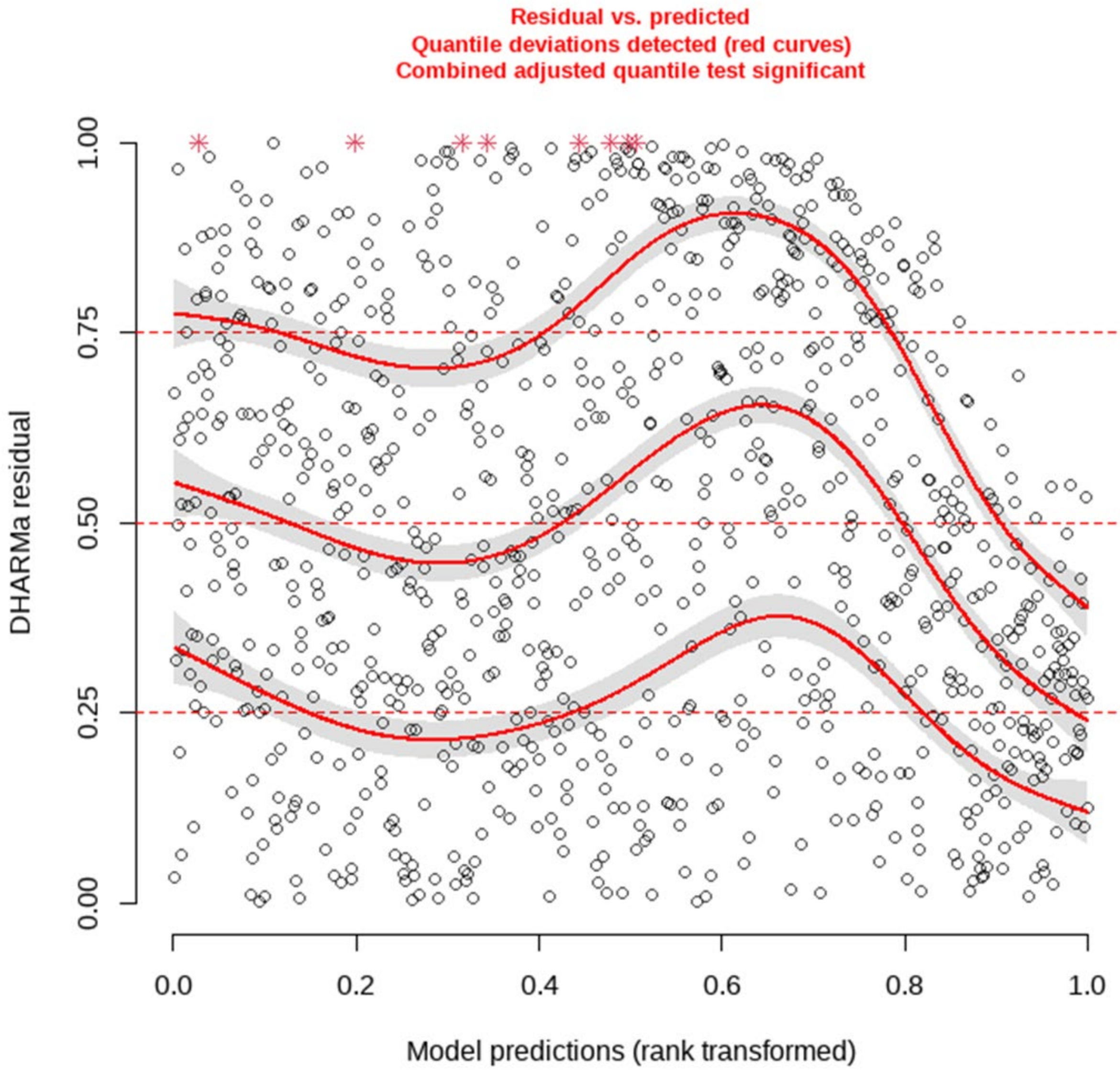

Figure 12. Dharma output of residuals with rank transformed model predictions.

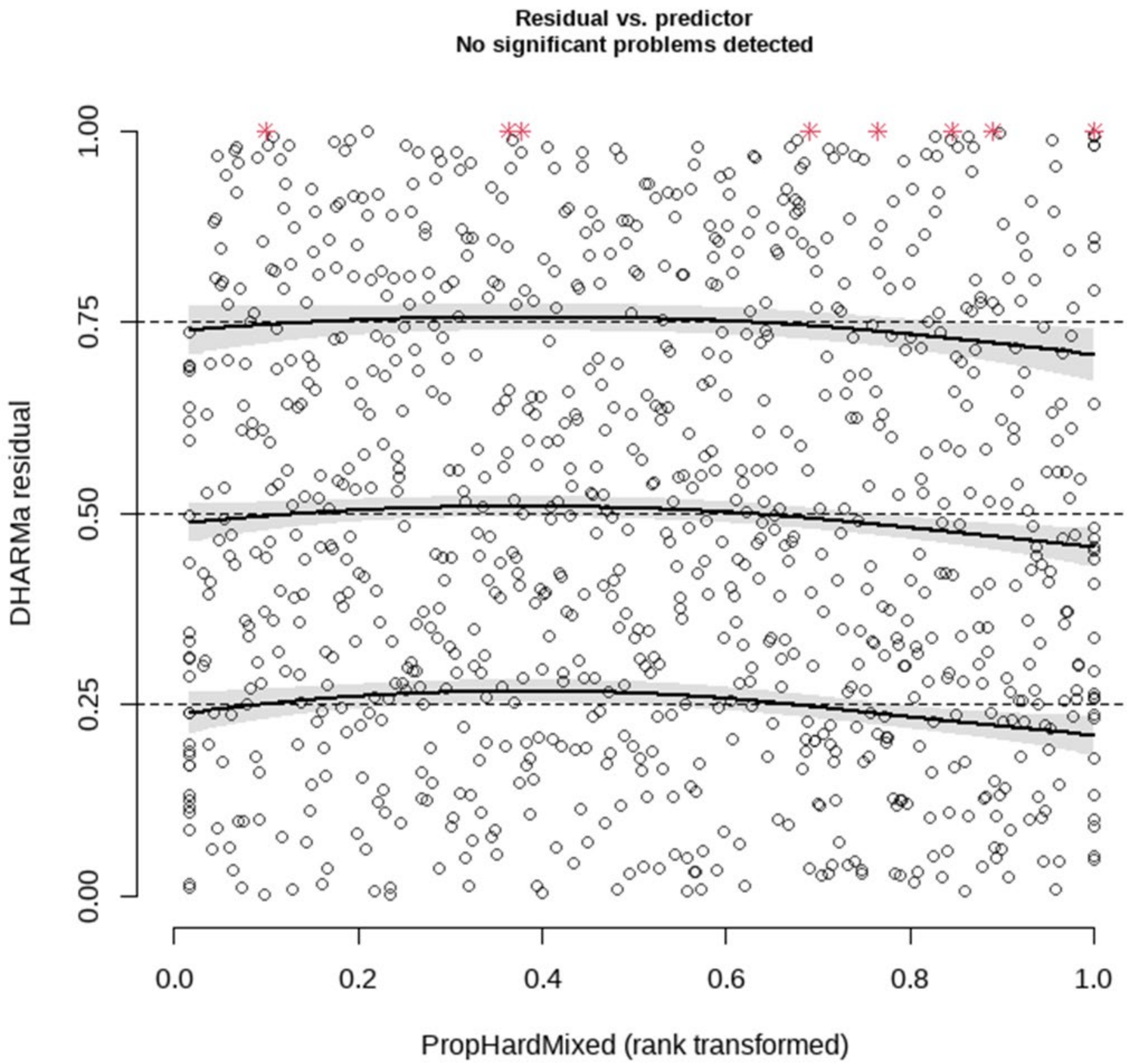

Figure 13. Dharma output of residuals with rank transformed proportion of hard and mixed substrate.

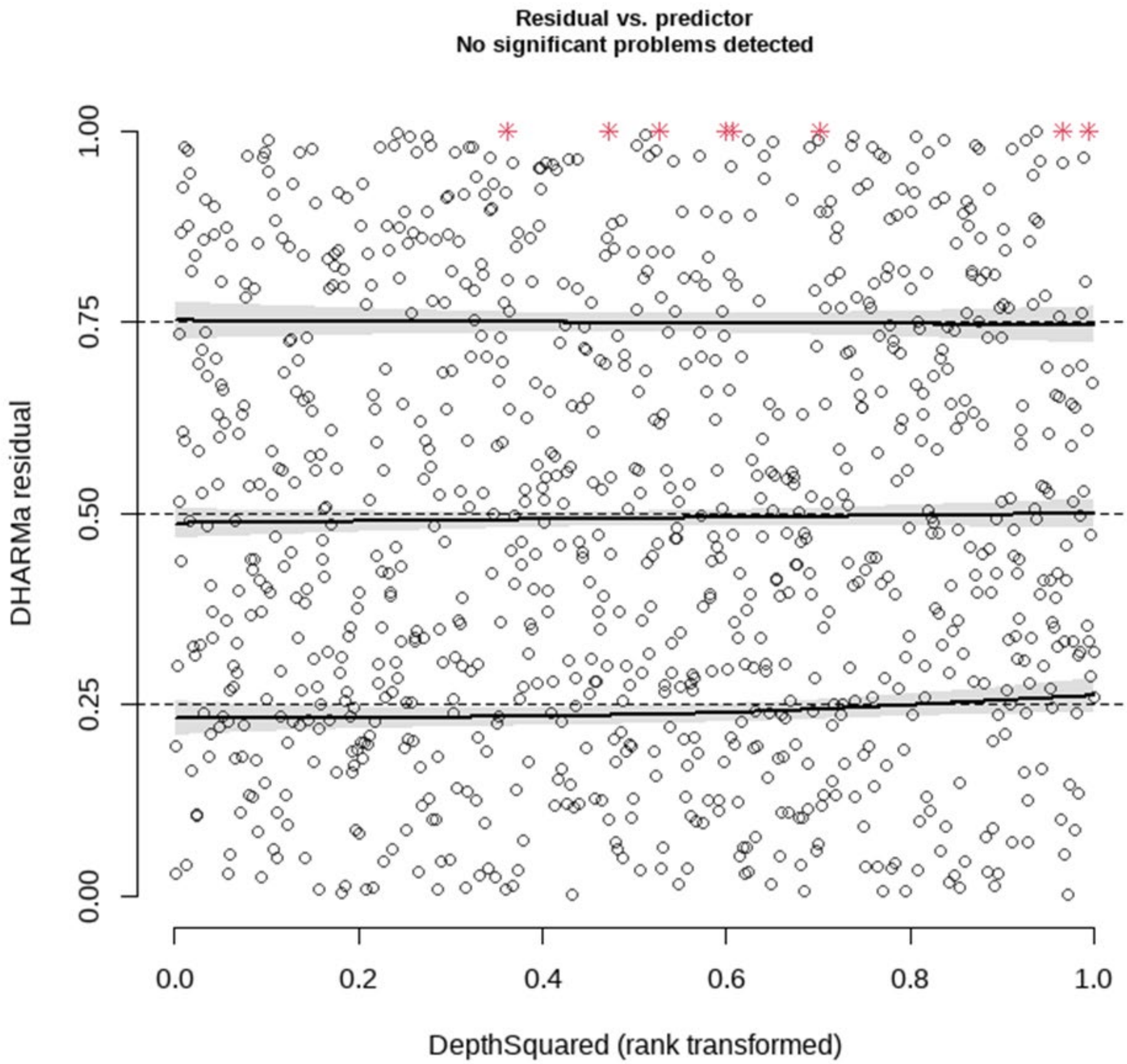

Figure 14. Dharma output of residuals with rank transformed depth squared.

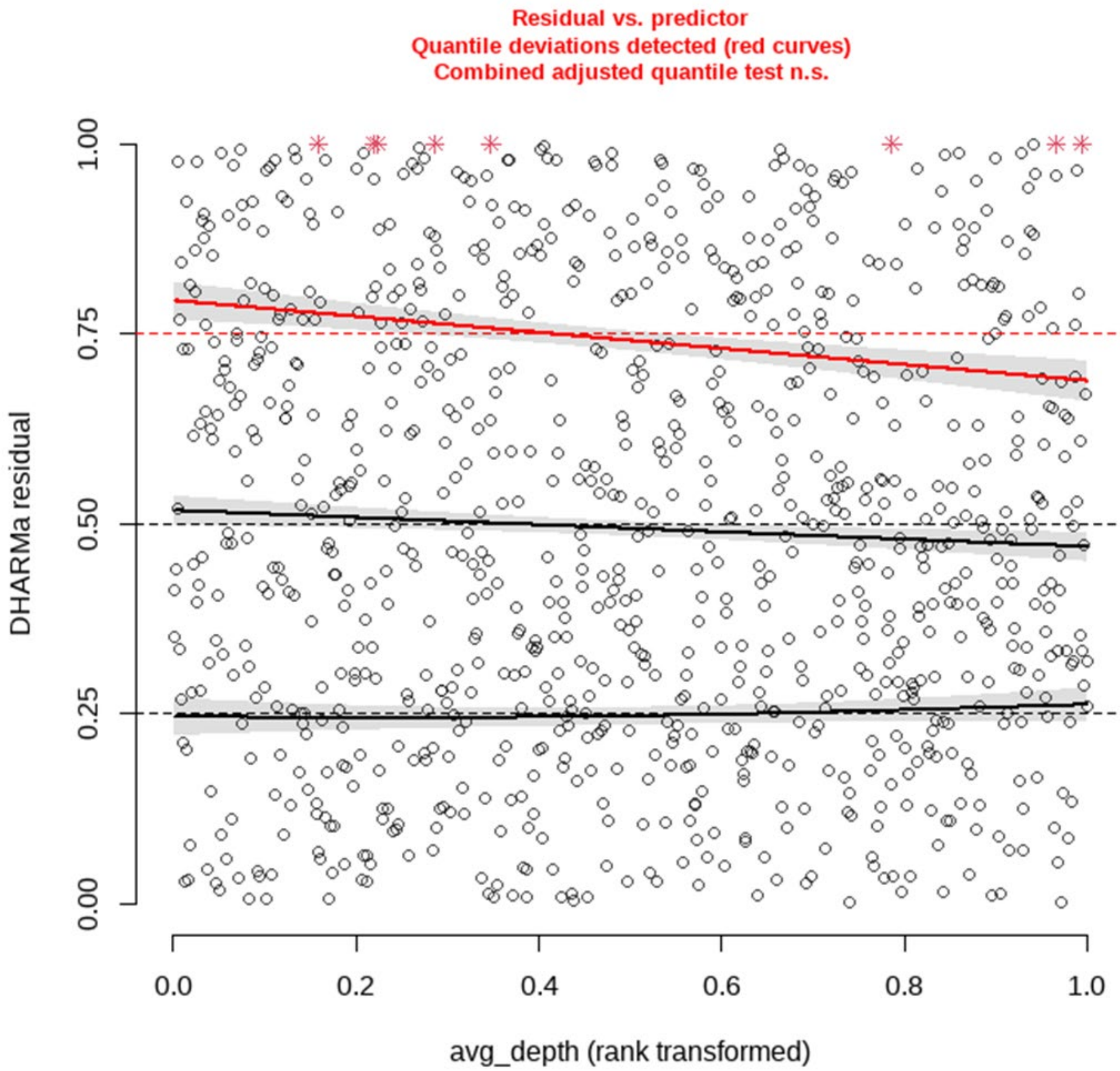

Figure 15. Dharma output of residuals with rank transformed depth with average depth.

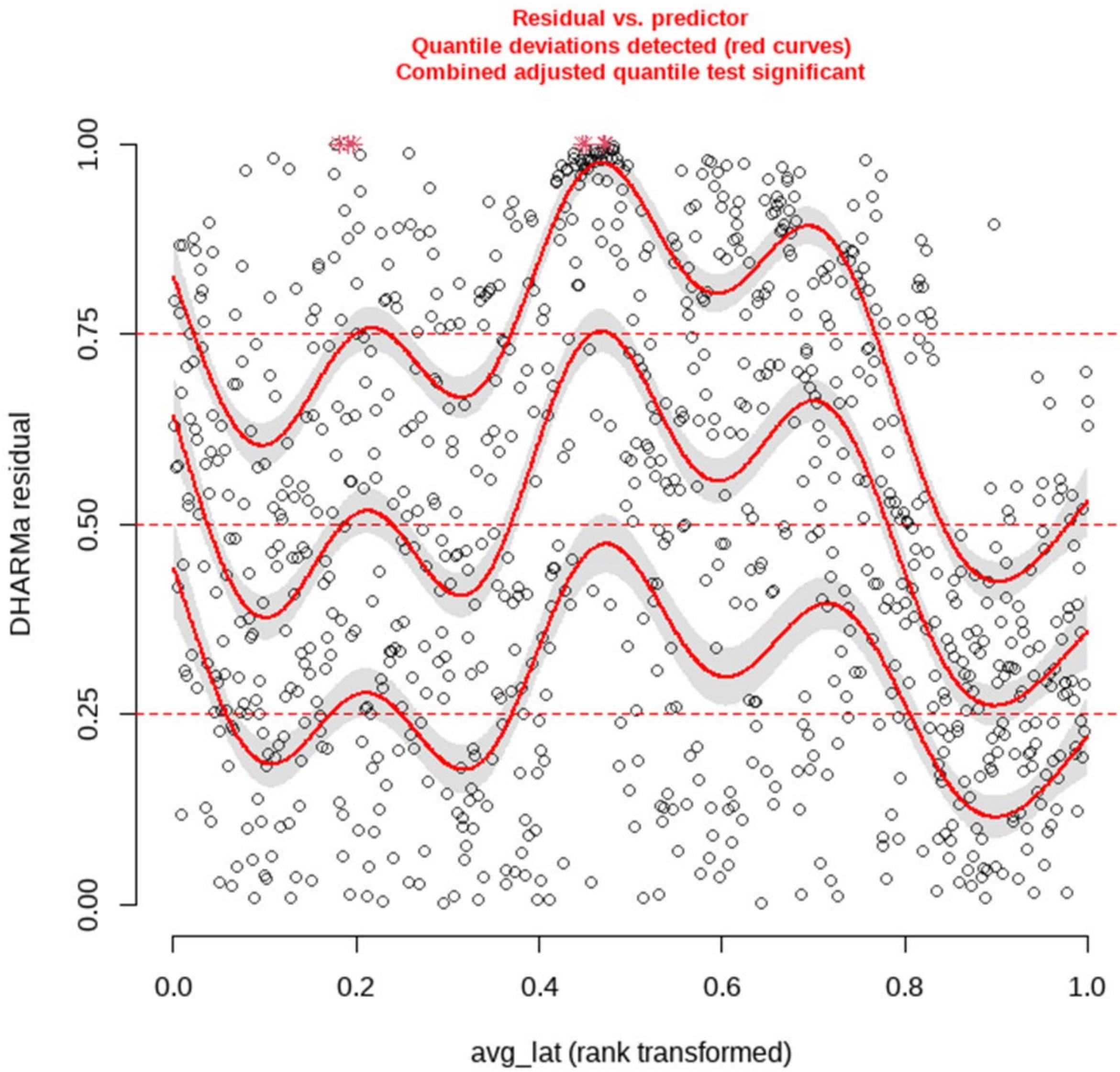

Figure 16. Dharma output of residuals with rank transformed average latitude.

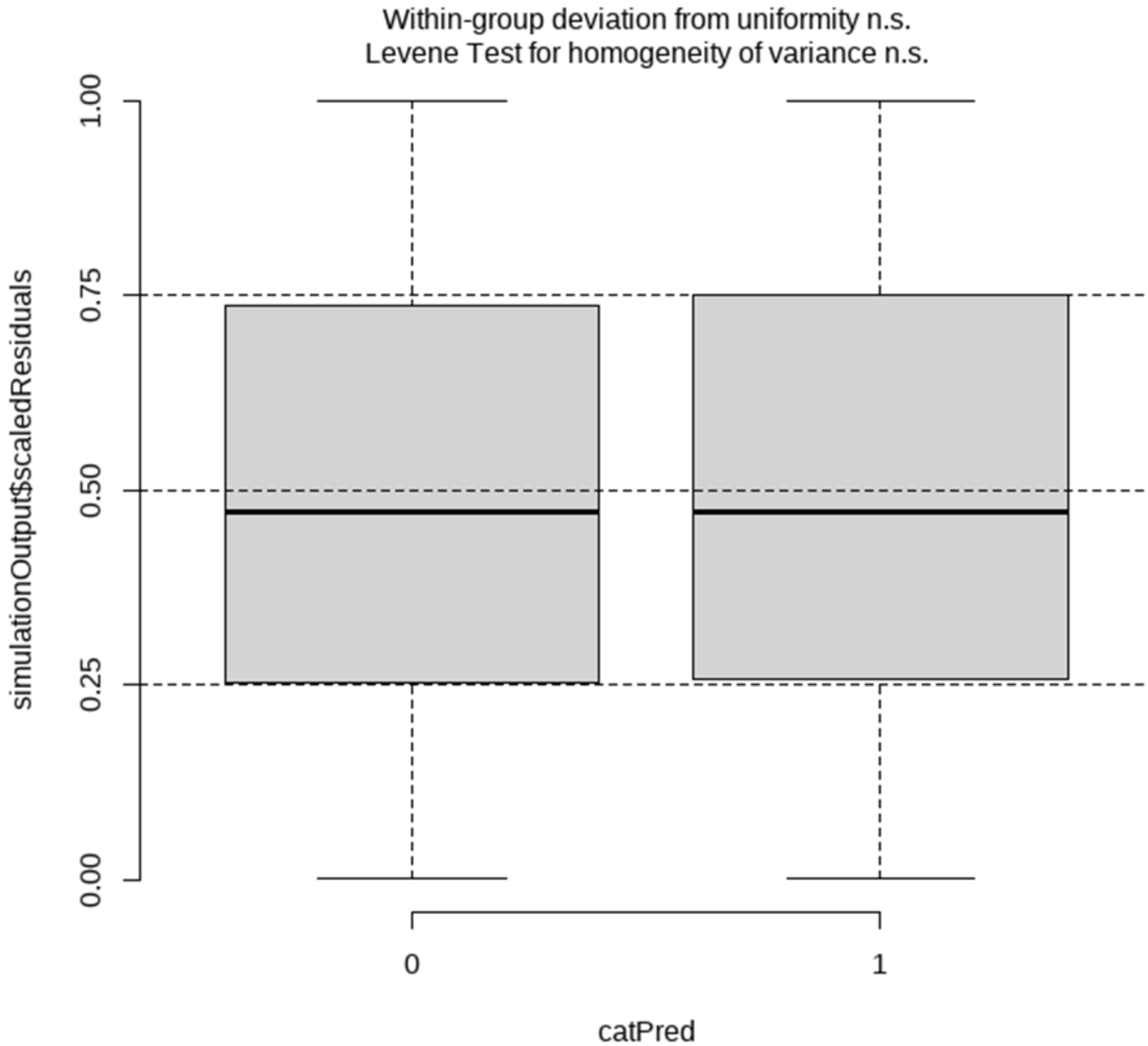

Figure 17. Tests for homogeneity of variance between areas with (1) and without (0) protection in MPAs.

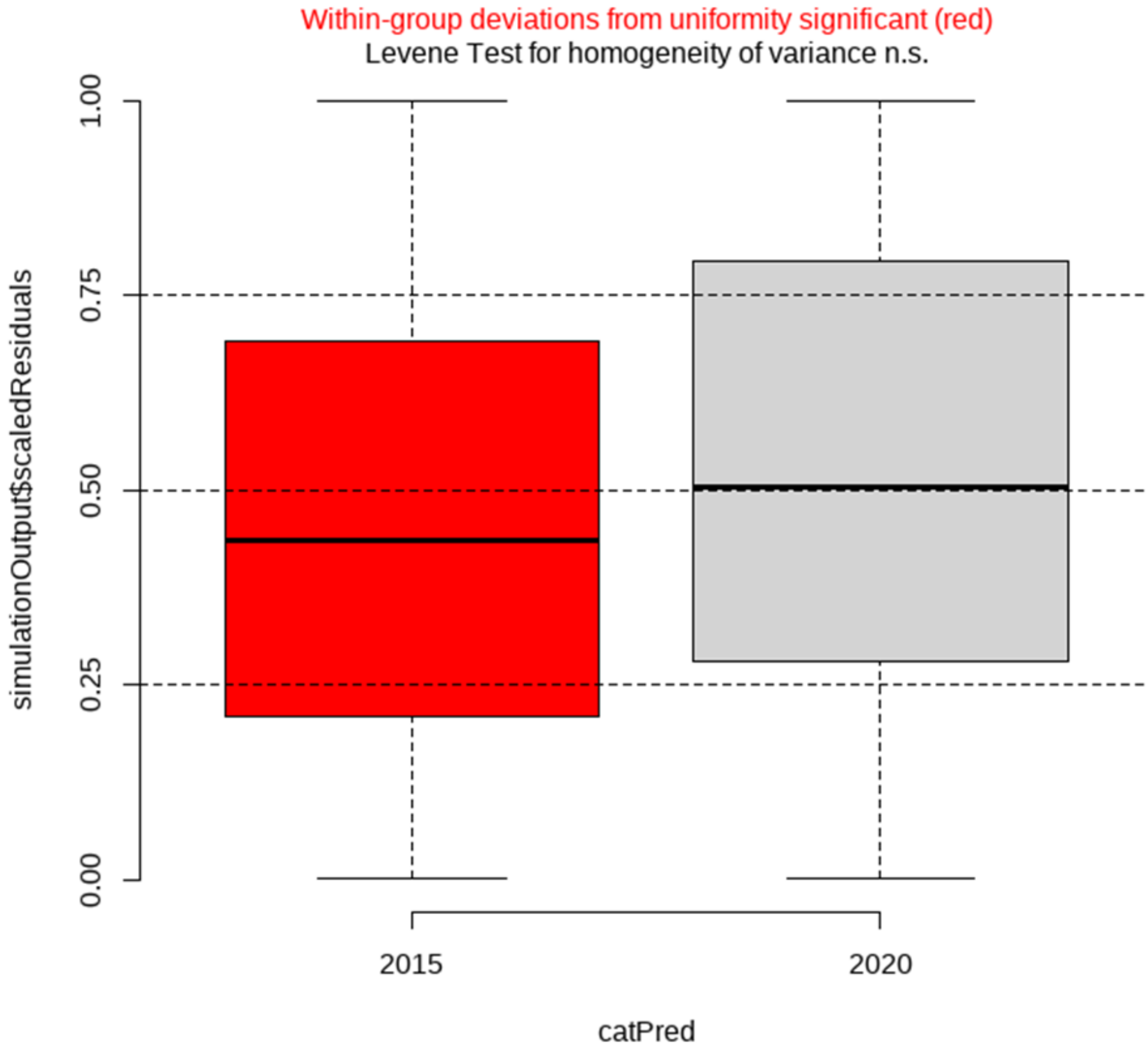

Figure 18. Tests for homogeneity of variance between 2015 and 2020 super years.

Request iii: Given that several data filtering processes were conducted, the GFSC highly recommends the development of a table that depicts the number of transects removed in addition to the justifications for each step.

Response: The number of transects removed and quillback rockfish sampled in the removed transects is provided for each filtering step in Table 2, as well as the total of the remaining transects and quillback rockfish after all filters were applied.

Table 2. The beginning number of transects removed and quillback rockfish sampled statewide, the number of each remaining after each filtering was completed.

Filter	Description	Transects Remaining	Quillback Rockfish Remaining
Start	Prior to Filters	3274	1554
South of Conception	Removing sample locations south of Point Conception where quillback rockfish are not found	1505	1551
Prior to 2014	Removing sampling before 2014 before the first full coverage of the state in the first super year 2015 (2014-2016)	1145	1336
Depth Range	Relegating the depth range of the analysis to within 110 m depth range where quillback rockfish were observed by the ROV	1125	1331
Not Resampled	Removal of any sites not sampled at least once in each super year	955	1184

Request from Text. 1: Reporting percent deviance explained would better capture how well the model describes variation in the data.

Response: The percent deviance explained by models is useful in identifying model configurations as are other considerations such stepwise removal/addition and examination of AIC among others. The glm function provides both the null and full model deviance with which to manually calculate the percent deviance, but cannot handle random effect of 1/Site, while glmer that can, does not provide percent deviance in provided analytics and it must be computed manually. AIC and other criteria under the Dharma package provide additional means of model selection that may also be informative, yet are readily available, having been deemed by the authors to be of use in model selection. The percent deviance was explored relative to average latitude vs. distance along the coast from Point Conception to capture the increasing density of quillback rockfish to the north under request C.4.i. above.

D. California ROV: Design-based estimates for use in groundfish stock assessments.

D.1. Overview of design-based estimates of abundance

No analyses were identified for this section.

D.2. Stratification for length and density estimates: The GFSC and meeting participants discussed differences in depth sampling between the California Recreational Fisheries Survey (CRFS) and ROV survey and potential concerns about the representativeness of the ROV survey to the total habitat available to quillback rockfish, particularly from Pigeon Point to Point Conception. Accordingly, the GFSC recommends the following analyses.

Request i: Investigate relationships between distance to port and length distributions to provide support for or against the high fishing pressure hypothesis.

Response: We looked at the relationship between length and distance to port both statewide and by region. Statewide (Figure 19), there does not appear to be a clear visual relationship between the length distribution of fish sampled and distance to port. We included site designation to explore whether larger fish might be predominantly within MPAs at a given distance from port but didn't see a clear pattern (Figure 19).

Looking at each region individually, the length distributions of quillback rockfish observed do not seem to change much as you move farther from port (looking down each column in Figure 20). In the region from Point Arena to Pigeon Point, there are not very many fish observed at the farther distances from port (other than at the Farallon Islands, which are considered separately). There are larger fish observed at the Farallon Islands than at areas closer to port within the Point Arena-Pigeon Point region but it isn't clear whether that is an effect of distance from port or habitat characteristics at the Farallon Islands given the depth of sampling or ontogenetic migration to the islands from the mainland affecting size composition at the islands. Additional sampling at intermediate sites such as off of Point Reyes or Deep Reef 17 miles South of Half Moon Bay would better inform whether there is continuity in the pattern at intermediate distances from port, while additional sampling past the Farallon Islands at the Isle of Saint James, Rittenburg Bank, Soap Bank and Cordell Bank would provide additional data on the trends with even greater distance from port.

There are many ports included in each region - we did not have the data to separate out individual ports in this analysis. It is possible that patterns with distance from port might be clearer at the level of individual ports, rather than region- or state-wide.

The high fishing pressure hypothesis is not supported when the ROV data from Pt. Arena to Pigeon Pt. is compared to CRFS data from the same area. Figure C1-12 from the Departments December report for the GFSC workshop (displayed below for convenience) shows the ROV and CRFS data overlaid from Pt. Arena - Pigeon Pt. in panel A. Panel B shows the CRFS and ROV data only for the Farallon Islands and Panel C shows the CRFS and ROV data overlaid for areas only along the coast (excludes the Farallon Islands).While the ROV data in Panel C shows smaller fish along the coast, the CRFS length data from the same area does not and is similar to the lengths observed at the Farallon Islands. If the high fishing pressure hypothesis were true we would expect to see the CRFS data along the coast show shorter lengths like the ROV data in the same area. The ROV data includes data from MPA's which are protected from fishing while the CRFS data is almost exclusively from areas where fishing is allowed (baring poaching which is present to a limited extent in the CRFS data).

The Department believes the discrepancy between the lengths between the CRFS and ROV data sets along the coast between Pt. Arena to Pigeon Pt.is due to quillback rockfish being taken from deeper depths in the CRFS data as compared to the ROV data. The depth distribution of MPA sites selected dictates the depth distribution of sampling in the vicinity in the reference sites outside the MPA selected for sampling. The report submitted to the GFSC for the December review provided Figure C1-4 indicating the ROV transects between Pt. Arena - Pigeon Pt. are shallower than the rest of the state due to a combination of bathymetry in the area and the locations MPAs were created in this area. Since the ROV survey was designed to sample MPA's the average depth for the ROV samples along the coast is biased shallower than other areas or the state for ROV sites along the coast from Pt. Arena - Pigeon Pt. CRFS data comes from anglers whose depth is bound by area closures from the Rockfish Conservation Area boundaries and other closed areas such as MPA's and is more representative of the entre depth range for the population of quillback rockfish between Pt. Arena - Pigeon Pt. than the ROV data. Response to D.2.ii of this section showed quillback rockfish lengths increase with depth, lending support to this conclusion.

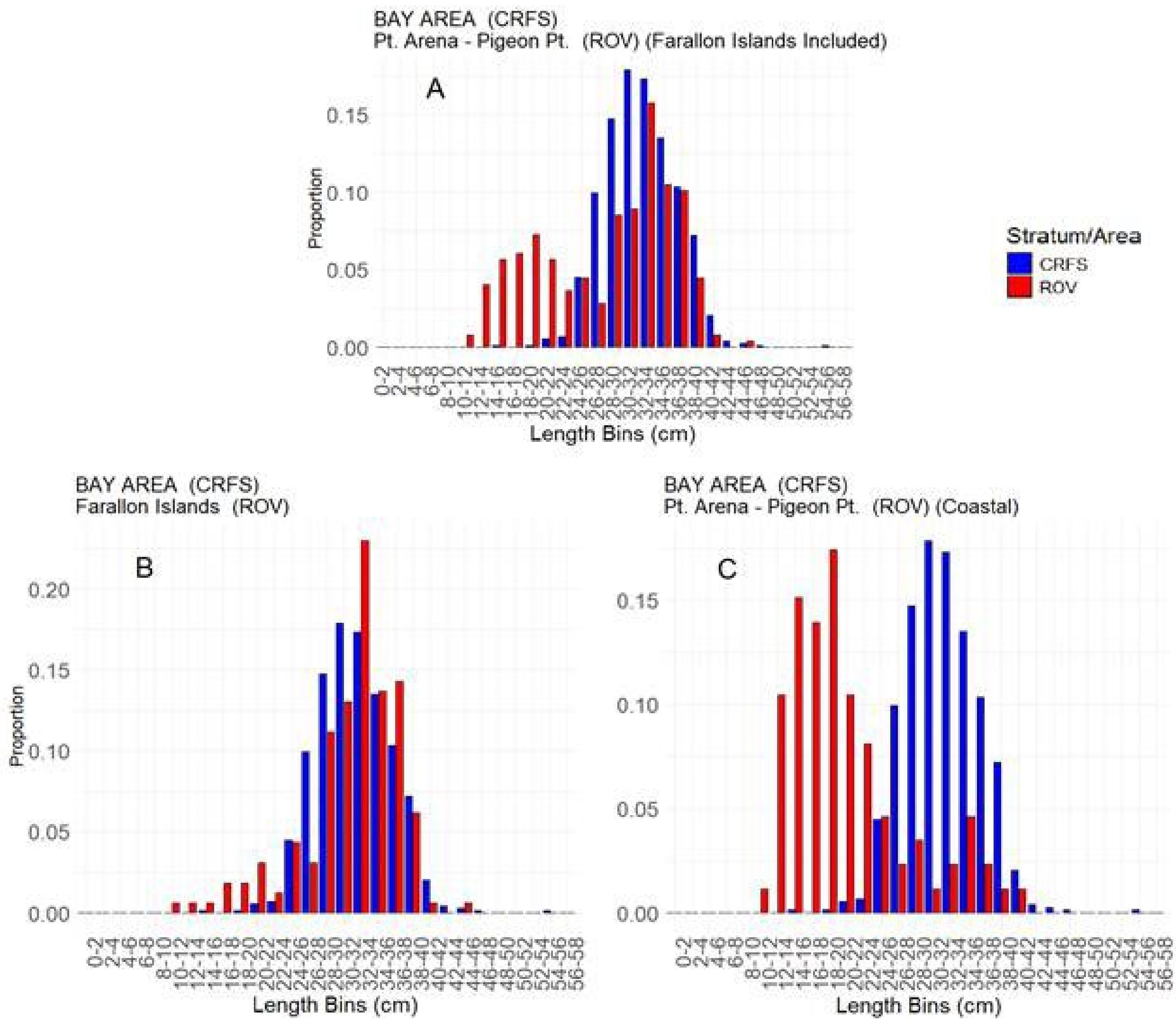

Figure C1-12. Length frequency distributions of quillback rockfish for the A) Bay Area (CRFS) and Pt. Arena – Pigeon Pt. (Farallon Islands included) (ROV) strata; B) Bay Area (CRFS) and Farallon Islands (ROV); and C) Bay Area (CRFS) and Pt. Arena – Pigeon Pt. (Coastal). All available ROV years are included (2014 – 2021) with matching CRFS years**.**

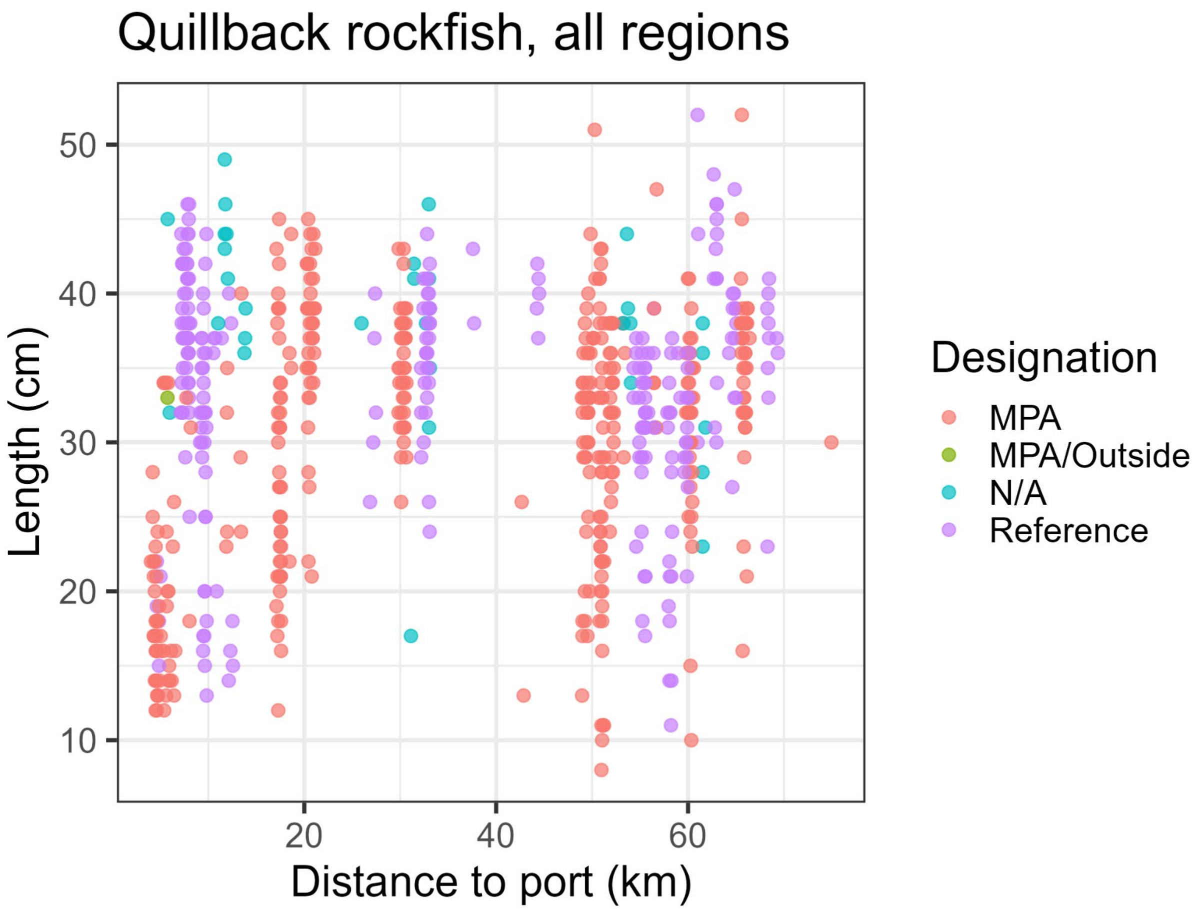

Figure 19. Scatter plot of lengths of fish sampled and the distance to port of the samples. Each point is an observed quillback rockfish, colored by the MPA designation of the site sampled.

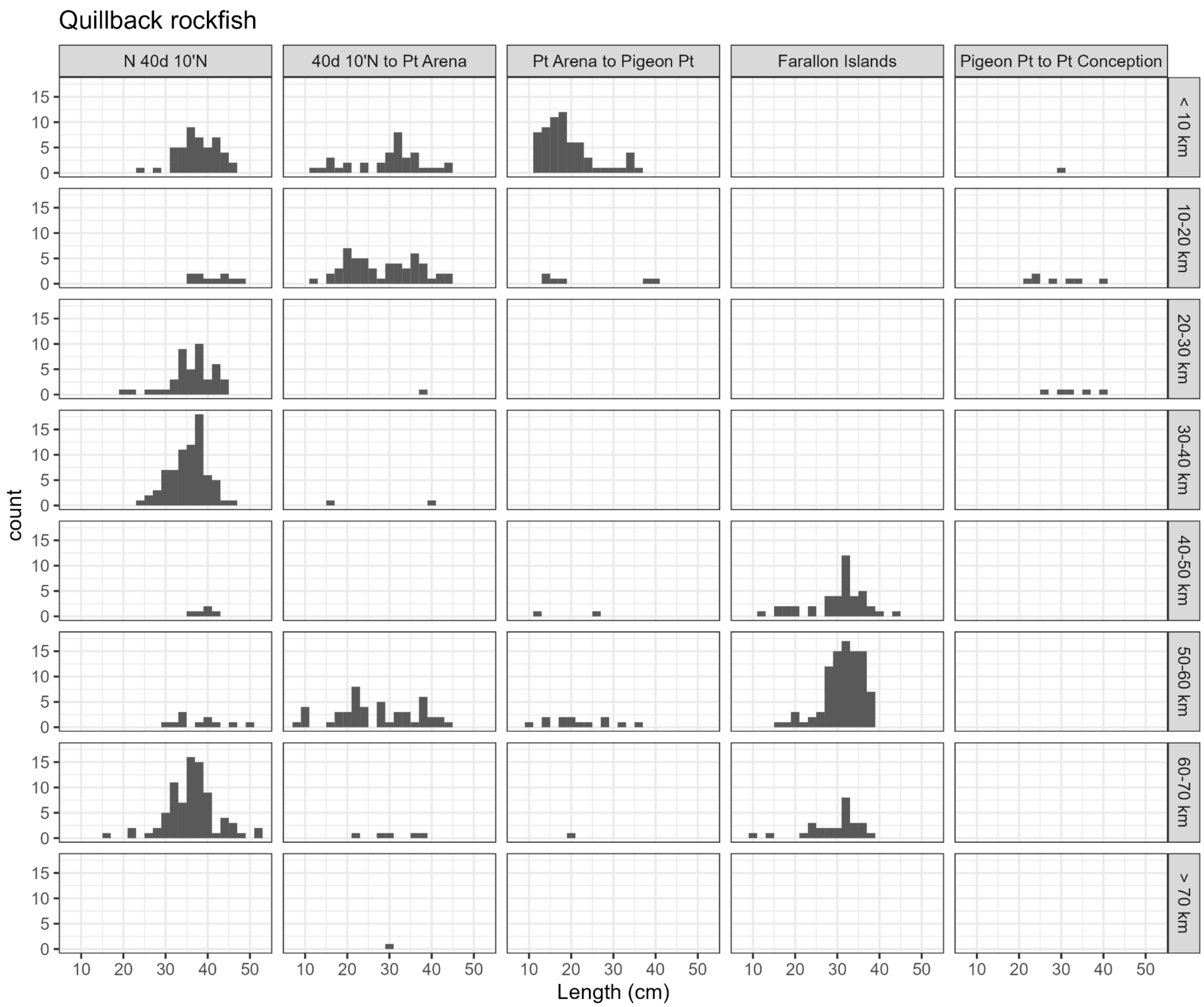

Figure 20. Length histograms of quillback rockfish observed across regions and 10 km bins of distance from port. Each region is a column, with rows moving down getting farther from port. Regions are arranged N-S as you move left to right across columns.

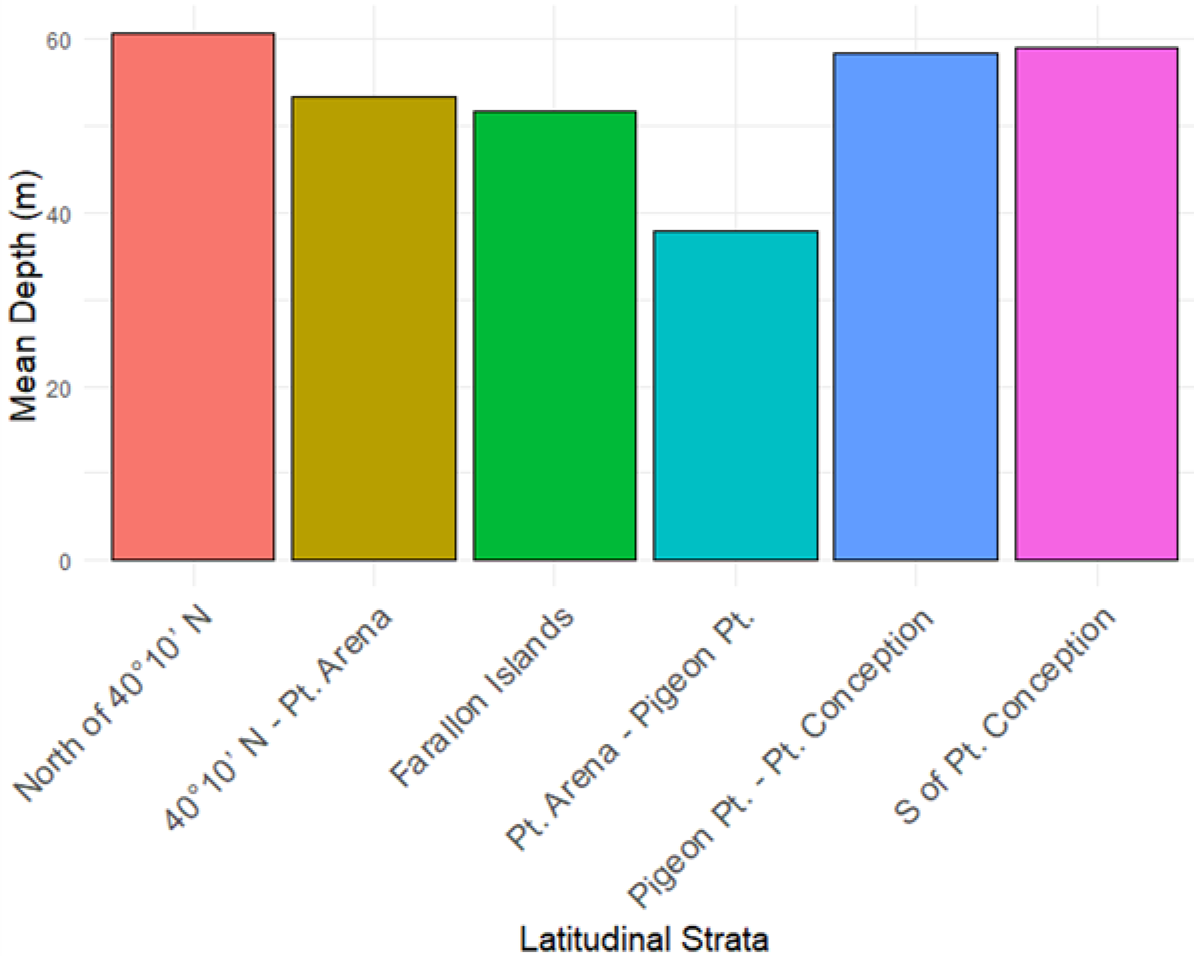

Figure C1-4. Average depth of all ROV transects within each latitudinal stratum.

Request ii: Compare length distributions across latitudes after sub-setting the data to only include the same depth regions (i.e., filter out deeper depths in the northern regions).

Response: We compared length distributions across latitude and depth two ways: first by comparing length distributions of fish sampled in 10 m depth bins across regions (Figure 21) and second by comparing the length distributions of fish sampled in the "core habitat" depths of 40-70 m across regions (Figure 22).

More fish were sampled at deeper depths for some regions, particularly the northern-most region and the Farallon Islands where sampling was more focused on deeper habitat, while sampling and thus data was more sparse between Point Arena and Pigeon Point in deeper depths (Figure 21). There was a visual trend of larger fish being caught at deeper depths, especially north of Point Arena. The fish south of Point Arena were smaller than in areas to the north at a given depth bin. This was also the case at the Farallon Islands, but to a lesser extent. To the south of Pigeon Point, all fish were caught in deeper depths presumably distributed in colder deeper water at the southern end of their range.

The length distributions across regions of quillback sampled at all depths (Figure 22, right side) were compared to quillback sampled in the primary depth distribution commonly sampled at 40-70 m depths (Figure 22, left side). Visually, the distributions look similar, with a slightly greater number of large fish at deeper depths at the Farallon Islands and north of Point Arena on the right for all depths sampled. The pattern of larger fish north of Point Arena and at the Farallon Islands was as compared to Point Arena to Pigeon Point was consistently observed for the full and limited suite of depths examined. Shallower depths more consistent with the depth distribution MPAs in the area were sampled in this later region, potentially contributing to the pattern of smaller fish, while deeper depths were predominantly sampled north of 40° 10' N. Lat. potentially contributing to the observed pattern, though less fishing effort is exerted in the north, leaving the potential for a combined effect.

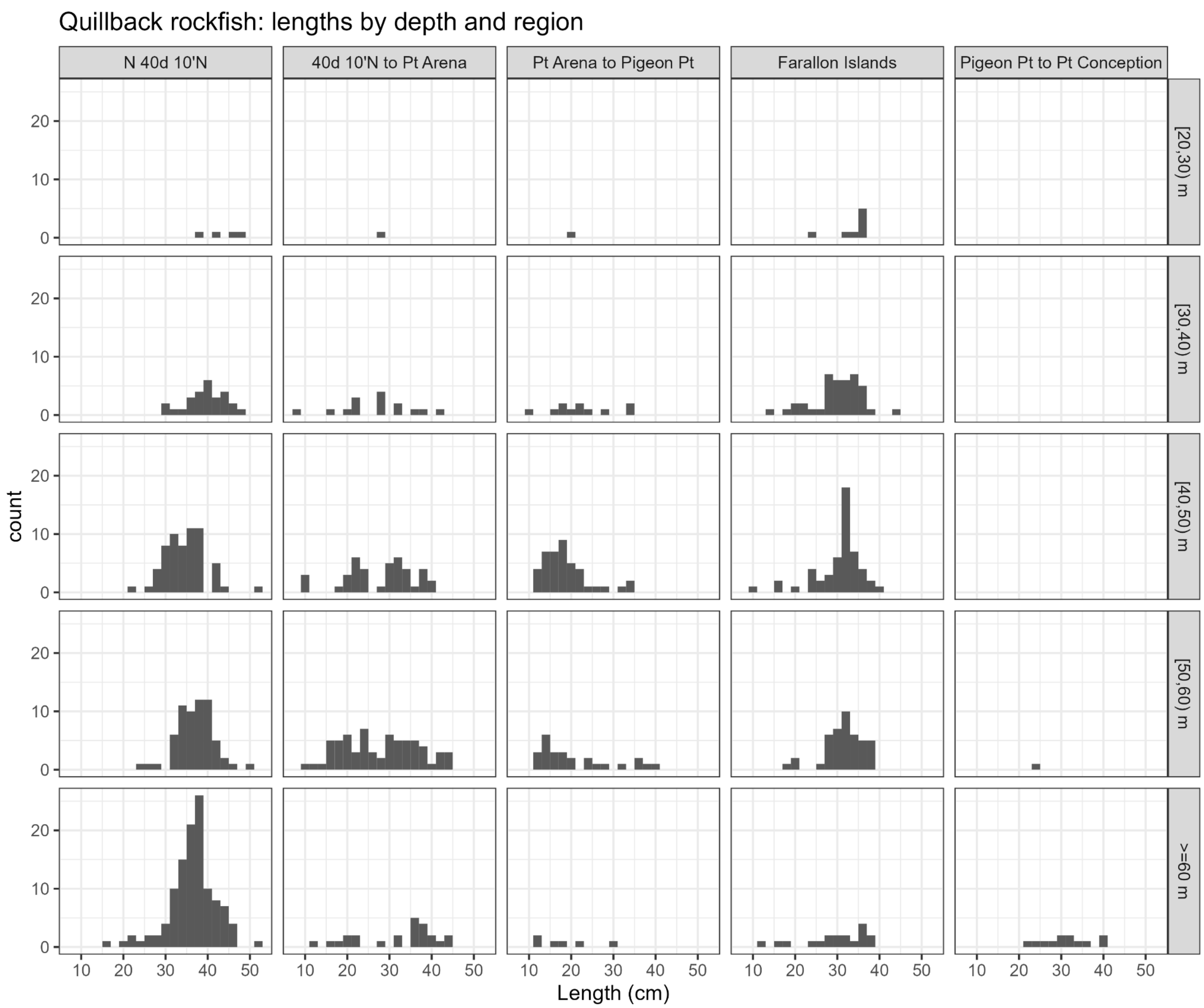

Figure 21. Length histograms of quillback rockfish observed across regions and 10 m depth bins. Each region is a column, with deeper depth bins moving down rows. Regions are arranged N-S as you move left to right across columns.

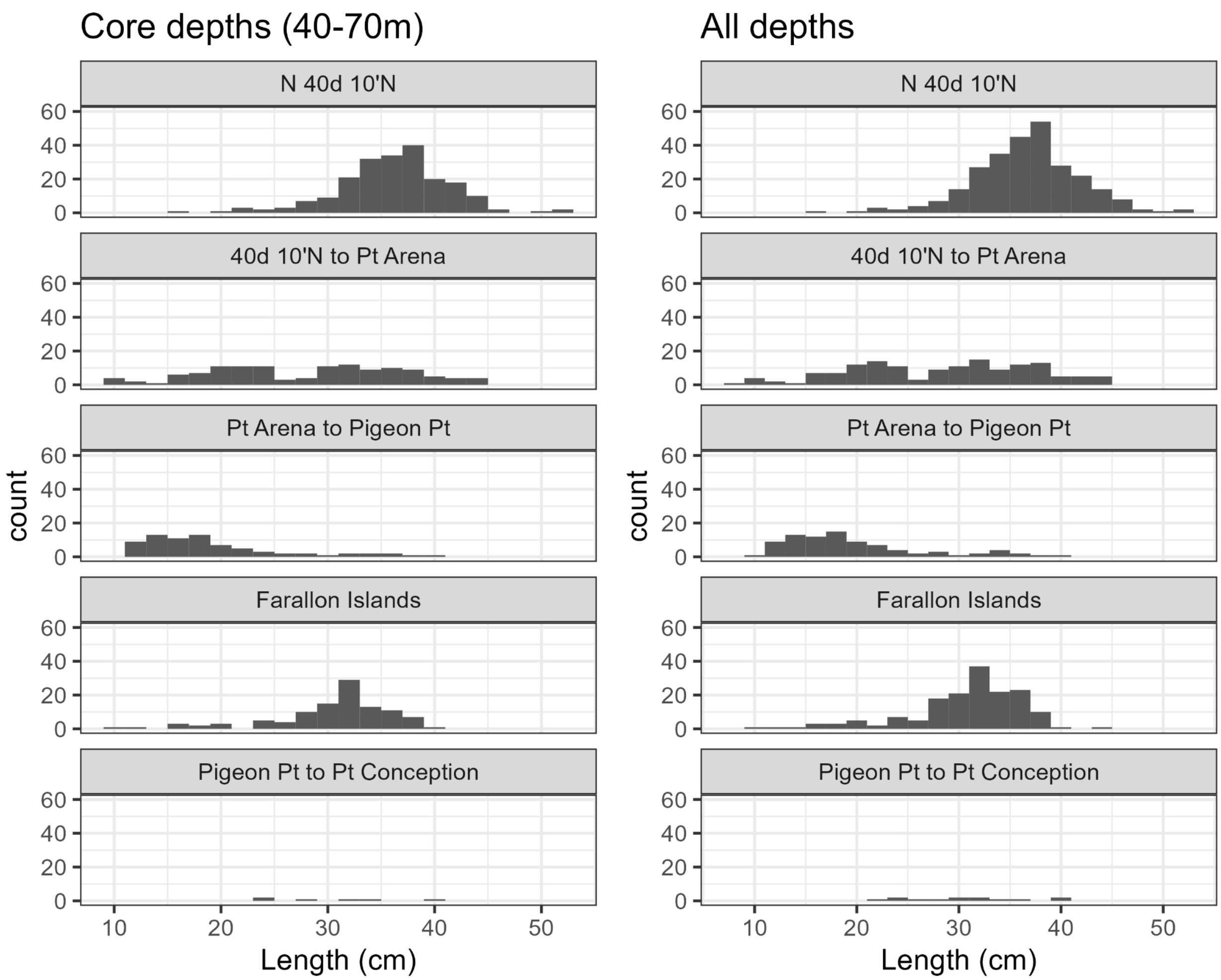

Figure 22: Length distributions of quillback rockfish sampled at core habitat depths (left side) and all depths (right side), shown across regions.

Request iii: Compare habitat depths sampled by the ROV survey to total habitat available to quillback rockfish by depth, both statewide and by latitudinal stratum.

Response: Discrete latitudinal and depth bins were created spatially for ocean waters off California. These bins represent 10 m increments of depth from 0 to 120 m and 0.5 degree increments of latitude (Figure 23). Other latitudinal divisions important to groundfish management were also added such as relevant points and management boundaries (Point Arena, Pigeon Point, etc).

Figure 23. Map showing an example area with discrete depth and latitudinal bins used for this analysis.

While these bins are at a miniature scale and are often sparse with available data, they provide the foundational pieces to compare available habitat and ROV data over various ranges of latitudinal and depth strata when aggregated together. For each of these latitudinal and depth bins, the following were calculated:

- Total hard area indicated by the California Seafloor Mapping Project (CSMP)
- Area covered by CSMP data.
- Total rocky reef area indicated by the Substrate Component of the Coastal and Marine Ecological Classification Standard (CMECS).
- Area covered by CMECS data.
- Total number of ROV transects.

Using the aggregated totals by depth and latitudinal ranges, the habitat and ROV area totals can be further summed to compare distributions across various strata in Figures 24 and 25.

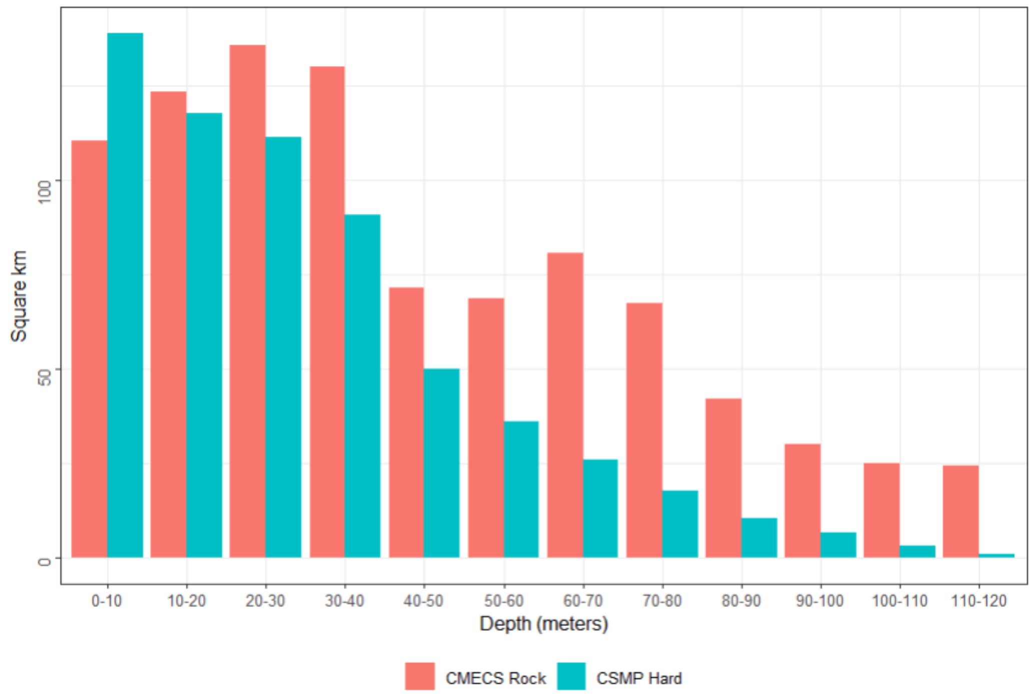

Figure 24. Distribution of area of rocky reef habitat by 10 m depth increments for CSMP and CMECS data from Point Sur to the California/Oregon border.

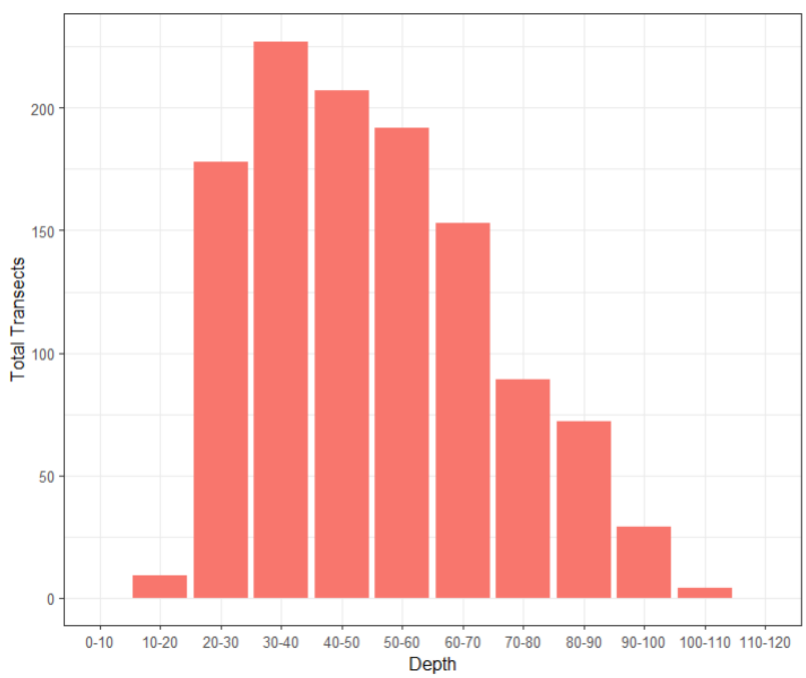

Figure 25. Count of ROV transects in 10-meter depth bins from Point Sur to the California/Oregon border.

To compare the sampling depth distribution of ROV transects to available reef habit, the proportions of transects and reef habitat within each depth range to all available data was used. The difference in the proportion of ROV transects that were performed in that depth range compared to the proportion of reef habitat within the depth range compared to all available habitat data (Figure 26). Depths 0 - 20 m were excluded from this analysis due to lack of ROV data and being outside of quillback's primary depth range.

Large deviations would represent that ROV transects are over or under sampling a given depth range compared to the available habitat data. Overall, there appears to be under sampling in shallower zones. This is most likely due to the greater abundance of reef habitat present. Also there appears to be under sampling of deeper reefs when considering CMECS data. This is due to the greater availability of reef data within the CMECS dataset in deeper areas outside of California state waters.

Figure 26. Comparison of the proportion of ROV transects performed in that range to the relative proportions of habitat data within each depth range to all available habitat data. Negative values represent where the proportion of rocky reef in this depth range is greater than the proportion of ROV transects performed.

An alternative analysis to look at the overlap of sampling and reef depth distributions was proposed by the SSC (Request D6 viii). This involved using the Pastore (2018) and Pastore and Calcagní (2019) R package ‘overlapping’ to provide an approximation of the intersecting area of the kernel density estimations for the ROV transect and reef habitat depths.

This analysis was only possible with CSMP habitat data due to the raw structure of the data. To use the Pastore 2018 methodology, a list input of depths associated with reefs were required to compare to the average depths of the ROV transects. This is not possible with ‘polygon’ representations of rocky reefs since these polygons can vary greatly in size and depths which is seen in the CMECS data. CSMP was originally collected in raster format where each ‘cell’ can be seen as a section of either ‘hard’ or ‘soft’ with a discrete depth for that cell. All depth values of these uniform ‘hard’ cells can be used to create a probability density distribution needed for this analysis .

The depths associated with these ‘hard’ cells can be directly compared to the ROV transect depths through the kernel density intersection methodology (Figure 27). Future steps can be taken to resample CMECS data into a raster format suitable for this analysis. Overall, there is an 81% overlapping area between these two distributions. Additionally, these results confirm that there is an under sampling at shallower depths from the ROV survey (20-40m) and an oversampling from 40-100m.

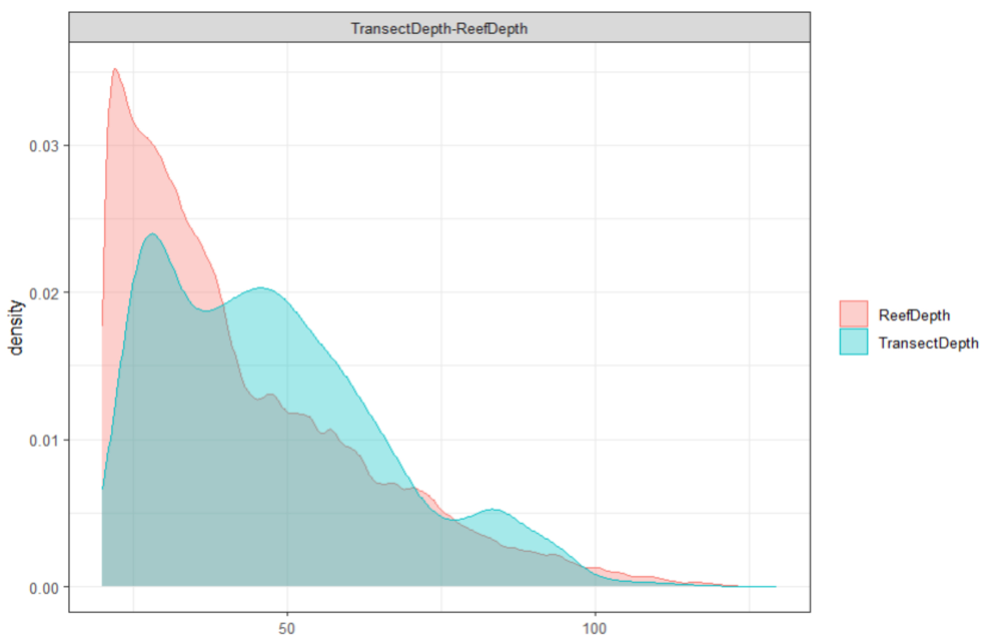

Figure 27. Plot output from the overlapping R package comparing the kernel densities of the ROV transect and reef habitat depths for Point Sur to the California/Oregon border. Depths in meters are provided on the x-axis and only ROV and reef depths between 20 - 130 meters were used to align with the quillback depth distribution.

The results of the analysis comparing the depth distribution of CSMP and CMECS habitat estimates in square kilometers (Figure 28), ROV average transect depths (Figure 29) and the difference in habitat distribution and sampling distribution (Figure 30) in each of the five strata resulting from stratification at the 40° 10' N. Lat., Point Arena, Farallon Islands and Pigeon Point in stratification scheme 1 from the design-based estimates of abundance are provided. The results stratification scheme 4 stratified at 40° 10' N. Lat. and Point Arena from the design-based estimates of abundance are provided of the analysis comparing the depth distribution of CSMP and CMECS habitat estimates in square kilometers (Figure 31), ROV average transect depths (Figure 32) and the difference in habitat distribution and sampling distribution (Figure 33). The results stratification scheme 5 stratified at Point Arena from the design-based estimates of abundance are provided of the analysis comparing the depth distribution of CSMP and CMECS habitat estimates in square kilometers (Figure 34), ROV average transect depths (Figure 35) and the difference in habitat distribution and sampling distribution (Figure 36). The results are consistent with the relative proportion analysis above, with proportions of habitat and sampling only off by a maximum of 12% in any of the strata resulting from stratification schemes analyzed with most differing by considerably less.

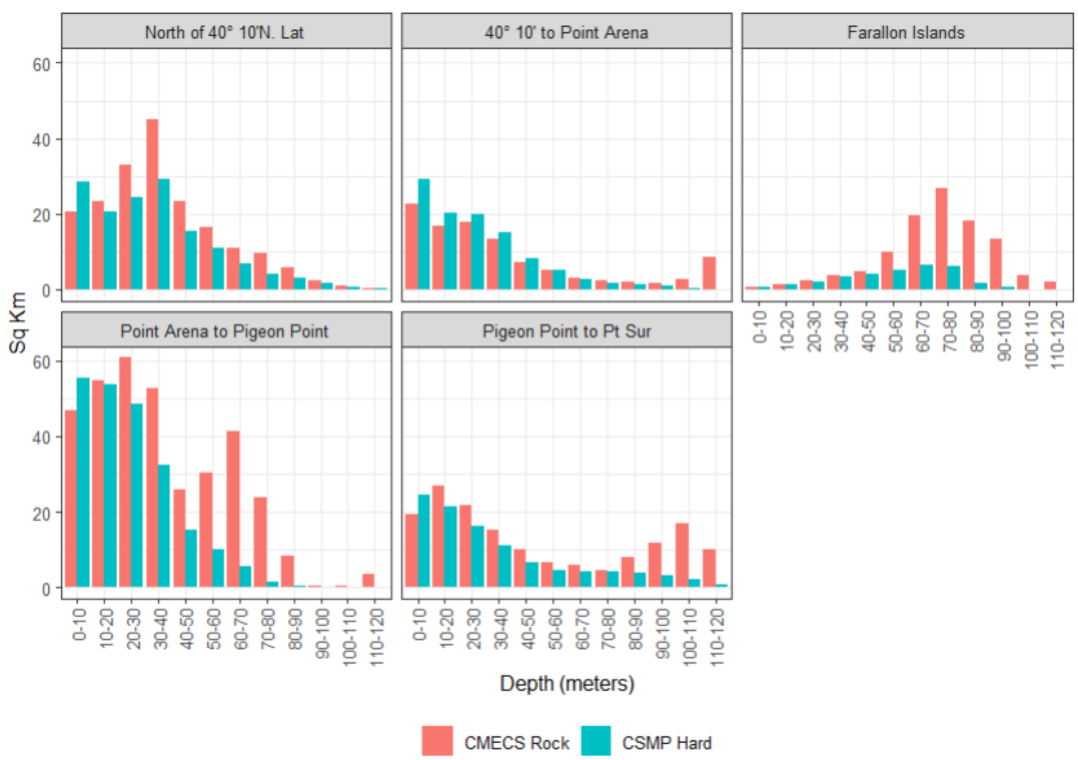

Figure 28. Distribution of area of rocky reef habitat by 10 m depth increments for CSMP and CMECS data for stratification scheme 1.

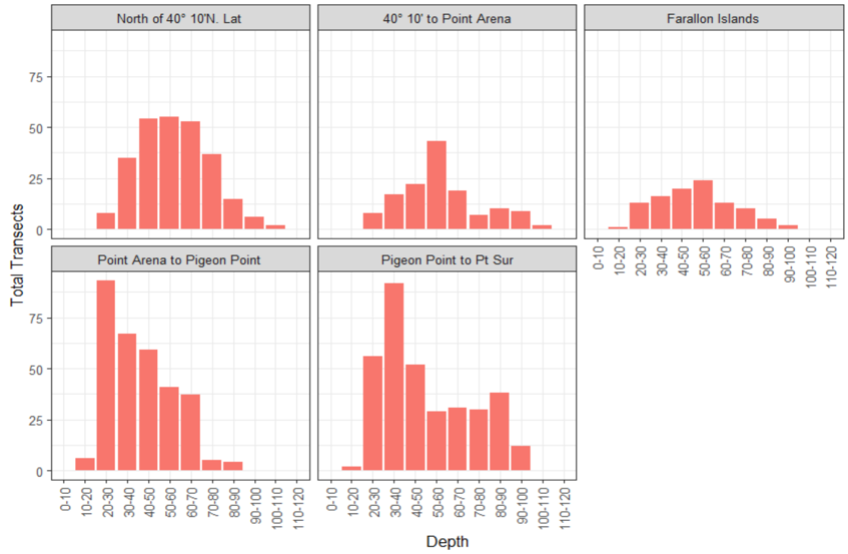

Figure 29. Count of ROV transects in 10-meter depth bins for each strata for stratification scheme 1.

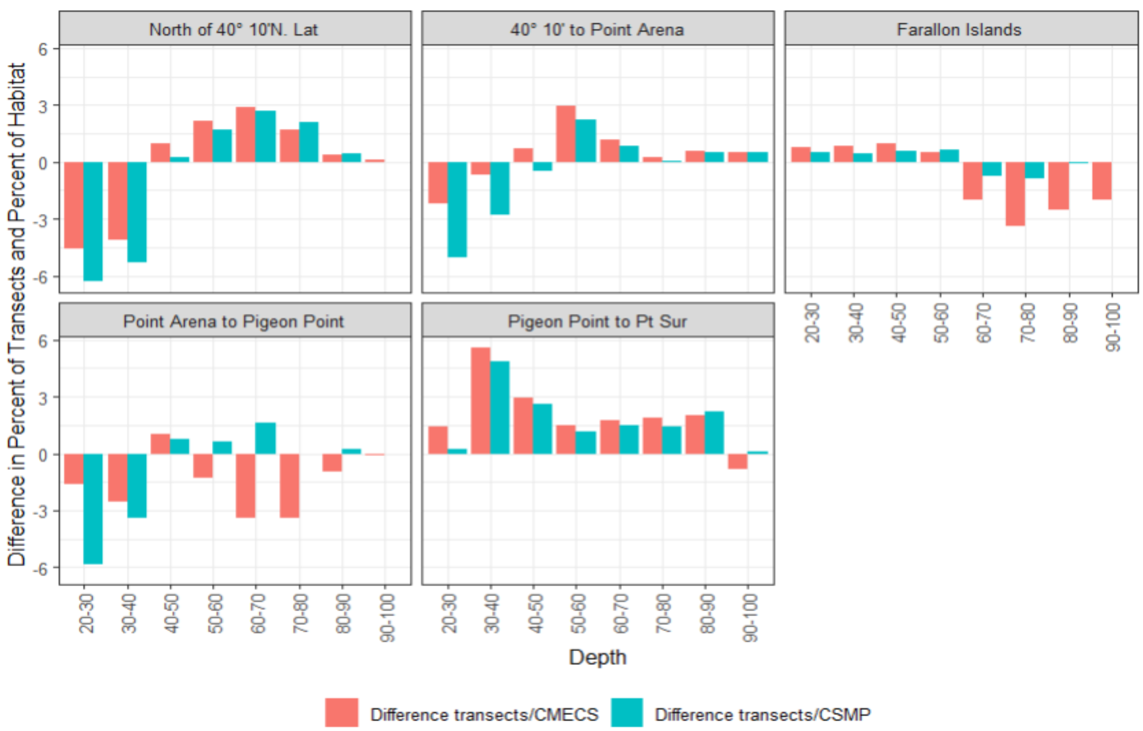

Figure 30. Comparison of the relative proportions of habitat data within each depth range to all available habitat data to the proportion of ROV transects performed for each stratum under stratification scheme 1. Negative values represent where the proportion of rocky reef in this depth range is greater than the proportion of ROV transects performed.

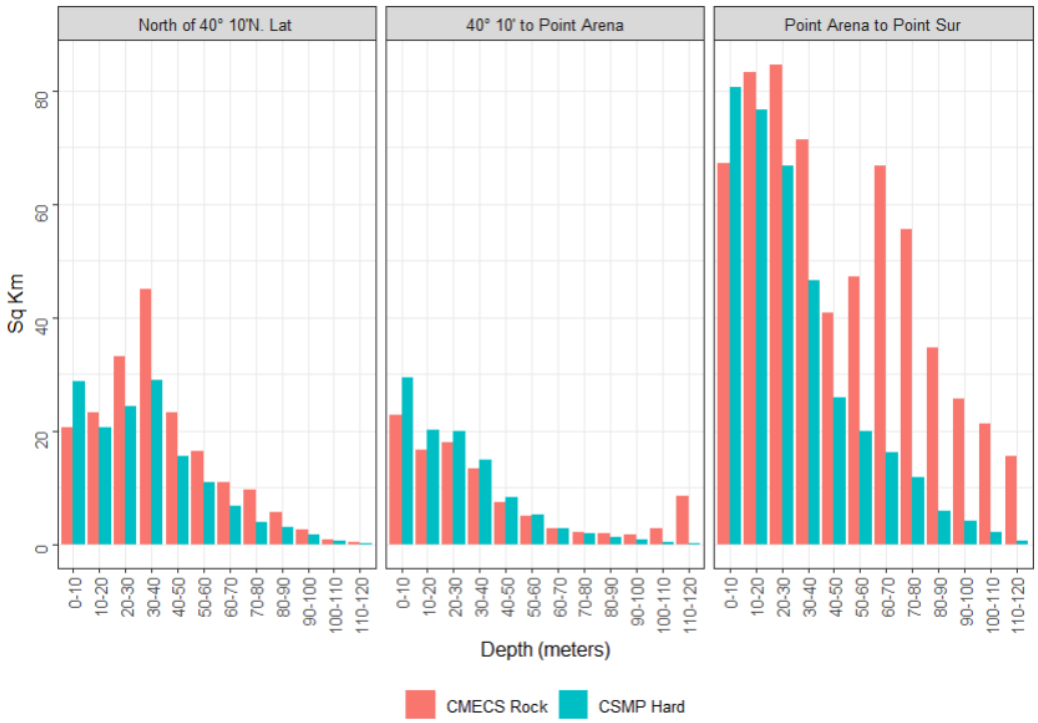

Figure 31. Distribution of area of rocky reef habitat by 10m depth increments for CSMP and CMECS data for each stratum in stratification scheme 4.

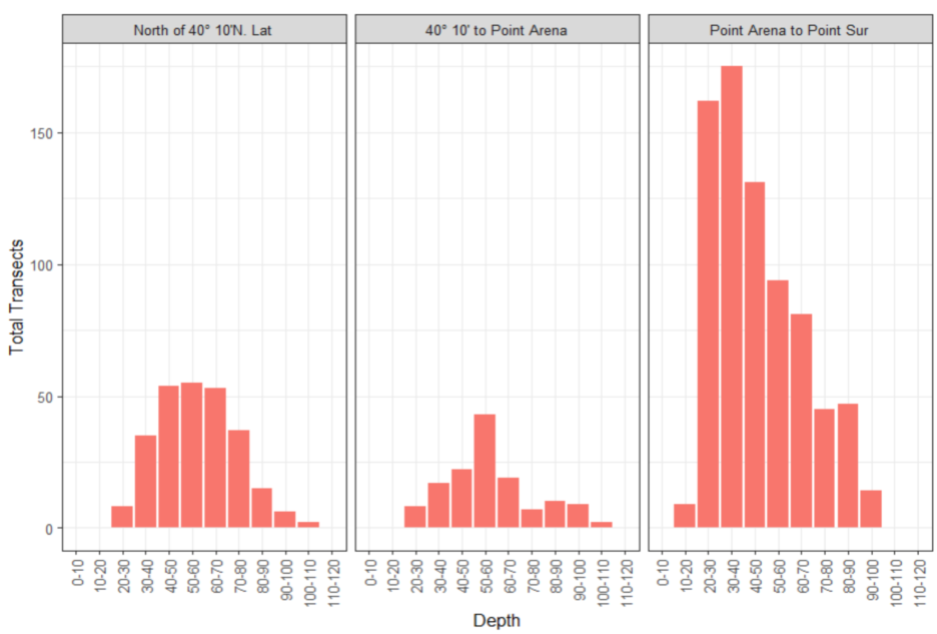

Figure 32. Count of ROV transects in 10-meter depth bins for each stratum of stratification scheme 4.

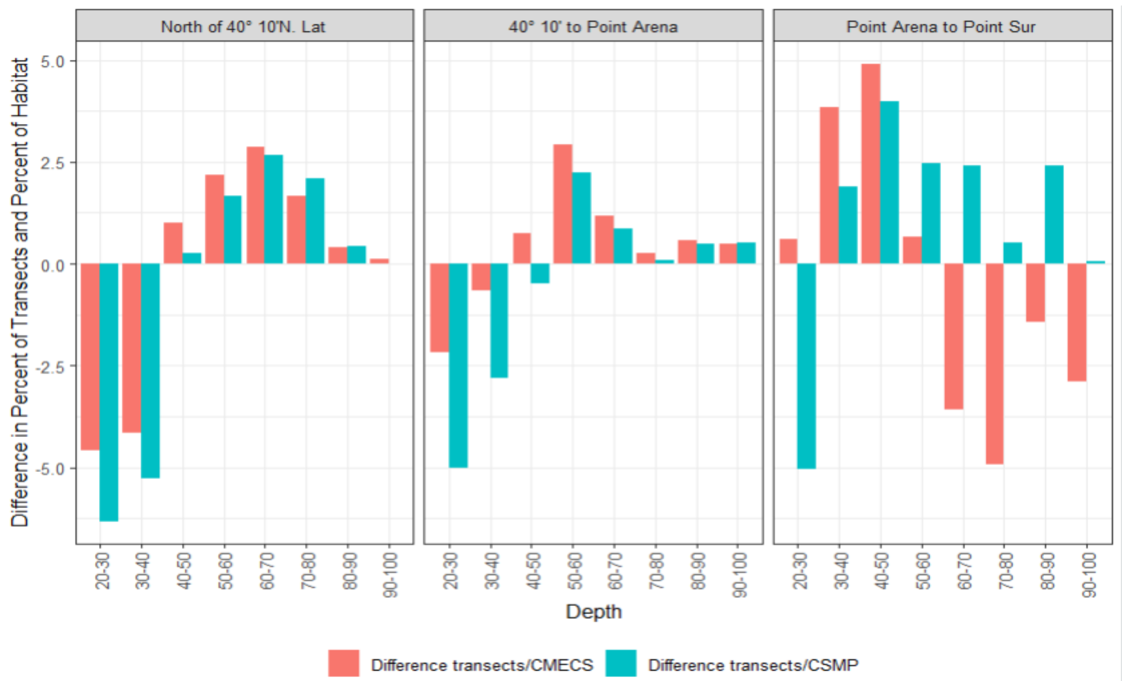

Figure 33. Comparison of the relative proportions of habitat data within each depth range to all available habitat data to the proportion of ROV transects performed in each stratum of stratification scheme 4. Negative values represent where the proportion of rocky-reef in this depth range is greater than the proportion of ROV transects performed.

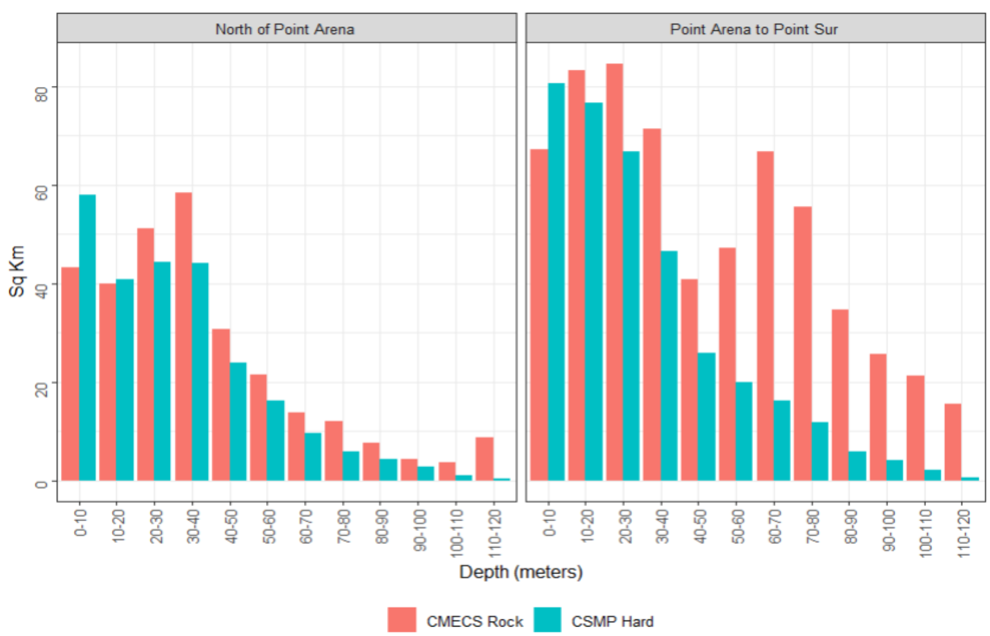

Figure 34. Distribution of area of rocky reef habitat by 10m depth increments for CSMP and CMECS data for stratification scheme five.

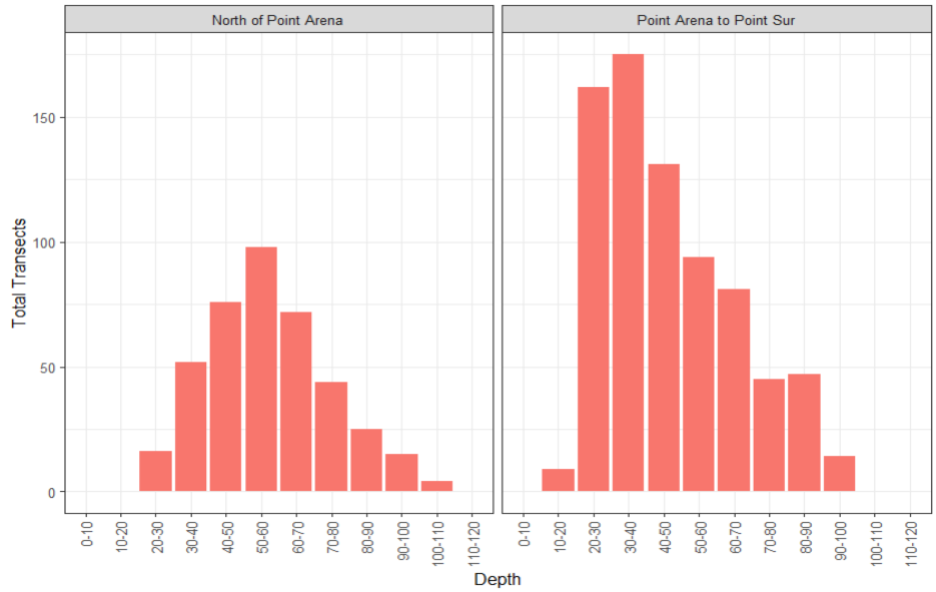

Figure 35. Count of ROV transects in 10-meter depth bins for each stratum in stratification scheme 5.

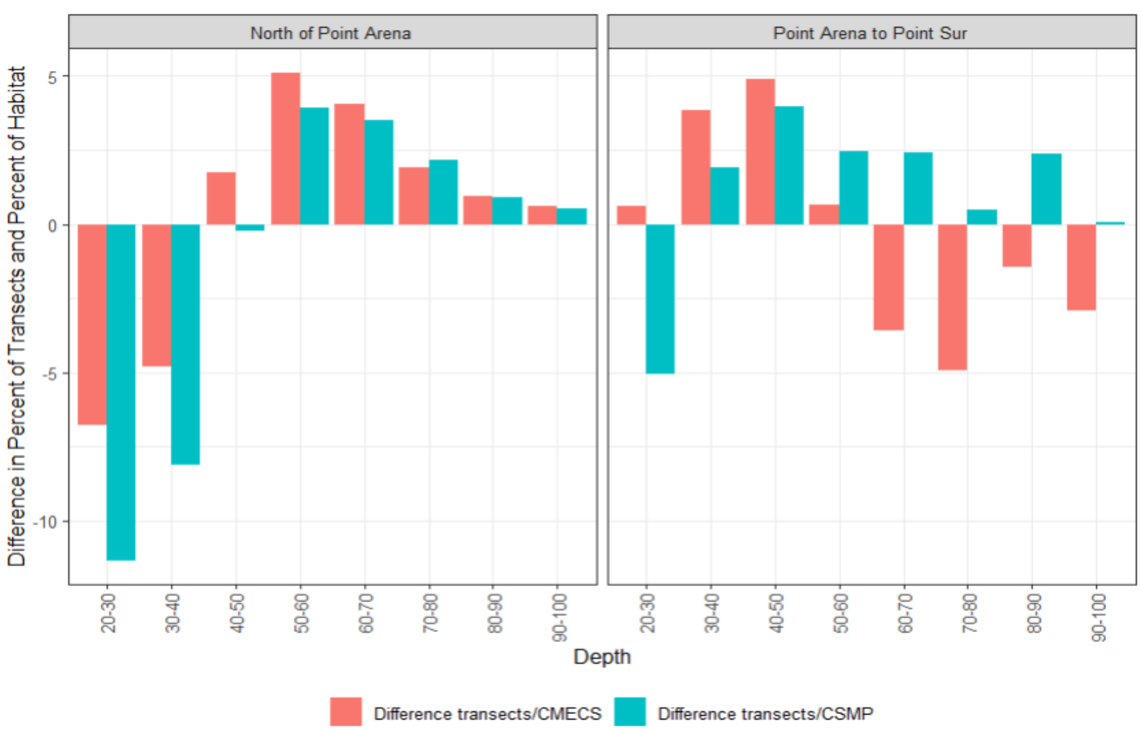

Figure 36. Comparison of the relative proportions of habitat data within each depth range to all available habitat data to the proportion of ROV transects performed each stratum under stratification scheme five. Negative values represent where the proportion of rocky reef in this depth range is greater than the proportion of ROV transects performed.

Request iv: For the density analysis, group depths more coarsely to increase the sample size in each respective depth bin, to be able to compare inside and outside MPAs.

Response: In Figure 37, the density of quillback rockfish in each area resulting from stratification at 40 10 N. Latitude, Point Arena, Pigeon Point and the Farallon Islands are presented for 2015 and 2020 inside (1) and outside (0) of MPAs. While some results were mixed in comparison in 2015 inside and outside of MPAs, the 2020 results showed increasing abundance inside of MPAs relative to outside with the recent recruitment evident in length composition data.

Figure 38. shows the density inside and outside MPAs statewide in 20 m depth increments in 2015 and 2020 combined to identify the primary depth distribution. The primary depth distribution of quillback rockfish from previous analysis at a higher resolution is between 40 and 70 m, which was used as the primary depth distribution for comparison of abundance inside and outside of MPAs statewide combining 2015 and 2020 data (Figure 39), in each year (Figure 40) showing little difference in 2015, north and south of Point Arena for both super years combined (Figure 41) and comparing 2015 and 2020 super years north and south of Point Arena (Figure 42). All comparisons indicate little difference inside and outside of MPAs in 2015, but a higher density inside MPAs in 2020.

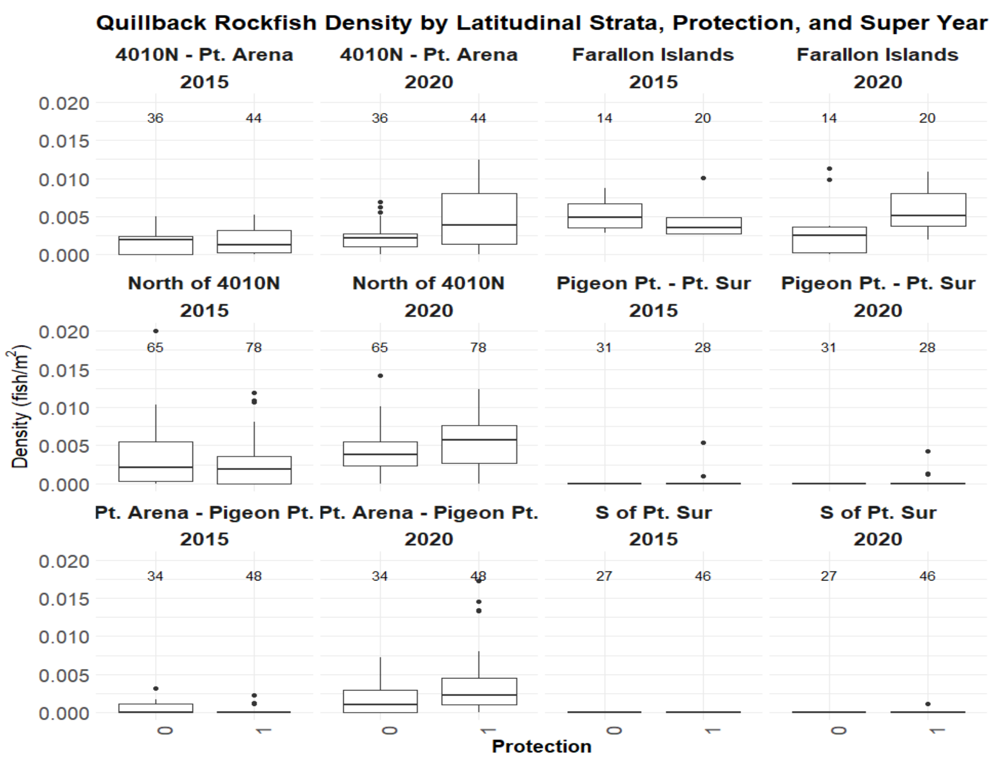

Figure 37. Density comparisons between 40 and 70 m with (1) and without (0) protection in each area resulting from stratification at 40°10' N. Lat, Point Arena, Pigeon Point, Point Sur and the Farallon Islands in each super year period 2015 and 2020.

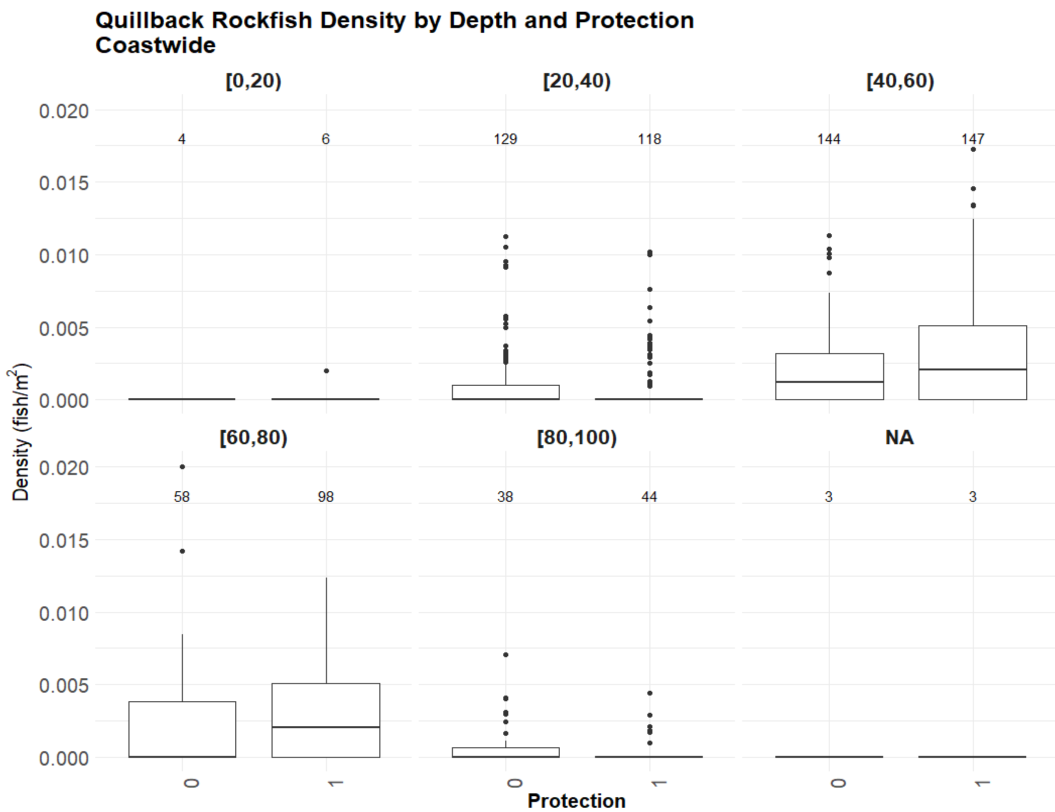

Figure 38. Coastwide density comparisons by 20 m strata between MPAs with (1) and reference areas without (0) protection for both 2015 and 2020 combined.

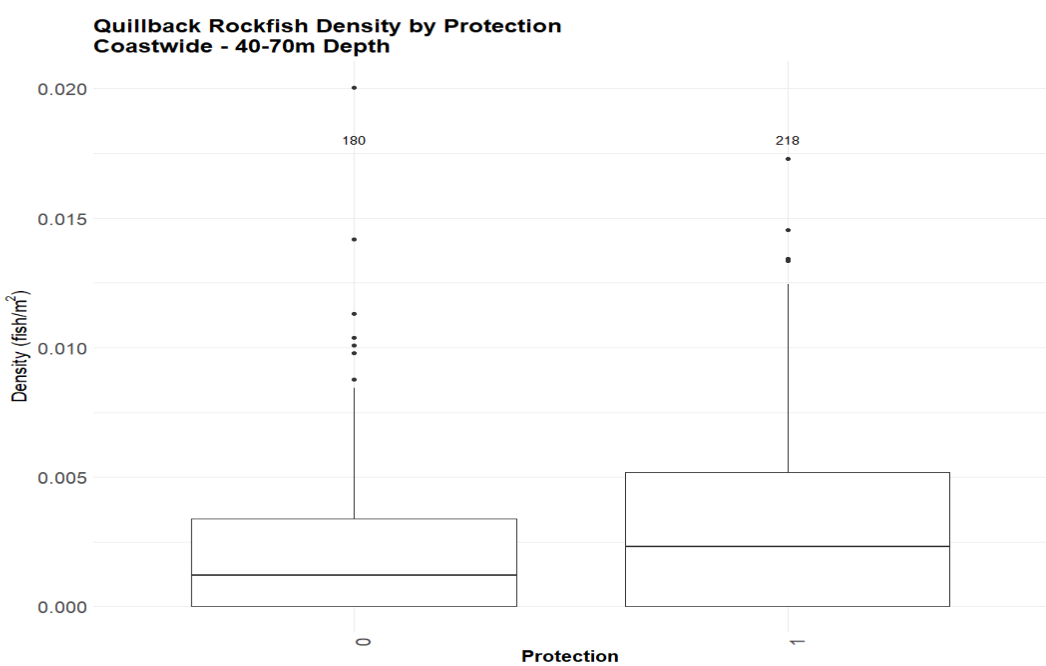

Figure 39. Density comparisons between 40 and 70 m with (1) and without (0) protection Coastwide combining super year periods 2015 and 2020.

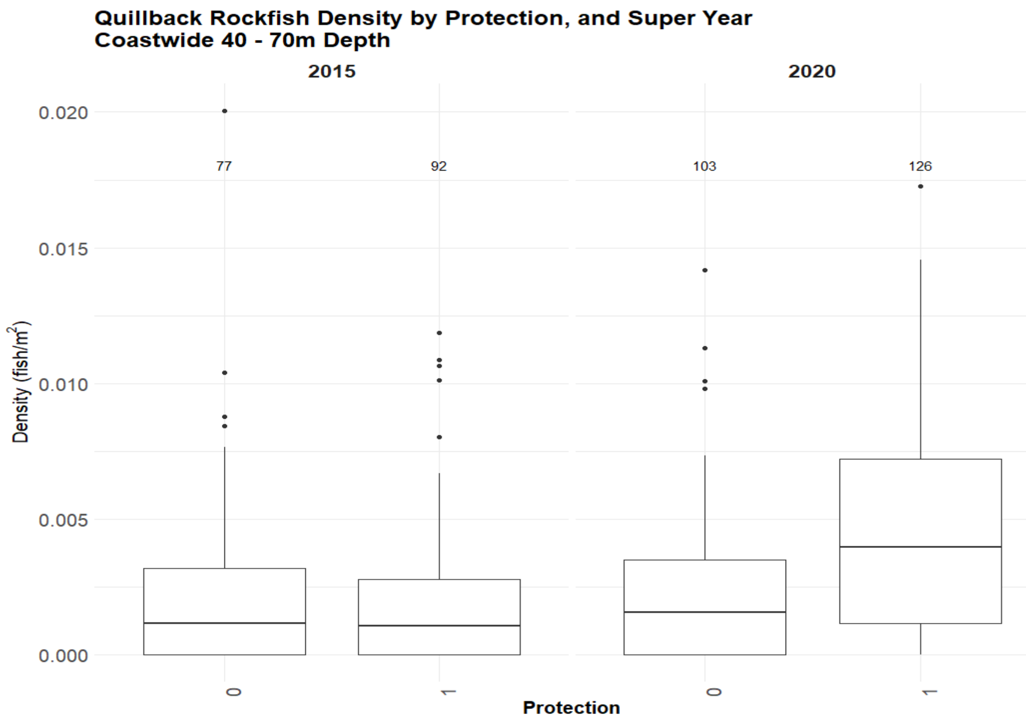

Figure 40. Density comparisons between 40 and 70 m with (1) and without (0) protection coastwide in each super year period 2015 and 2020.

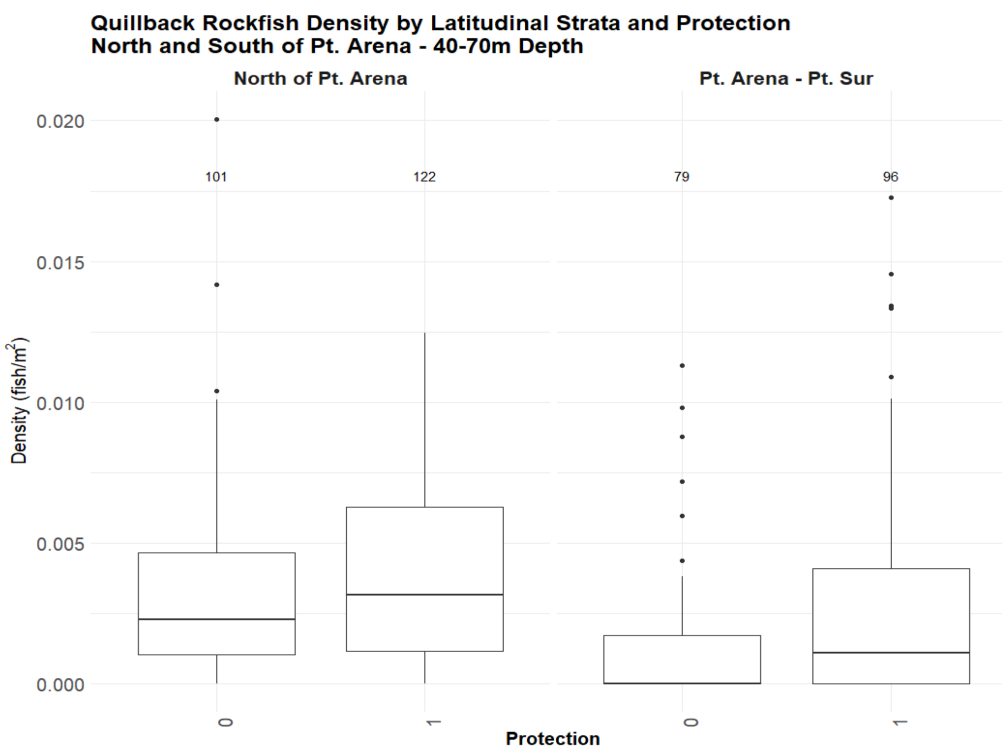

Figure 41. Density comparisons between 40 and 70 m with (1) and without (0) protection north and south of Point Arena combining super year periods 2015 and 2020.

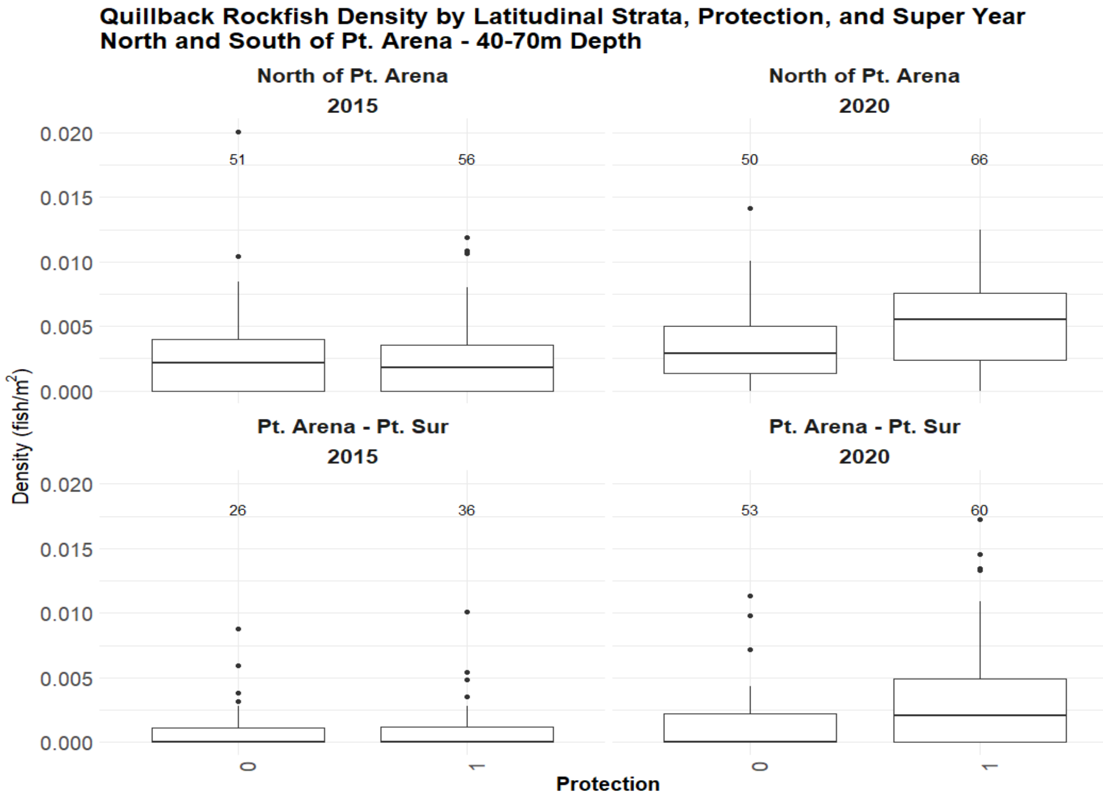

Figure 42. Density comparisons between 40 and 70 m with (1) and without (0) protection north and south of Point Arena in each super year period 2015 and 2020.

Request v. Summarize the data by both the number of transects and the sample sizes of quillback rockfish, by year, latitude and course depth bins, to provide reviewers with a better sense of the overall dataset.

Response: See D.6 request i for the result.

D.3. Seafloor mapping and area-specific estimates

Request i: It would be helpful to compare the two seafloor mapping data sources in the areas that they overlap as a validation.

Response: The CMECS datasource is a compilation of the best available habitat data in ocean waters. Where the CSMP data is present, it is included in the CMECS data as the best available source. To confirm that this is the case, areas where CSMP is present were compared within the CMECS and CSMP data sources. These datasets are in alignment. However, it was found that CMECS does lose some of the interstitial space present in CSMP data which can lead to a slight overestimate of rocky reef habitat. This is most likely due to how the CSMP data was spatially processed for inclusion within the CMECS dataset. CMECS was included in the ROV project due to it containing other habitat data sources outside of CSMP. These other data sources have various resolutions and quality, which can greatly impact habitat estimates.

D.4. Estimates of abundance

The GFSC and meeting participants discussed the assumptions and implications for the analysis and made the following suggestions/requests.

Request i: Continue exploring potential sources of bias that could be introduced in the expansions.

Response: Expansions are dependent on three major data sources, seafloor habitat from CSMP or CMECS for habitat area, fish density (fish per square meter) estimates from the ROV survey and length estimates converted to average weight using length/weight relationships. The potential sources of bias in each include.

1. Seafloor Habitat: The higher the resolution of seafloor characterization the lower the error in its attribution to hard or soft seafloor designations until a resolution is reached that no longer affects distribution at some level below which fish do not respond and their relative distribution is unaffected. The CSMP and CMECS differ in their resolution presenting variable uncertainty in seafloor.
    - CSMP: Has higher resolution data at multiple scales, specifically 2x2 m (77%), 5x5 m (8%) or 10x10 m (2%) resolution.
    - CMECS: Includes CSMP, but lower resolution where not available, greater potential overestimation of rocky reef habitat due to interstitial soft habitat in larger areas classified as rock.

2. Fish Density: There is increased potential misidentification of smaller rockfish as they can appear similar until differentiating characteristics become more prominent with development. Fish identified as unidentified YOY rockfish species are not counted toward species specific density estimates, potentially biasing estimates lower for smaller individuals. This affect is expected to be minor since most most fish are identifiable by the time they are observed by the ROV at 10-12 cm. In high relief structure, fish may be hiding out of site and not be counted, presenting a potential negative bias, though the magnitude is likely low. Habitat area estimation along the course of the ROV may present some error in terms of the estimation of observed seafloor forming the denominator for density estimates, though the error appears to be two sided with the potential for over and underestimation without a clear source of directional bias.

3. Estimates of Average Weight: Length/Weight relationships are from average estimates over many years and areas, which may not represent the area or time in question if major shifts in El Nino/La Nina or ENSO patterns affect body condition or sampling occurred during the spawning or resting phases of reproduction. The direction and extent of any biases is unknown relative to current condition. Estimation of lengths with the paired stereo-cameras may be less able to estimate

length for very small fish depending on orientation and tolerance for error in accepting sizing estimates.

While these potential sources of uncertainty may affect estimates to some degree, the magnitude of effect can be difficult to quantify. The current methods reflect the best efforts of the authors to address them. Future efforts can be undertaken where prudent and necessary to further reduce potential sources of uncertainty.

Request ii: Consider course depth stratifications, at least in the areas of greater density to capture variability in density or length (e.g., northern regions, where data may be sufficiently informative to inform a small number of depth strata).

Response: The number of transects and lengths available in each stratum decreased when additional stratification for depth was applied that no data was available to inform estimates in strata identified in Table 3. The values from the 40-70 m depth stratum was used as a proxy when data was not available in the deeper or shallower strata for six strata to inform density estimates and six strata for weight samples once data sets were stratified by latitude, depth and protection, thus limiting the available data in each stratum and necessitating use of proxy values. Using data from 40-70 m stratum to inform deeper depths is expected to result in a biased high density since densities are lower in the deeper depths, but conversely a biased low average weight is expected as larger fish are found in deeper depths with ontogenetic migration to deeper depths. A lower density is expected in shallower depths than values proxied with the 40-70 m stratum in the primary center of their depth distribution, biasing high proxy estimates in shallower depths, while average weight would also be biased high as larger fish are observed in deeper depths.

The estimates generated using bootstrap values with direct observations or proxy values for strata noted in Table 3 were applied in deriving estimates in Figure 43, which also displays the value without depth stratification for comparison. In stratification scheme 4 stratified at 40 deg. 10 min N. Lat. and Point Arena, ten proxy values for vacant strata were applied. The estimates of abundance were nearly 100 mt lower than the estimate without depth stratification for both 2015 and 2020 for stratification scheme 4. For stratification scheme 5 stratified only at Point Arena, only four proxy values were required. The estimates of abundance were lower than the non-depth stratified estimates in 2015, though the estimate for 2020 was around 50 mt higher than the non-depth stratified estimate for the same regional stratification scheme, increasing the change in abundance estimated over the five year period The Confidence interval for the 2020 estimate for scheme 5 was also substantially wider, presumably in part as a result of lower sample sizes in each stratum as a result of stratifying by depth.

Given the need to use proxy data to propagate estimates when greater depths are stratified, stratification scheme 5 stratifying only at Point Arena may be preferable to scheme 4 that also stratifies at 40 deg. 10 min N. Lat. further reducing sample sizes in the increased number of strata. The estimates of abundance for stratification scheme 5 with depth stratification is the preferred estimate at present and will be provided to the STAT for consideration in sensitivity analyses to evaluate parameterization of variables affecting scale in the assessment. These values can also be considered by the STAT as another potential value to examine in a relative sense in addition to the index of abundance from the GLMM for the ROV survey sensitivities.

Table 3. The strata in which proxy values were needed to inform density and lengths of observed fish informing average weight applied to the stratum in question.

Area	Super Year	Depth Bin	Protection	m2	Density Sample Size	Weight Sample Size
North of 4010N	2015	[20, 40)	1	8720411	0	0
Pt. Arena - Pt. Sur	2015	[70, 90)	1	5447880	14	0
Pt. Arena - Pt. Sur	2015	[70, 90)	0	84667113	13	0
4010N - Pt. Arena	2020	[70, 90)	1	175234.8	0	0
4010N - Pt. Arena	2020	[70, 90)	0	4022234	0	0
4010N - Pt. Arena	2020	[20, 40)	0	28774715	0	0

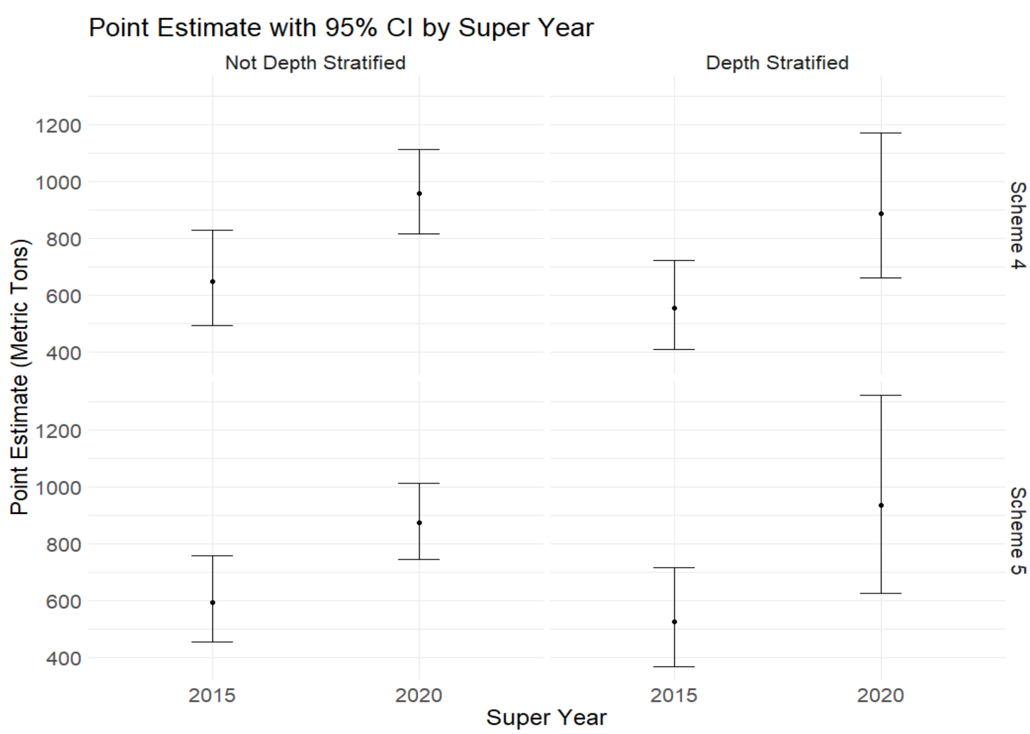

Figure 43. Estimates of abundance in 2015 and 2020 under stratification schemes 4 (stratified at 40 deg. 10 min. N. Lat and Point Arena) and stratification scheme 5 (stratified at Point Arena) with and without depth stratification in 20-40 m, 40-70 m and 70-90 m.

Request iii. Abundance estimates presented in the report tables appear overly precise and should be further explored to ensure they accurately represent the uncertainty.

Response: The previous estimates of abundance for stratification schemes 4 and 5 were not stratified by depth. The estimates stratified by depth as well as latitude reduced the sample size in each stratum, resulting in wider confidence intervals reflected in figure 43 above. Unaccounted for sources of variance may have contributed to the lower confidence intervals, though identifying and accounting for their contribution may prove challenging.

Request iv. Explore bootstrapping at the site level in addition to the transect level. If there is greater variability among sites than transects, bootstrapping at the transect level could lead to underestimates of uncertainty.

Response: Bootstrapping takes place at the level of the proscribed stratification; thus the current confidence intervals reflect the lowest resolution encompassing the full degree of variability within each stratum whether by depth or latitude.

Request v. Ensure reproducibility in the workflow to estimate abundance by producing R code to do the calculations and expansions that could be shared with assessment analysts.

Response: The ROV MS Access database provided by MARE requires merging of data sources for ROV observations and counts, then manipulations in Excel, all of which are described in the Data User Manual (Appendix 2). The quillback rockfish STAT has been provided with the R code for analyses that follow for indices and estimates of abundance that were presented at the GFSC at the methodology review on Dec 2-3, 2024. CDFW will continue to refine our estimate of abundance based on previous guidance in the GFSC report and any additional guidance received between now and the quillback rockfish data deadline on March 31, 2025. CDFW will provide the R code to do the calculations, expansions and any necessary workflows to the quillback rockfish STAT by the data deadline.

Request vi. Clarify documentation on length expansions to make it clear that the length data were expanded within a strata and not across the entire region.

Response: Lengths were stratified at the same resolution as the density estimates in each stratum and lengths converted to weights before generating estimates of average weight within each stratum.

Request from Text 1: The GFSC discussed results from the alternative stratifications and suggests that schemes 4 and 5, which combined areas south of Pigeon Point and the Farallon Islands with the area further south, were most promising.

Response: Stratification 4 reflects stratification at 40°10' N. Lat. and Point Arena, while stratification 5 reflects stratification only at Point Arena accounting for differences in the length distribution and density over space. The additional analyses completed to incorporate three depth strata as well, used stratification schemes 4 and 5 as latitudinal stratifications. Stratification scheme 4 may result in reduced sample sizes requiring use of proxy data from other depth bins when depth strata are introduced, thus stratification scheme 5 may be preferred when depth strata are added.

Request from Text 2: The GFSC recommends evaluating whether the surveyed reefs are representative of unsurveyed reefs statewide and within spatial strata. In particular, the GFSC recommends confirming that the depth distributions of surveyed and unsurveyed reefs within latitudinal strata are similar.

Response: See response to D.2.iii of this section.

D.5. Data gaps and future research efforts

D.6. Discussion

The GFSC supports these products being considered for use in the quillback rockfish assessment, but additional analyses are needed prior to implementation. To that end, the GFSC focused on what could be done in time for review at the March 2025 Council meeting along with longer-term goals.

Shorter-term recommendations:

Request i: Evaluate the availability of length and density data across latitude and depth for each super year in a matrix to identify where data are available for further stratification or where sample sizes are low and aggregation is necessary. This will help inform the ability to develop estimates that include stratification by both depth and latitude in design-based methods.

Response: Tables providing the requested number of transects and stereo-camera measured length information available by degree of latitude and 10 m depth bin were produced for each super year (2015, 2020) and protection (0 open to fishing, 1 protected). The number of transects for 2015 and 2020 inside and outside MPAs in Tables 4 through 7. The analogous tables for the number of stereo-camera measurements are provided in Tables 8 through 11. The approximate proposed strata at Point Arena and 40 deg 10 min N. Lat. as well as 20 to 40 m, 40-70 m and 70 to 90 m within the primary distribution of quillback rockfish in California are superimposed to provide an indication of data availability within each stratum.

The sample sizes for respective strata for which proxies from other depth bins or areas would be required for 10 strata to inform weight or density for the respective strata in design-based estimates reflected in Table 12, in which a zero indicates no data available and thus the need to use a proxy. In most instances the data from the 40-70 m depth bin where most quillback rockfish were encountered were used as the basis for the proxy for shallower and deeper depth bins within each latitudinal area.

Spatial autocorrelation may be present given the scale observed by Perkins 2024 was 4-6 km. Inclusion of the site variable, latitude and depth help to account for spatial components that may affect the pattern of spatial autocorrelation. That said, it is possible that the variance is underestimated and use of methods available in VAST and SDM-TMB may offer a means of directly accounting for spatial autocorrelation through the parameter Rho, though this requires additional efforts beyond the scope of the current analysis. While such autocorrelation may also exist in indices often used in assessments from fishery dependent indices from Marine Recreational Fisheries Statistical Survey (MRFSS) and CRFS data as well as independent surveys such as California Collaborative Fisheries Research Program (CCFRP), spatial autocorrelation is seldom accounted for outside of the trawl survey index as other examples are lacking. Consistency in expectations and the bar for best scientific information available should be considered when thinking of how much concern or need there is to account for spatial autocorrelation without singling out a given method.

Table 4. Number of sampled transects in the 2015 super year by 10 m depth increment and degree of latitude for all sampled sites from 2014-2016 outside MPAs, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2015
Protection	0

Count of Transect ID	Avg Depth										
Avg Lat	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	Grand Total
35-36		2	4	3	4	1	3	2	1		20
36-37		3	5	6	4	2	2	7		1	30
37-38		11	4	3	3		3	2			26
38-39	1	6	6	5	5	3					26
39-40		1	2	6	9	2	1	2	1		24
40-41		3	2			2	1	1			9
41-42		1	10	9	13	10	5		1		49
Grand Total	1	27	33	32	38	20	15	14	3	1	184

Table 5. Number of sampled transects in the 2015 super year by 10 m depth increment and degree of latitude for all sampled sites from 2014-2016 inside MPAs combined, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2015
Protection	1

Count of Transect ID	Avg Depth										
Avg Lat	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	Grand Total
35-36		3	5	3	2	1	1				15
36-37		3	8	4	5	12	1	4	4		41
37-38	2	14	6	3	2	1	2	2	1	1	34
38-39		6	8	10	9	6	3	2			44
39-40	1	1	2	5	6	2	1		1		19
40-41						2	5	3	2		12
41-42				8	10	18	3	1		1	41
Grand Total	3	27	29	33	34	42	16	12	8	2	206

Table 6. Number of sampled transects in the 2020 super year by 10 m depth increment and degree of latitude for all sampled sites from 2019-2021 outside MPAs combined, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2020
Protection	0

Count of Transect ID	Avg Depth										
Avg Lat	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	Grand Total
35-36		5	7	4	5	1					22
36-37		3	9	11	8	4	6	18	1	2	62
37-38		30	8	5	7	1	2				53
38-39	3	10	12	9	8	4					46
39-40				5	14						19
40-41		4	4				4	5			17
41-42				11	11	9					31
Grand Total	3	52	40	45	53	19	12	23	1	2	250

Table 7. Number of sampled transects in the 2020 super year by 10 m depth increment and degree of latitude for all sampled sites from 2019-2021 inside MPAs combined, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2020
Protection	1

Count of Transect ID	Avg Depth										
Avg Lat	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	Grand Total
35-36		4	7	6	4	1					22
36-37		6	14	8	9	17	4	9	5	1	73
37-38	3	28	14	6	7	3	2	2			65
38-39		9	13	12	14	9	2	2			61
39-40				9	9	1					19
40-41			5	4		2	4	4	2		21
41-42				12	5	17					34
Grand Total	3	47	53	57	48	50	12	17	7	1	295

Table 8. Number of quillback rockfish measured with a stereo-camera in the 2015 super year by 10 m depth increment and degree of latitude for all sampled sites from 2014-2016 inside MPAs, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2015
Protection	1

Count of Stereo Size	Depth											
Latitude	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	Grand Total
35-36												
36-37						1	2					3
37-38												
38-39				5	7	1	2					15
39-40				1	5	10	2	1				19
40-41					5	7	5	9	2			28
41-42					2	1						3
Grand Total				7	19	21	11	10	2			70

Table 9. Number of quillback rockfish measured with a stereo-camera in the 2015 super year by 10 m depth increment and degree of latitude for all sampled sites from 2014-2016 outside MPAs, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2015
Protection	0

Count of Stereo Size	Depth											
Latitude	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	Grand Total
35-36												
36-37												
37-38												
38-39				2	2							4
39-40				1	4	8	9	2	3			27
40-41				7	3	6	2		1	1		20
41-42			4	6	4	22	13	2				51
Grand Total			4	16	13	36	24	4	4	1		102

Table 10. Number of fish measured with a stereo-camera in the 2020 super year by 10 m depth increment and degree of latitude for all sampled sites from 2019-2021 inside MPAs combined, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2020
Protection	1

Count of Stereo Size	Depth											
Latitude	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	Grand Total
35-36												
36-37							3	1				4
37-38			7	17	34	32	7	4				101
38-39			1	14	41	26	7					89
39-40				1	11	17	2					31
40-41				2	6		11	5	1	1		26
41-42					30	6	39					75
Grand Total			8	34	122	81	69	10	1	1		330

Table 11. Number of fish measured with a stereo-camera in the 2020 super year by 10 m depth increment and degree of latitude for all sampled sites from 2019-2021 outside MPAs combined, with proposed stratification scheme at Point Arena (38° 57.5' N. Lat.) and 40°10' N. Lat as well as 20 to 40 m, 40-70 m and 70 to 90 m strata superimposed as vertical and horizontal lines approximating their locations.

Super Year	2020
Protection	0

Count of Stereo Size	Depth											
Latitude	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	Grand Total
35-36												
36-37								1	5			6
37-38			1	24	17	11	4	3				60
38-39			1	2	9	9						21
39-40					2	21	2					25
40-41				12				11	2			25
41-42					12	21	10					43
Grand Total			2	38	40	62	16	15	7			181

Table 12. The sample sizes for respective strata for which proxies from other depth bins or areas would be required to inform weight or density for the respective strata in design-based estimates. A zero indicates no data available and thus the need to use a proxy.

Area	Super Year	Depth Bin	Protection	m2	Density Sample Size	Weight Sample Size
North of 4010N	2015	[20, 40)	1	8720411	0	0
Pt. Arena - Pt. Sur	2015	[70, 90)	1	5447880	14	0
Pt. Arena - Pt. Sur	2015	[70, 90)	0	84667113	13	0
4010N - Pt. Arena	2020	[70, 90)	1	175234.8	0	0
4010N - Pt. Arena	2020	[70, 90)	0	4022234	0	0
4010N - Pt. Arena	2020	[20, 40)	0	28774715	0	0

Request ii: For super year estimates, discussion and analysis of what is included in the uncertainty estimates presented, or improvements to how uncertainty was measured.

Response: Some concern was expressed in the GFSC review of estimates of abundance that inclusion of data from multiple years it takes to cover the state given concerns about visibility and operating conditions standards limiting days at sea. A more regional approach providing estimates for part of the state in a year or more sparse sampling to facilitate sampling present their own limitations in terms of data availability and spatio-temporal considerations. The two or so years of sampling to cover all sites across the state to provide a robust data set to bring to bear in estimating abundance may encompass some interannual variability. Fish may move to deeper or shallower depths or shift northward with water temperature regime shifts, presented at the meeting as concerns regarding sampling the state over longer periods than an annual basis. Though many species of rockfish such as quillback rockfish are not thought to move large distances apart from seasonal migrations to deeper waters in larger swells in the nearshore (Stakeholder Input on the Quillback Rockfish Pre-Assessment Workshop), quillback rockfish already occupy deeper nearshore depths predominantly deeper than 20 m outside of the areas subject to surge even with large swells. The extent of potential bias presented by use of super-year estimates is limited by the potential magnitude of effect of the variables dictating their distribution, which is itself uncertain. The potential magnitude of effect of a particular variable would need to be quantified to fully understand the degree of impact on estimates. CDFW recognizes the potential concerns raised by conducting ROV sampling over multiple years, however the logistical and funding limitations make this the best current methodology. The GFSC concerns have been shared and will be considered in future ROV methodology change discussions.

Uncertainty in seafloor habitat characterization in estimating the amount of rocky reef habitat is dependent on the scale at which the seafloor habitat is characterized. The majority (77%) of the habitat within state waters north of Point Conception from the CSMP are collected at a 2x2 m resolution and another 8% from 5x5 m resolution, providing less potential for mischaracterization of interstitial soft habitat amongst the rocky reef habitat. Outside of state waters the CMECS data set uses variable habitat resolutions, the lower resolution aspects of the area estimates are likely to be more uncertain. There are not overlapping characterizations of seafloor at various resolutions for the same location with which to produce estimates to directly estimate the magnitude of uncertainty for lower resolution seafloor characterizations in comparison to the 2 m resolution estimates. Thus, there is latent uncertainty from seafloor characterization at various resolutions in the CMECS data set and the deepest areas within state waters characterized at a 5x5 m or 10x10 m resolution. That said, these data sources provide the most comprehensive and up to date representation of the seafloor available at present and until higher resolution information becomes available, will be the best scientific information available.

Estimates of abundance for each super year accounted for the variability in the density and average weight of quillback rockfish in each of the strata employed propagated through the estimates using bootstrapping methods and reflected in 95% confidence intervals as described in section C.4 of the December 2024 report submitted for review by the GFSC. Uncertainty from potential variability of length/weight relationships over time were not accounted for explicitly, though the source of the relationship incorporates observations from several years, coastwide, from various data sources and thus incorporates some of this interannual variability (Table 13). Specific examination of relationships during El Nino and La Nina events or during spawning vs. non-spawning times of year may provide more explicit information on the potential causes of variability and the extent of their effect on the actual length-weight relationship. Spatial variability in length weight relationships within California are accounted for to some extent through the geographical representation of data composing the current relationship. Quillback rockfish range within California is limited to areas north of Point Sur just south of Monterey, California, thus only the northern half of the state contains them, thus limiting the potential for geographic variability as it does not exist across major temperature differences along the coast at Point Conception. As with the integrated stock assessment, the current length-weight relationship is used to reflect the current understanding of variability in the relationship and a consistent basis in accounting for variability in the length-weight relationship. As such, the length-weight relationships reflect the best scientific information available with which to estimate weight from observed lengths.

Future explorations of methods to incorporate additional sources of uncertainty can pursue means of quantifying these sources of uncertainty for incorporation if the magnitude of effect appears to be sufficient to justify their inclusion.

Table 53. Source and sample size of data informing the length-weight relationship used in the 2021 length-based data-moderate stock assessment for quillback rockfish stock and converting stereo-lengths to weights for estimation of biomass with ROV design-based estimates of abundance.

Table 5: Summary of the number of samples by year from the NWFSC WCGBTS, and the commercial (com) and recreational (rec) fisheries by state used to estimate weight-at-length parameters.

	CA NWFSC WCG-BTS	CA Rec	OR Com	OR NWFSC WCG-BTS	OR Rec	WA Com	WA NWFSC WCG-BTS	WA Rec
1993	0	50	0	0	47	0	0	0
1994	0	28	0	0	43	0	0	0
1995	0	17	0	0	16	0	0	0
1996	0	37	0	0	13	0	0	0
1997	0	9	0	0	49	0	0	0
1998	0	7	0	0	115	0	0	0
1999	0	21	0	0	152	0	0	0
2000	0	38	20	0	59	0	0	0
2001	0	11	8	0	372	0	0	0
2002	0	4	45	0	811	0	0	18
2003	0	14	17	0	882	0	0	16
2004	0	21	65	0	498	0	0	26
2005	0	82	20	0	930	0	2	67
2006	0	118	73	2	1033	0	1	73
2007	15	203	127	1	1074	0	0	41
2008	0	163	56	22	1115	0	0	21
2009	0	119	59	3	824	0	0	10
2010	0	49	63	1	918	0	1	0
2011	0	70	191	6	1044	0	0	0
2012	0	173	129	0	1238	0	26	0
2013	0	167	211	1	752	0	0	0
2014	4	61	157	4	484	0	17	65
2015	0	113	102	5	10	0	3	14
2016	0	148	72	8	0	0	1	33
2017	2	385	214	5	724	0	9	10
2018	0	367	199	16	1341	8	5	25
2019	0	364	351	11	1206	1	5	61
2020	0	0	216	0	39	0	0	0

Request iii: Consider unaccounted for sources of variability and bias for estimates of abundance, including habitat classification or spatial uncertainty, swath width, which fish lengths are estimated, site selection, spatiotemporal variation in weight at length using MRFSS and CRFS sampling data, etc.

Response: The following potential sources of variability and bias have have been identified and considerations provided.

1. Habitat Classification or spatial uncertainty: See response to D.6 ii.
2. Swath Width: The method for determining swath area relies on readings from an acoustic ranging sonar which is aligned with the center of the ROV video view which thereby allows an estimate of the viewable seafloor at every second of video. These one-second estimates of viewable width are combined with the acoustically tracked position of the ROV to assemble total swath area for the desired transect or transect segment. It is difficult to estimate what error could be introduced by small errors of the width estimation but they are likely not introducing significant bias to the overall variation.
3. Which fish lengths are estimated: In order to be measurable by the stereographic software a fish needs to be viewable within both stereo cameras, in a straight uncurved body position and angular orientation that allows the viewing of both the tail and nose. Distance from the cameras also affects measurability with uncertainty increasing with distance. The relationship between measurability and fish length is likely to introduce some biases due to variability in interaction with the ROV and smaller sizes being less discernible in video due to image resolution and quality.
4. Site selection: See response to D.6, Request vi.
5. Spatiotemporal variation in weight at length: See response to D.6 ii.

Request iv: Develop absolute abundance and associated uncertainty estimates for another stock/species for which we have a more robust stock assessment for comparison, such as copper, gopher or China rockfishes.

Response: This is a workload intensive request, which the Department will seek to complete for consideration by the stock assessment review panel for quillback rockfish. For copper rockfish, sample sizes are much higher for lengths and encounters and a recent assessment is available for comparison.

Request v: Develop absolute abundance associated uncertainty estimates within MPAs alone, with discussion of survey coverage, potential biases, etc.

Response: Efforts are underway to provide design-based estimates of abundance for quillback rockfish within MPAs at the STAR panel as well as for copper rockfish inside and outside of MPAs for comparison to scale from the assessment for a more commonly encountered species. Additional efforts are underway by NMFS to produce estimates of abundance within MPAs using the model-based methods.

Request vi: Discuss potential bias in the selection of reference sites outside of MPAs and issues of coverage to help inform uncertainty.

Response: The sampling design for ROV surveys was designed to enable detection of changes in abundance of species in response to protection afforded by marine protected areas. An index site strategy was chosen knowing that fully characterizing variability across rocky reefs within MPAs was not possible due to logistical and funding limitations. Sites were chosen within MPAs according to the reef characteristics of individual MPAs. Depth and reef characteristics varied between MPAs and thereby required different size and number of index sites across MPAs. Similarly, reference sites (unprotected) varied in their comparability to MPA sites in depth and reef characteristics. As much as possible reference sites were chosen to have similar depth and reef characteristics as their MPA counterparts but in some cases these comparable conditions did not exist. Due to the selective nature of this sampling design, reference areas will be biased towards depth and habitat characteristics that resemble those found in their paired MPAs. However, with the intent on better representation of non-protected areas, surveys conducted in 2014-2016 were expanded to reef areas across the state that were not paired with MPAs.

The addition of these sites for the 2014-2016 surveys increased the overall coverage and depth range as well as a broader range of reef characteristics. Surveys in 2019-2021 were less extensive and largely were focused on MPA and reference paired sites with similar characteristics, however 12 new sites were added inside and outside MPAs attempting to capture deeper depth range in sites where it was available and reef areas identified by new or refined seafloor mapping data. Although the sampling design did not specifically set out to fully stratify by depth and available rocky habitat it is substantial and robust in spatial and temporal coverage especially for nearshore species such as Quillback rockfish who's depth and spatial distribution are well captured by these surveys. We feel that it is unlikely that there are large sources of biases introduced by site selection or undetected variability in unsurveyed areas that would significantly alter the estimates presented in this analysis. Increased sampling effort performed using a more spatially balanced survey design would allow for more precise examination of the spatial distribution of the population and allow for more refined examination of drivers such as habitat variables and fishing effort.

In 2023 the California MPA monitoring program initiated a formal review of mid-depth monitoring methods, sampling design and analytical approaches. This review resulted in a report of findings and recommendations by an international panel of experts and a competitive request for proposals (RFP) with proposals expected to be selected in February 2025. The examination and refinement of sampling designs was identified by the technical expert panel as a need and included as part of the RFP with a goal of moving towards sampling designs stratified minimally by depth and habitat and exploring more spatially balanced distribution to allow for examination of other driving factors on MPA performance metrics. These efforts to identify gaps and to examine trade-offs of spatial and temporal survey coverage will be congruent with needs to more fully capture variation in single species abundance in rocky habitats to inform stock assessments and fisheries management.

Request vii: Provide annotated script/code so that others can replicate and investigate.

Response: The quillback rockfish STAT has been provided with the R code for analyses that follow for indices and estimates of abundance that were presented at the GFSC at the methodology review on Dec 2-3, 2024. CDFW will continue to refine our estimate of abundance based on previous guidance in the GFSC report and any additional guidance received between now and the quillback rockfish data deadline on March 31, 2025. CDFW will provide the R code to do the calculations, expansions and any necessary workflows to the quillback rockfish STAT by the data deadline.

Request viii. Plot histograms of depth for reef habitat in state waters and compare them to histograms of mean depth for ROV transects. Explore estimating the degree of overlap between distributions (*sensu* Pastore 2018; Pastore and Calcagní 2019).

Response: See response to D.2.iii of this section.

Long-Term recommendations: These requests will be addressed in the future as they will take more time than is currently available and model-based estimation methods are subject to a number of requests from the methodology review that have not been addressed due to higher prioritization of indices and design-based estimates of abundance. These requests can be addressed at a future workshop with the state of Oregon and California responding to requests from the methodology review and new developments from the GFSC review in December 2024.

Request ix. Analyzing the data using alternative transect lengths (longer than 10 m, but shorter than 500 m full transects).

Response: Such an analysis may be worthwhile in examining trends in abundance with seafloor characteristics etc. as opposed to the transect level data with more macro scale variables. The work required is time intensive and future exploration in the context of a spatio-temporal model accounting for spatial autocorrelation may be more advantageous.

Request x. Explore other model-based approaches for abundance estimation, such as a negative binomial model with the following categorical covariates (number of factor levels in parentheses):

a. Super year (2)
b. Region (5; same as before, with Farallon Islands separate)
c. Depth (4; e.g., <30, 30-50, 50-70, >70)
d. Protection status (2)
e. Interaction between super year and protection status
f. Site as random effect
g. Test other 2-way interactions, if possible

The GFSC provided additional guidance to:

1. Use model selection to identify important sources of variability.
2. Use model predictions of density with habitat areas to produce estimates of numerical abundance
3. Use estimates of numerical abundance by stratum to expand length composition data.
4. Derive mean weights from those expansions and derive biomass estimates from the expanded length compositions.

Response: Model-based estimates of abundance are the third method reviewed by the GFSC in 2020 at the methodology review for which numerous requests have been made. The workload is planned in the lead up to a workshop to be held to review results in conjunction with review of the efforts of the Oregon Department of Fish and Wildlife effort to address requests specific to their efforts. NMFS has moved forward with efforts to estimate abundance inside of MPAs to provide additional perspective in the 2025 quillback rockfish assessment, which the Department has been supportive of while keeping in mind the requests made at the methodology review that remain to be addressed.

Appendix II. ROV Data User Manual

ROV Data User Manual

Overview

This document provides an overview of the ROV dataset compiled from surveys conducted by the California Department of Fish and Wildlife (CDFW) and Marine Applied Research and Exploration (MARE), which were designed to make observations of benthic fish, invertebrates and habitat within swept area video transects over predominantly rocky habitat. These transects allow the measurement of fish density (fish/m², hereafter referred to as density) and fish size inside marine protected areas (MPAs) and at reference locations open to fishing. Following the introduction is a section discussing data caveats and methodological background to orient new users of the data to information relevant to using these data sets. A brief description of each component of the ROV data set can be found in the Description of Data Sets section. A table of columns/fields from the ROV data set along with their descriptions are provided in Table 1.

The methodology for these surveys was developed and first implemented in annual MPA monitoring surveys at the northern Channel Islands (2004-2009) and central coast (2006-2008). Subsequently, surveys of the entire coast (Figure 1) have now been undertaken twice, each taking three years to complete. For examination of focal rockfish species to inform stock assessments, data were combined into super years of 2015 (2014-2016) and 2020 (2019-2021) available for analysis to examine the changes between 2014 and 2021. The 500 m strip survey transects in each rocky reef sample site were selected by first randomly selecting the deepest transect at a given site, then selecting transects on a constant interval into shallower depths to evenly cover the depth range of a given site (Figure 2). The number of transects allocated to a site was determined by the patchiness of rock habitat with a goal of collecting at least 3 km of aggregated rocky habitat within a site. Transects were designed to be oriented parallel to general depth contours, though they were carried out using a fixed bearing that crossed depths in some cases. Species encountered by the ROV along the transect were identified to species or lowest taxonomic grouping possible with a forward facing camera and fish size was captured with stereo cameras (stereo cameras were implemented beginning 2014). A brief description of the different tables available can be found on Page

Spatial Distribution of Sampling

The ROV data sets were derived from surveys designed to monitor changes in species density due to protection by California's marine protected area (MPA) network. An index site sampling design was developed by CDFW and MARE, selecting fixed sites inside and outside MPAs with similar habitats to detect changes over time attributed to fishing prohibitions. Each site consisted of a rectangular survey region 500 m wide, with the length varying based on the local extent of the rocky reef. Random systematic sampling was employed, starting from a random point in the deeper end and deploying equally spaced transects across the area, aiming for 4 km of linear transect to ensure sufficient statistical power to detect density differences between protected and reference sites. The number of survey lines (4 to 10) per site depended on local reef characteristics, with more lines needed for areas with sparse, patchy habitats or wide depth ranges. An example of the spatial positioning sampling grids and orientation of transects with bathymetry is provided in Figure 1.

Depth Data

The predominant depth range sampled in this survey is less than 150 meters, which encompasses the depth distribution of nearshore rockfish species allowing both indices of abundance and estimates of abundance to be estimated. Schooling species that are semi-pelagic (i.e. black rockfish, blue rockfish and canary rockfish) present difficulties as a result of variable detection probability given that the ROV focuses on the seafloor. Demersal species that are not cryptic and do not exhibit strong avoidance thus evading detection are good candidates. If you are interested in more details regarding previous analyses, specifications or equipment used by the MARE ROV, see the 2020 California ROV Methodology Panel Review Document.

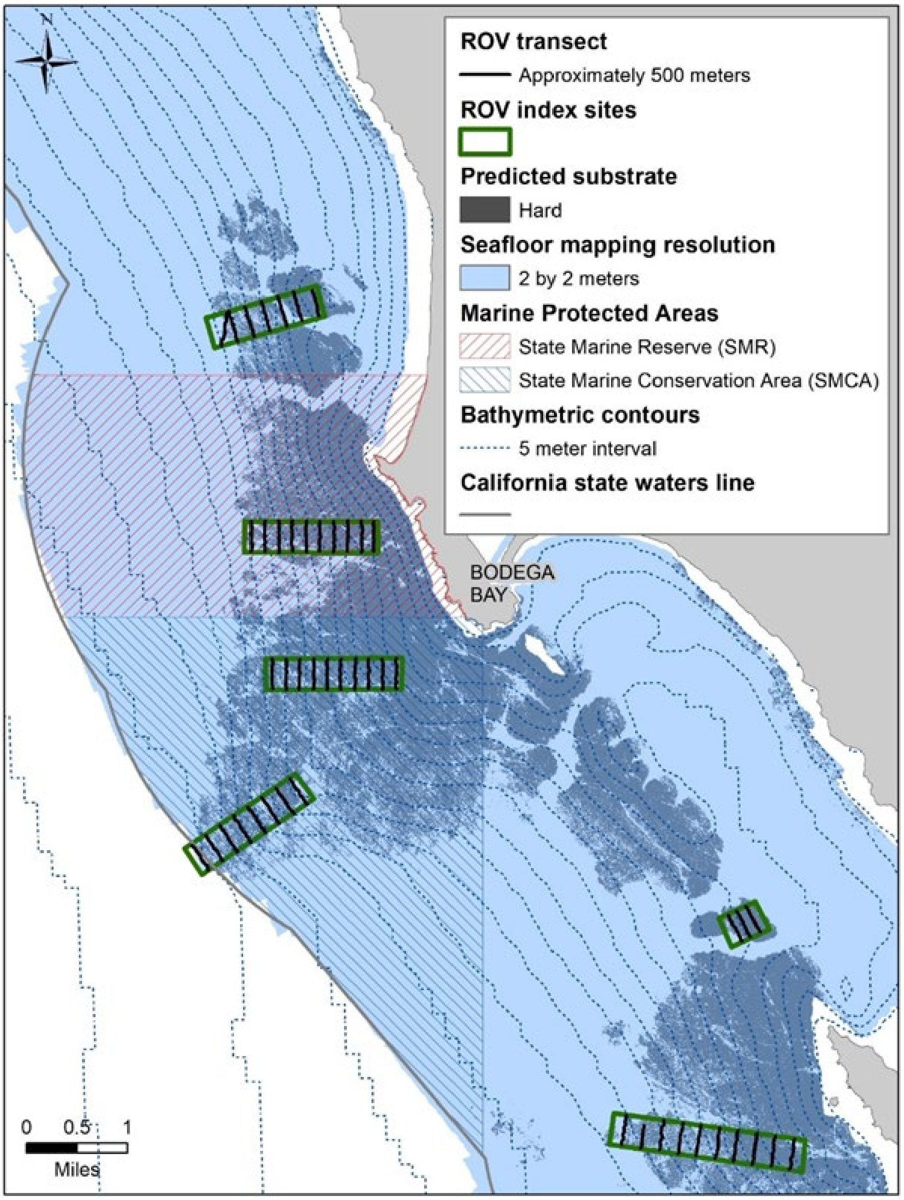

Figure 1. Depiction of the sampling design showing the boxes that identify sampling locations over hard substrate and the 500 m transect lines oriented to align with bathymetry contours and other features pertinent to the study.

Figure 2. Sample locations for the California ROV sampling project.

Data Caveats and Methodological Background

Accuracy of Location Tracking

Positional data is generated from an acoustic tracking system located on the ROV. Acoustic tracking systems generate numerous erroneous positional fixes due to underwater acoustic noise and vessel movement that is not adequately compensated for by the tracking system pitch and roll sensors. For this reason, the positional data is manually cleaned of large outliers then averaged (i.e., 21-position running mean created by averaging of ten (X,Y) values before and after every position (Karpov et al. 2006)). The spatial error of an ROV observation point is estimated to be between three and six meters.

Gaps in Positional Data

It should be noted that gaps in the positional data exist due to deviations from quantitative protocols, such as pulls (ROV pulled back by ship induced tension on the umbilical), stops (ROV stops to let the ship catch up) or loss of target altitude caused by traveling over the back side of high relief structures (visual loss of 4 m target distance measured by the forward facing ranging sonar for more than 6 seconds which typically occurs on the downward slope of high relief habitat). Unusable microframes, which are data points that resulted from stops, pulls, back sides, or any other event that renders the observation unusable, were excluded when grouping data for the transect level data. These gaps are flagged in the datasets with the Unusable_Data and UnusableFish_Area fields.

Spatial Units

In addition to transect level data, the most recent data set is aggregated at a 10-meter resolution. The 10-meter resolution was selected for further exploration of a higher resolution of data with the potential for application with terrain attributes derived from the California Seafloor Mapping Program at the native 2x2 m resolution at which the data is collected as opposed to averaging across a more aggregated resolution with the 20-meter resolution data used in the methodology review. The 10-meter resolution data also allows a higher resolution analysis of depth as the transects are run on a bearing approximating the depth contour on paper rather than following a fixed depth. This also allows for a higher resolution analysis with seafloor composition of aggregated soft, mixed or hard substrate categories or alternatively mud, sand, gravel, cobble, boulders or rocky reef categorizations for correlation with individual fish positions using methods described further in the methodology review document. The 10-meter resolution is also consistent with the home range of many demersal Sebastes and was undertaken for evaluation of MPA effects (Perkins et al. 2024). Spatial autocorrelation was evaluated in the INLA package and found to have low to moderate spatial standard deviation on a scale of 8 to 12 km in the copper rockfish study.

Substrate Determination and Scoring

A protocol was developed to characterize substrate types along survey transect lines, enabling the computation of area coverage for individual substrates or combinations at varying scales for different analyses. Substrates were classified from video footage into rock, boulder, cobble, gravel, sand, or mud, with each type defined by specific size and material criteria. These were recorded as discrete segments of transects, with a segment considered continuous unless interrupted by at least two meters or the substrate coverage dropped below 20% over a three-meter distance. Substrate data were further categorized into three habitat types (hard, mixed, or soft) and recorded for every microframe in the database, providing flexibility for creating additional habitat categories or analyzing ecotones between substrates. The 10 Meter Subunit ID Summary data set and the Transect ID Summary data set contain both classifications - the rock, boulder, cobble, gravel, sand, or mud classification and the broader hard, mixed, or soft classification. The length data set and the Fish 1 Second data set both only contain the broader hard, mixed, or soft classification.

Water Clarity Assumption

Water clarity is a factor in determining whether sampling can be conducted on a given day. Threshold levels have been established to ensure that field of view or visible distance into the foreground does not affect detection probability. It is difficult to account for behavioral differences within the range of clarity that are suitable for sampling, as a result behavior affecting the probability of detection was previously assumed by CDFW to be unaffected. It is uncommon to experience sufficient frequency of sampling or variation in clarity at a given location to allow for examination of changes in habitat preference with water clarity at a site level.

Fish Scoring and Enumeration

Fish viewed within the forward video were classified to the lowest taxonomic level possible. Individuals that could not be classified to the species level were grouped into higher taxonomic levels or a complex of visually similar species. Using the sonar range, fish enumeration was restricted to a maximum distance of four meters to avoid missing fish being obscured by objects in the foreground or their shadows at greater distances adversely affecting the ability to accurately identify fish. A transparent screen overlay with lines representing a diminishing perspective was used during fish review to approximate the three dimensional transect extending away from viewing screen. Fish that entered the viewing area were only counted if more than half the fish crossed the overlay guidelines.

Time Code entry

To accurately correlate the location of the fish with habitat, timecode entry was made when the fish crossed the mid-screen line. For fish that were within four meters but swam away before they crossed the mid-screen line, timecode entry was made when the location where the finfish had been observed reached the mid-screen point. Time stamps are available to the one second resolution.

Height off Bottom

Concern was initially expressed at the 2020 Methodology review regarding ROV height-off-bottom (HOB) because it is related to measurement error, it is directly related to transect width, and because it may be influential on the species-specific probability of detection. Upon investigation, correlations between HOB and density (fish/m^2) and between HOB and habitat were found to be the result of the necessity to fly the ROV higher off the bottom to avoid high relief habitat such as pinnacles. The HOB and density relationship is due to the preference of the subject species for more complex habitat rather than any bias. Thus, apart from behavioral interactions with the ROV, it is likely that detection probability is greater at lower HOB (narrower transect width) despite the higher densities at greater HOB observed as a result of correlations resulting from operating logistics requiring greater height off of bottom associated with the rocky reef habitat that the species of interest are associated with.

The transect width during surveys was constrained to a minimum of 0.5 m due to the camera arrangement on the ROV, with a target width of approximately 1.5 m at a height off bottom (HOB) of 0.3 m. The width was restricted to a maximum of 3.4 m by maintaining the target HOB and filtering out data where the sonar exceeded 4 m for more than 6 seconds. This protocol aimed to balance the need for wider coverage with maintaining image quality for species identification, minimizing bias from detection probability differences. Testing for correlations between species density and "backsides" (loss of seafloor sight due to high relief) showed few significant correlations, suggesting that the omission of "backsides" from transect segments did not significantly affect detection probability. The number of “backsides” for each transect or segment is provided in the density data sets to provide a variable for seafloor relief.

Unusable Data Resulting from Backsides of High-relief Areas

ROV observation points representing backsides of high-relief areas are flagged as unusable in California’s ROV dataset when the forward ranging sonar exceeded 4 meters for more than 6 consecutive seconds. The 20-meter segments used for California’s analyses were generated by grouping consecutive ROV observation points (both usable and unusable) until the resulting segment was 20 meters in length. After the data points were grouped into 20-meter segments the unusable data points were removed from the 20-meter segment meaning that these data points did not contribute to the surveyed area or to the counts of fish observed. If removal of unusable points resulted in a segment length was less than 12 meters (60% of potential segment length) then the segment was excluded from subsequent analyses. For comparison, Oregon's methods indicate that less than 10 meters squared was the threshold used for exclusion of short segments. California's 12-meter threshold translates to approximately 25 meters squared. This method mitigates against the potential for very high fish densities due to small segments. It should be noted that removing unusable data from transects may have an effect of increasing the density of fish (i.e., fish density and usable area may be negatively correlated).

Evaluation of Variable Detection Probability

The following methodologies help mitigate variability in detection probability: Video collected data was only used for density calculations when visibility was sufficient to view the entire video field of view at least 2 m in front of the ROV; implementation of a constant speed for transects and use an autopilot thruster control to smooth the flight of the ROV and reduce pilot tendency to drive erratically or slow down to view fish or speed up during boring stretches; during the course of a transect, the angle of the ROV camera relative to the substrate was adjusted by the pilot to maintain an oblique field of view with the horizon slightly below the top of the viewing area thereby insuring that fish behaving evasively in front of the ROV could be detected. The vast majority of demersal rockfish were found to be relatively unresponsive (MARE personal communication).

Description of Data Sets

Overview

Four data sets are provided from the ROV surveys, post data processing in MS Access. They are described as 10mSubunitID_Summary, Fish1sec, TransectID_Summary, plus the length data. For all data sets, the count for the number of fish may not be whole numbers if more than one fish is observed since there is a process of extrapolating back to 1 second observations and ascribing fish to an interval when more than that were observed in the 1 second data set. Table 1 describes the fields of the 10 m segment and transect summaries in more detail.

10 Meter Subunit ID Data Set

This data set provides a summary of observations made within 10-meter segments of each transect. Each row represents a 10-meter segment and contains various covariate/categorical data including, temperature, location information, bottom type, survey year, and site information to name a few. Fields are provided that describe data that is unusable for reasons described previously. In this data set, bottom type is described in detail (i.e., rock and cobble distances are provided along with the corresponding "Hard" habitat type.)

Transect ID Summary Data Set

This data set is similar to the *10 Meter Subunit ID* data set, however all data is provided at the transect level versus the 10 meter subunit level.

Fish 1 Sec Data Set

In this data set each row represents an observation of each fish. This data set provides more detail as to the exact location of each fish. This means it can be used to evaluate specific observations at a higher resolution. Although individuals are not identified at lower resolutions to allow cross comparisons, the 10 Meter subunit is provided to match which subunit this fish was observed.

Only the hard, mixed, and soft substrate classification is used in this data set.

Length Data

Each row in the length data set represents an observation of a fish. The Stereo Size field indicates the fish's length in centimeters as estimated from the ROV stereo-cameras. This dataset also contains information on project details, survey implementation, species-specific information such as common name and scientific name, geographic coordinates, habitat types, and environmental variables, as well as unique identifiers and notes relevant to each observation. The Stereo size cannot be tied 1 to 1 to fish observed, since there can be more than one fish in the vicinity making assigning lengths to a specific fish counted difficult. Lengths can be converted to weights using the length-weight relationship from the most recent assessment or appropriate references.

Table 1. Descriptions of the columns provided in the ROV dataset (length data set excluded).

Field_Descriptions	
Name	**Description**
10mSubunit_ID	Unique identifier for individual 10 m subunits [Project]_[LineID]_[SubunitNumber]
Analysis_Sites	Sites used in MPA long term monitoring
Avg_Depth	Average ROV depth [Meters]

Avg_Heading	Average magnetic heading of ROV [Degree]
Avg_Lat	Average latitude in decimal degrees for a segment or series of points where the observation was made. Precision to 5 decimal places. Geographic Coordinate System WGS 84
Avg_Lon	Average longitude in decimal degrees for a segment or series of points where the observation was made. Precision to 5 decimal places. Geographic Coordinate System WGS 84
Avg_Temperature	Water temperature (Degrees Celsius) measured by the ROV.
Avg_X	Average of processsed data for the x-coordinate in UTM zone 10N, WGS 84 (Karpov et al. 2006)
Avg_Y	Average of processsed data for the y-coordinate in UTM zone 10N, WGS 84 (Karpov et al. 2006)
Backsides	Backside (forward range greater than 4 m or less than 0.5 m for greater than 6 seconds)
Boulder	Rocky substrate larger than 25 cm in diameter that is detached and clearly movable
Coarse_Size	Total length of the fish species observed in centimeters. Length estimated using lasers as a scale
Cobble	Rocky substrate that is 6 to 25 cm in diameter
CommonName	The common name for the species
Count	Number of animals in this observation
Depth	Positive value used to express the ROV depth (meters)
Designation	Site designation: MPA, Reference or other
Dive	ROV dive number (project based)
Gravel	Granular rocky material that is 0.5 to 6 cm in diameter

Habitat_Type	Habitat classification as dictated by presence of only hard substrates (rock and/or boulder), a mix of substrates (both soft and hard habitat) or soft substrates (unconsolidated habitats comprised of mud, sand, gravel and/or cobble substrates)
Hard_Area	Total area of rocky habitats comprised of rock and/or boulder substrates [m2]
Hard_Distance	Total distance of rocky habitats comprised of rock and/or boulder substrates [m]
Implementation Year	Year the specific MPA protection was implemented
Implementation_Region	MPA implementation region: north, north central, central or south
Lat	Latitude in decimal degrees where the observation was made. Precision to 5 decimal places. Geographic Coordinate System WGS 84
LineID	Unique identifier for each line (Dive_Line)
Lon	Longitude in decimal degrees where the observation was made. Precision to 5 decimal places. Geographic Coordinate System WGS 84
LongTerm_Region	MPA monitoring region: north, central or south
Max_Depth	Positive value used to express the maximum depth of the observation
Min_Depth	Positive value used to express the minimum depth of the observation
Mixed_Area	Total area of habitats comprised of both soft habitat (mud, sand, gravel and/or cobble substates) and hard habitat (rock and/or boulder substrates) [m2]
Mixed_Distance	Total distance of habitats comprised of both soft habitat (mud, sand, gravel and/or cobble substates) and hard habitat (rock and/or boulder substrates) [m]

MPA_Group	The particular SMCA or SMR within the location, e.g. Farnsworth Offshore SMCA (off the coast of Catalina Island)
Mud	Very fine sediments that stay suspended in the water when disturbed (loss of visibility)
Note	Notes
Project	Project identifier and year of the specific cruise the data was collected on
Rock	Consolidated rocky substrates that appears attached to the bottom and not movable
Sand	Granular material that is mostly free of fine sediments that do not stay suspended in the water when disturbed
ScientificName	The scientific name or taxonomic grouping
Sec	Cumulative sec from 1/1/2000. Calculation Formula in MS Access: DateDiff("s","1/1/2000 12:00:00 AM",[SurveyDate] & " " & [TC])
Sex	M (male), F (female), T (transitional), J (juvenile) or U (unknown)
Site	The specific survey location the data was gathered
Soft_Area	Total area of unconsolidated habitats comprised of mud, sand, gravel and/or cobble substrates [m2]
Soft_Distance	Total distance of unconsolidated habitats comprised of mud, sand, gravel and/or cobble substrates [m]
Survey_Date	Survey Date: month/day/year (UTC)
Survey_Year	Year the survey was completed
Taxserial	ITIS unified taxonomic serial code of fish or invertebrate or fish observations. If no ITIS number, then in-house numbers generated (less than 6 digits)
TC	Timecode of observation (UTC)

Total_Area_Fish	Total area covered by ROV travel from start to end (sum of (Xydist x Width_Midscreen) as calculated at middle of viewing screen for each second) [m2]. (UsableArea_Fish is the preferred offset/denominator for density analyses)
Total_Area_Inverts	Total area covered by ROV travel from start to end (sum of (Xydist x Width_Bottomscreen) as calculated at bottom of viewing screen for each second) [m2]. (Usable_Area_Inverts is the preferred offset/denominator for density analyses)
Total_Xydist	Distance from start to end in meters (sum of DistancePerSecond for transect)
Transect Line	Survey line number
TransectID	Additional ID of the observation = [Project]_[LineID]
Type	Type of MPA Group: SMCA, SMR, Reference or other
Unusable_Data	Data that cannot be processed due to backside, off bottom, stop/pull/off transect, and/or no habitat
Usable_Xydist	Distance data that can be processed (i.e. not a backside, off bottom, stop/pull/off transect, or no habitat) [m2]
UsableArea_Fish	Area data that can be processed (i.e. not a backside, off bottom, stop/pull/off transect, or no habitat) [m]

Recommended Data Processing Steps

In addition to the MS Access Database, three Excel data sets are derived from it including lengths, transect, and 10 m segment data sets. The latter two are the result of merging the habitat observations and fish observations from the MS Access database. Additional variables are added in the following steps.

1. While an SQL Server approach has been developed to process the 1 second interval observations into larger segments allowing analysis at any resolution from 1 second to the full transect, a length of 10 meters has been selected for high resolution analysis in addition to the full transect length. The MS Access file containing the data-base provides separate files for the fish counts at 1 second intervals,Transect and 10 m ROV habitat observation data.

2. The observations and fish counts must be merged by first creating a crosstab query (Fish1_sec_Crosstab) with the year and either transect ID or subunit ID in the rows and common name in the column and the sum of counts in the body of the columns for each species seen in the Fish_1sec_Crosstab 10m or Fish_1sec_Crosstab Transect queries. Run this query, then merge the resulting file with the observation data in the TransectID_Summary or 10mSubunit_Summary tables to provide a working data set as seen in Merge 10 m -Counts or Merge Transect -Counts queries.
3. Export the resulting file to excel for further processing and reduction to suit the needs of your analysis.
4. Add variables for distance from port derived from GIS analyses for each segment or transect in ArcGIS to align it with the appropriate segment or transect data for counts and habitat data .
5. Sort by Survey Year, create a new column and add the super year in the field heading, then paste 2020 for years 2019-2021 and 2015 for years 2014-2016. The years preceding 2014 are not associated with a statewide coverage and thus do not receive a super year, though limited regional analyses may be possible further back in the time series.
6. Insert four columns to the right of the Soft Distance variable and calculate the proportion of hard, mixed, mixed/hard and soft habitat using the corresponding distance data to provide a variable that captures reef habitat characteristics along the transect.
7. Add in variables for protection open to fishing (0) and closed to fishing (1) using external tables of protection in each site. In a new column use the vlookup function to reference the table with the site and corresponding protection level to fill in the new column with zeros and ones corresponding to protection. An N/A in the Designation field indicates that this is a site that is not protected and also is not matched with a specific MPA site for pairwise analysis.
8. Add a new column to the right of protection to calculate the years of protection, subtracting implementation year from protection year. The following conditional statement provides calculation IF(Protection=0,0,Survey Year-Implementation Year).
9. Add a column and add depth squared to provide a non-linear relationship for analysis.
10. NMFS Filters: North or South of Point Conception, Upper and Lower 95% CI removed (may not be needed with transect level data set), remove depths greater and less than their distribution or poorly sampled (19-100 m were used for copper), MPA/Reference Transects Removed to provide either or only.
11. Perform filtering to ensure comparability over time, removing sites not consistently sampled between time periods of interest including Anacapa Island

Reference Area in the South as well as N. Farallon Islands Reference Area and Piedras Blancas Reference Area in the North.

12. Convert NA values to zero in fish count columns before analysis to make use of as many segments or transects as are available.

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