Oregon Department of Fish and Wildlife Video-Hydroacoustic Survey Methodology Review and

Washington Department of Fish and Wildlife Hook-and-Line Survey Workshop Report

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Introduction

A review of visual-hydroacoustic survey methods for semi-pelagic rockfish and associated data analyses developed by the Oregon Department of Fish and Wildlife (ODFW) and a workshop on the Washington Department of Fish and Wildlife (WDFW) hook and line survey activities was conducted remotely on September 27 to 30, 2022. The purpose of the Pacific Fishery Management Council (Council) methodology review meeting was to evaluate and review fishery independent visual-hydroacoustic survey methodology for nearshore groundfish species off the state of Oregon (with the potential to guide future surveys in California and Washington coastal waters). The goals and objectives specific of the review of the visual/hydroacoustic survey methodology is to: A) evaluate the sampling design used; B) evaluate proposed methods to develop indices or estimates of abundance from the survey, including the use of potential covariates; C) evaluate proposed methods to estimate size/age compositions of observed individuals of each species; and D) identify potential impediments to developing independent indices or estimates of abundance using the survey and incorporating them into stock assessments. The topics were as follows: (1) Data collection and survey design; (2) Data processing; (3) Producing population estimates; and (4) Future directions and use in stock assessment.

The workshop focused on the WDFW hook and line surveys to provide recommendations on survey designs of rod-and-reel surveys for nearshore groundfish species and setline survey for yelloweye rockfish, and to identify future research and data needs. Recommendations on the use of the survey data in assessments coming from the workshop will inform accepted practices guidance.

West Coast nearshore groundfish stock assessments have identified the current lack of fishery-independent data sources as a research and data need, which the methodology review and workshop were intended to address. The Panel commends the proponents for their thorough documentation and presentations, and willingness to respond to Panel requests.

Oregon Department of Fish and Wildlife Visual-Hydroacoustic Survey Methodology Review

Dr. Leif Rasmuson and ODFW staff presented the methods for each facet of the survey including acoustic, visual, hook and line and incorporation of environmental variables in estimating biomass of semi-pelagic species with particular emphasis on black rockfish. The Panel discussed considerations, made requests to evaluate concerns and identified research and data needs for each facet of the survey. The resulting text provides guidance on further development and application of the proposed methods.

ODFW Acoustic Survey

Major discussion topics, including considerations, concerns and clarifications regarding implementation of acoustic methods include the following:

1. There is a need for in situ calibration of the acoustic systems used in this survey, though there is difficulty imposed by lack of deep water wharfs and sheltered areas on the Oregon coast for doing this. No immediate solution was provided. A solution may involve a trip on the survey

vessel to deeper calmer yet similar waters on the Pacific coast where calibrations can be done under more ideal conditions. There is nothing incorrect about the current calibrations done at the Biosonics facility in Seattle but it is difficult to know how closely they mimic the performance of the systems in situ during surveys from different vessels. A recommendation follows to further explore in situ calibration using a calibration sphere in waters of Puget Sound or Monterey Bay where waters are deep and conditions are mild enough to provide an accurate calibration.

2. It was discussed if the survey design was systematic or random. The survey is designed with transects occurring every kilometer. Every 15 km a transect is completed from the 80 m depth to the shore. The transects in between these transects with 15 km spacing are only sampled if they occur over hard habitat. The transects are clipped to only survey the rocky habitat (with a 500 m buffer). Since the initial position was randomly chosen the equal spacing can be regarded as quasi-random.

3. To ID species and get in situ length data, video drops were used. Spatial correspondence of acoustic and video measures was a key concern. It was stated that the time lapse between observations was short (7-10 minutes) and that in most cases there was a match between acoustic observations (aggregation, no aggregation, nothing much at all) and what the camera observed during the drop. During previous work, repeated transects observed similar distributions, supporting the notion that aggregations of these species are relatively stationary at the scales of measure used in this survey, making spatial correspondence less difficult.

4. Some concern was expressed about the use of directed and haphazard video drops (60/40). It was mentioned that this depends on how data are to be used, but for length data the 60/40 split was thought adequate. There is some chance of bias with focus on high density aggregations but the sample size is very large and the diverse sampling should counter any bias.

5. Use of 38 and 201 kHz transducers and impacts on integration and Target Strength (TS) models to be used to convert integrated power levels to fish density was discussed. This has changed from the earlier surveys reported in the literature when only a 201 kHz transducer was used as it was the only system available at the time. For the present survey a 10 degree 38 kHz transducer was used for integration and the 7 degree 201 kHz transducer for counting single targets, taking advantage of narrow pulse widths and beam pattern of the 201 kHz transducer. A narrower beam 38 kHz transducer would likely assist both integration (lesser dead zone) and potential in situ TS measures and using 38 kHz for integration is a better choice than using the 201 kHz transducer for several reasons.

6. A dead-zone correction is being made using straight linear extrapolation from above the near bottom exclusion zone into the exclusion zone is used (Echoview software deadzone extrapolation method). The panel questioned how much this changes the integrated densities. Data show that the proportions of the total backscatter are quite high, but no strong objection was made to including these estimates in the total estimates of numbers and biomass.

7. There was much discussion ofvarious TS models cited here and others (and the synthetic free slope recommended for Atlantic Redfish (mostly *Sebastes mentella*) in the ICES report) for

various species of *Sebastes* and using various methods (in situ, ex situ, modeling of swim bladders and whole fish). No easy solution was offered to this as there has been no research on local species or under local conditions. Use of models from other species and/or other environments (or no environment in the case of models) is not optimal. A need for research on TS of black and blue/deacon rockfish in the local environment was repeatedly emphasized. It was suggested, for the present analyses, that from a list of presently available TS-length models for *Sebastes*, those with relatively extreme standard equation b values be ignored, and those in the middle, namely Kang and Hwang 2003, Gauthier and Rose 2002, Gauthier and Rose 2003, and Hwang 2015 be averaged, with standard deviation calculated from those four points as well to represent the uncertainty of present knowledge. It was agreed that these statistics be used to scale the integrated backscatter from the survey. Inquiries should also be made to see if any additional research on rockfish TS has been done beyond what was presented at the meeting.

8. Use of video-determined density to compute a target strength model to compare to other TS-length models resulted in a very low b value in the standard 20 log TS-length model. In addition, correlations of video-reported densities and acoustic densities of the same schools were poor and far from a theoretical 1:1 relationship. It is not clear why this occurred and further thought and analysis should be applied, as it is possible that video and acoustic sampling and resultant statistics represent different volumes and/or different parts of the identified aggregations. For now, these comparisons are too poorly informed to be meaningful.

Visual Survey/Underwater Camera System

Visual data was collected using the Benthically Anchored Suspended Stereo Camera (BASSCam) system, consisting of a forward facing stereo pair of cameras and a third downward facing camera which rests two meters above the sea floor when deployed. When a school was observed from the acoustic signal, the ship would turn around and deploy the BASSCam system which would be released at a location so that it would come to rest within the fish school. Time from observation of the school and deployment of the BASSCam was on the order of 10 minutes. The BASSCam was also deployed when some acoustic signals could not be easily identified as seen, and also at random locations (for about 40% of the drops). A video drop was conducted at every hook and line station.

The system was originally deployed for two minutes. However, deployment time was increased to four minutes due to the observation of a startle response not seen in the pilot study. This is potentially due to low light and oxygen conditions during a portion of the survey, such that the longer time allowed for more likely return to similar to pre-drop fish distribution. Camera information is used to determine proportions and length, not for absolute counts.

A previous study found that video transects on the order of an hour apart saw essentially the same fish, while over days and even weeks the same schools were in generally the same location, while their characteristics might change somewhat. The researchers have also tried taking video at the same time as collecting acoustic information. This does not appear to affect acoustic collections. Video shows that the target species do not move much, even in the presence of predators.

BASSCam stereo camera systems 3D calibration was conducted in a pool using a 3D calibration cube and scale bars at varying distance and orientation from camera, and these are checked against the software used to measure fish. Measurement error, precision, and root mean squared error (RMSE) values must meet calibration standards.

One approach for conducting species counts is to use, for each drop, the video frame with the maximum individuals observed, termed the MaxN approach. However, identifying this frame can be quite time consuming when there are large numbers in multiple frames. The MeanCount approach, taking the mean count of each species across multiple randomly sampled frames, provides similar species proportions with less review time and was therefore used. This involved sampling each selected video every five seconds for the duration of the drop.

Lengths were measured for five randomly sampled frames. Where the uncertainty in the measurement for a fish in a selected frame, as measured by the RMSE, was greater than 10 mm, another attempt at measurement was made. Lengths with associated RMSE values greater than 20 mm were not included. Length measurements from fish angled at over 30 degrees relative to the plane of observation were avoided, though if they were the only option attempts were made to provide a measurement, and none of the 19 such measurements had RMS values of concern (e.g., > 10 mm).

It is generally difficult to distinguish blue rockfish from deacon rockfish on the video recording, thus most were recorded as blue/deacon rockfish. In those cases of positive identification of a blue rockfish, however, the fish would be identified as a blue rockfish. Instances of positive deacon rockfish identification were not noted. Blue/deacon rockfish were seen proportionally less often in the downward facing camera as they tend to be higher in the water column.

To evaluate target strength relationships, paired acoustic and video observations of schools that occurred within ten meters of one another were used. The volumetric density of fish was calculated from forward camera observations and was compared to the conversion of the NASC of the associated school to density using different Target Strength to length relationships. Multiple models were assessed to determine what the best target strength-length relationship to use when converting NASC to density.

ODFW Hook-and-Line Sampling

Main objectives of the hook-and-line sampling are to construct length-weight relationships and growth curves. The length-weight relationships will be used to convert camera-based lengths and fish counts to biomass. Length and age data collected from the hook-and-line gear are not meant for constructing length and age compositions. The sampling protocol follows the NOAA/NWFSC Shelf Rockfish Hook-and-Line Survey. There are two stations sampled on a sampling day, the first station sampled around 10 AM and the second around 2 PM. There is no fishing if no school is observed.

Oceanographic Data (Conductivity, Temperature, and Depth)
Oceanographic data was collected on the larger survey vessel using CTD casts, which included a live feed readout of sensors for fluorometry, turbidity, and dissolved oxygen. A cast was done at the beginning of each day to inform the daily speed of sound calculations, and full transects were

sampled at 80 m, 60 m, 40 m, 20 m, and the shallowest possible depth. Casts were also done at other haphazard locations, and near the Yaquina Head Ocean Observatories Initiative (OOI) buoy whenever the vessel transited by the buoy.

Oceanographic data were ground-truthed against buoy observations. Strong agreement was observed between the temperatures recorded by CTD and the buoy at Yaquina head, with only one record that was observed to be very different. Salinity and oxygen concentrations also tracked the buoy well.

A speed of sound model was developed using a spatial Generalized Additive Model (GAM) to interpolate the speed of sound for the midpoint of each transect at a depth of 5 m. Each pass was modeled independently. These values were used in the calibration of the acoustics. The same spatial GAM approach was used to fit the near bottom oxygen data, which was categorized as normoxic (>=2.5 mg/L) or hypoxic (<2.5 mg/L)

Discussion and requests for data collection, processing, and target strength and biomass density estimates.

Request 1: Show the results of the calibration survey in an x-y plot for both frequencies (38 and 201 kHz).

Rationale: This will provide a stronger basis for evaluating the observed vs. predicted values.

Response from ODFW: A scatter plot of camera densities with their associated acoustic densities from the 38 kHz transducer are presented for eight b20 values (Figure 1). In each panel the acoustic densities are derived from different target strength models derived from either the literature (indicated references with dates) or a combination of b20 values (*Sebastes* Average and Andre Best Fit). *Sebastes* Average is an average of the b20 values from the 38 kHz transducer relationships reported in Kang and Hwang 2003 and Hwang 2015. Andre Best fit is based on a best fit regression suggested by Andre Punt during this review and presented in Request 4. Relationships show that, on average, densities were higher in the camera than they were in the acoustics. Reynisson 1992 and Gauthier and Rose 2001 were included in response to Request 5. Andre Punt’s recommended approach using the best fit was included in response to Request 4.

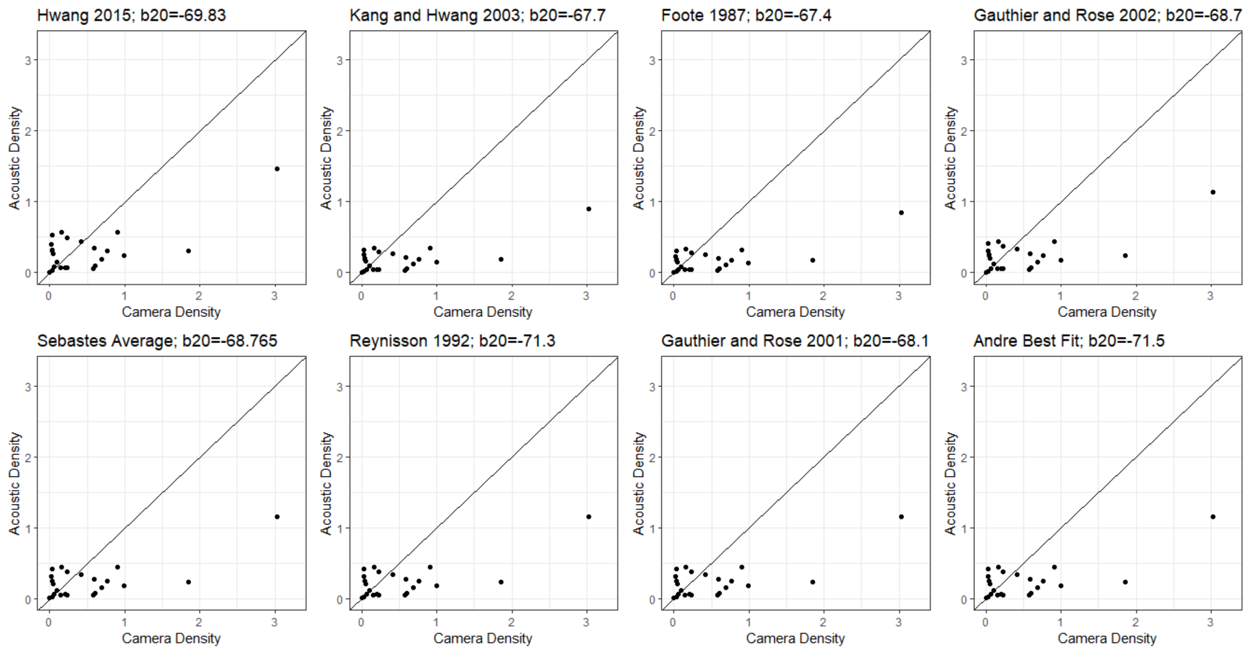

Figure 1. Comparing density from 38 kHz transducer to camera-derived densities using eight b20 values. These data were generated during the survey presently being reviewed (2021 statewide black rockfish survey).

A scatter plot of camera densities with their associated acoustic densities from the 200 kHz transducer are presented for four b20 values (Figure 2). These data were collected from a pilot study conducted before the survey (Rasmuson et al. 2021) being reviewed here but are presented for comparison.

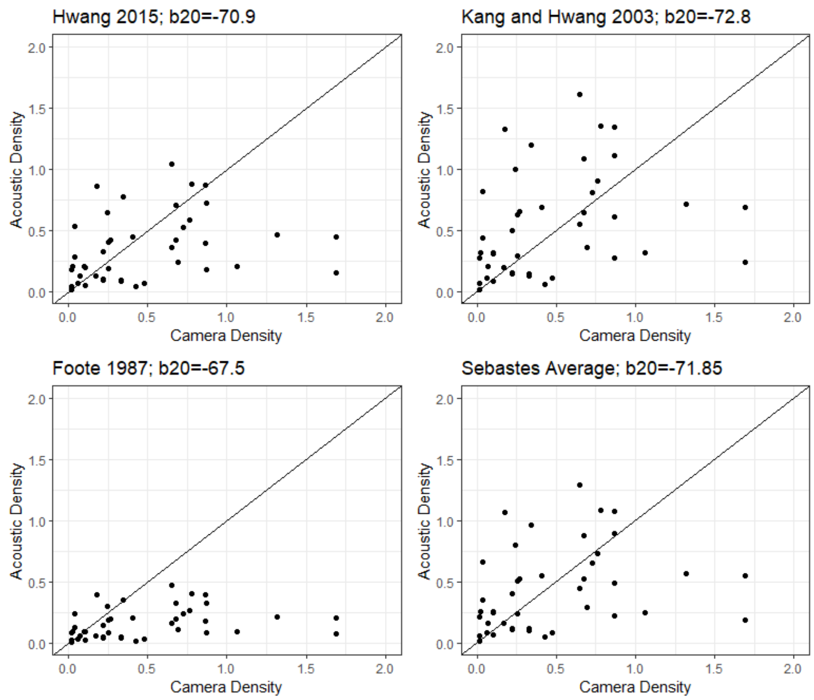

Figure 2. Plots from the 201 kHz transducer. These data were generated during the development of the Rasmuson et al. 2021 ICES paper.

Conclusion: The Panel discussed the relatively poor relationship between acoustic and camera densities, particularly when camera density was high. Less bias but more variability was observed with the 201 kHz transducer than with the 38 kHz, but neither shows a very strong positive correlation. There was some concern with the relatively few data points observed at higher camera densities as well as with the high variation in acoustic density observed under very low camera densities. One potential avenue discussed for more exploration was the role of the mean length of the fish and number of fish observed by the cameras, which would affect the target strength value applied. The Panel also suggested an additional alternative target strength model be explored to see if better correspondence between acoustic and camera densities could be obtained. The new alternative model (the 'free-slope' model) does not rely on the assumption of a fixed log-linear relationship between target strength and length. This resulted in requests 6 and 7 below.

Request 2: Provide a table of densities from the above exclusion zones using multiple target strength models.

Rationale: To understand the consequences of the choice of target strength models.

Response from ODFW: A table of pass 1 density estimates is presented summarizing black rockfish densities for the area above exclusion zone, in hard habitat. Data from Request 4 and Request 5 are included for completeness. All models take the form 20*log10(Length)-b20. It was noted during the discussion that Hwang 2015 was the 70 kHz value (-69.83) rather than the intended value from the 38 kHz (69.01). The correction has been made for both the Hwang 2015 and *Sebastes* Average in Request 9.

Table 1. Density and SD values associated with eight b20 values either directly from the literature, derived from the literature, or based on a best fit model described in Response 4. Density is calculated from data collected on pass 1, above the exclusion zone and in hard habitat only for black rockfish.

Paper	b20	Density	Standard Deviation
Andre Best Fit	-71.5	0.0415	0.113
Reynisson 1992	-71.3	0.0397	0.108
Hwang 2015	-69.83	0.0283	0.0771
Sebastes Average	-68.765	0.0221	0.0603
Gauthier and Rose 2002	-68.7	0.0218	0.0594
Gauthier and Rose 2001	-68.1	0.019	0.0517
Kang and Hwang 2003	-67.7	0.0173	0.0472
Foote 1987	-67.4	0.0162	0.044

Conclusion: Of these, the panel discounted the "Andre Best Fit" and Reynisson models as being less robust than the other alternatives and noted that even among the remaining models there is still a 30 to 50 percent difference between the values. An error was noted in a previous version of this table, which resulted in updating the b20 value from the Hwang (2015) study to the value presented here (see Request 9). An additional potential source of information on target strength was identified by the Panel and recommended for further exploration by the proponents (ICES, 2010). Moreover, the Panel strongly recommends further research be conducted in situ on an appropriate target strength - length relationship for black and blue/deacon rockfish.

Request 3: Provide example echograms showing the integrated values from both frequencies across a range of densities of schools.

Rationale: To better understand what is being seen by comparing the acoustic signature values (NASC values).

Response from ODFW: We have provided four echogram examples showing varying fish school densities and the corresponding increasing NASC values (Figures 3-6). We have also provided an example of single targets (Figure 7). Overall, school NASC values in the 38 kHz transducer are higher than those in the 201 kHz, which is likely due, at least in-part, to the larger beam angle of the 38 kHz.

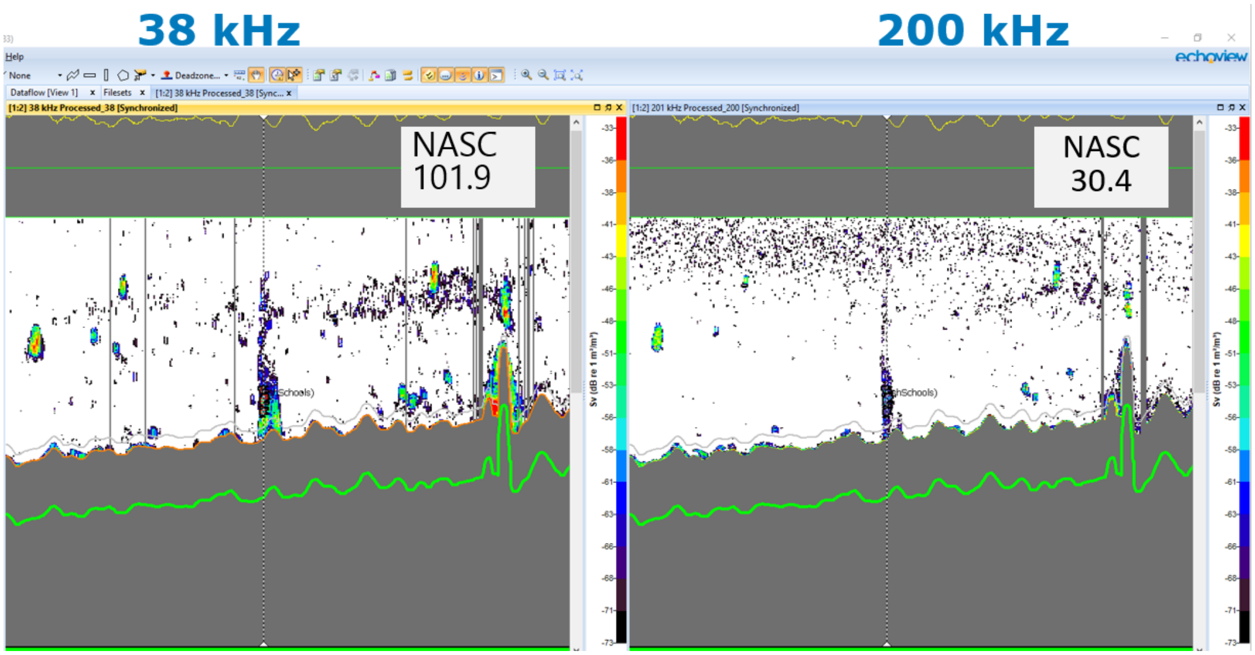

Figure 3. Low density example echogram; the integrated school is located next to the vertical dotted line.

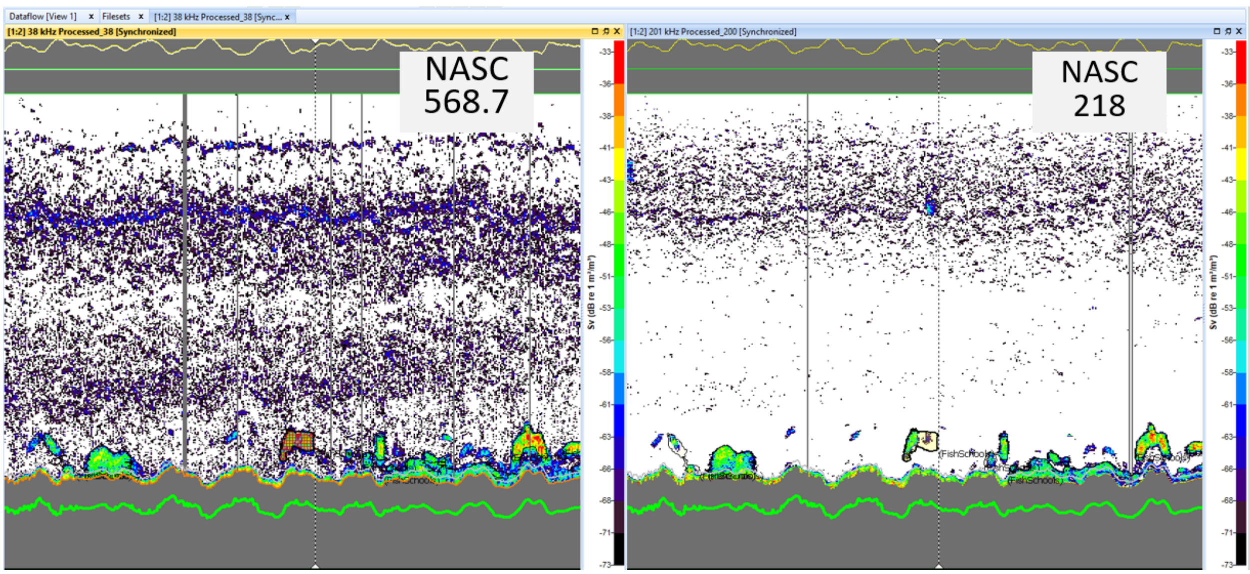

Figure 4. Low medium density example echogram; the integrated school is located next to the vertical dotted line.

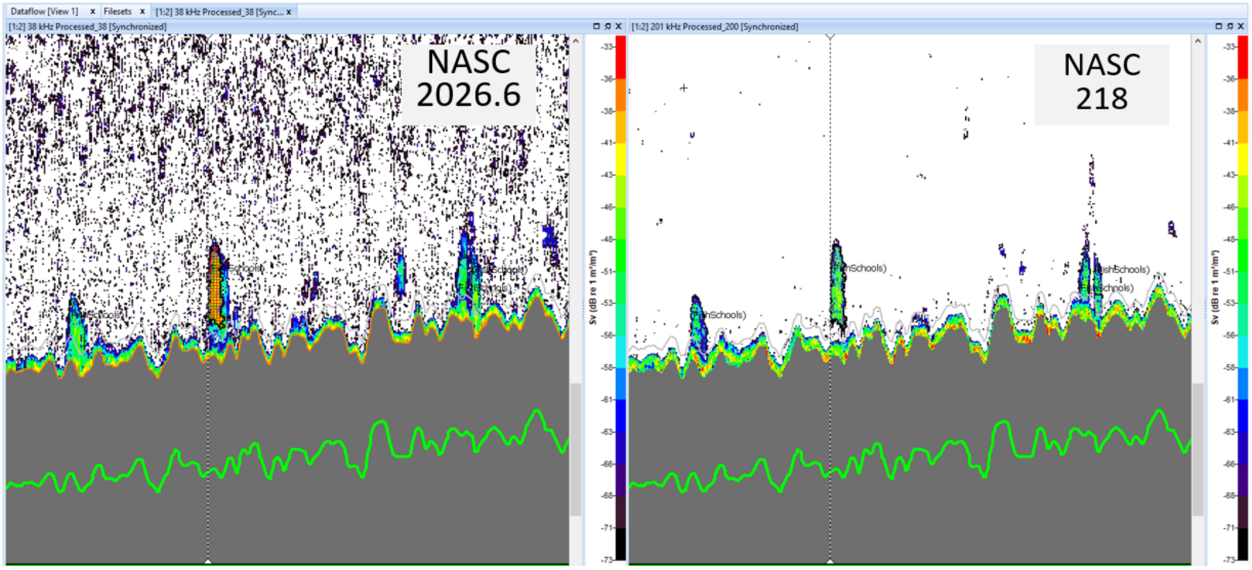

Figure 5. High medium density example echogram; the integrated school is located next to the vertical dotted line

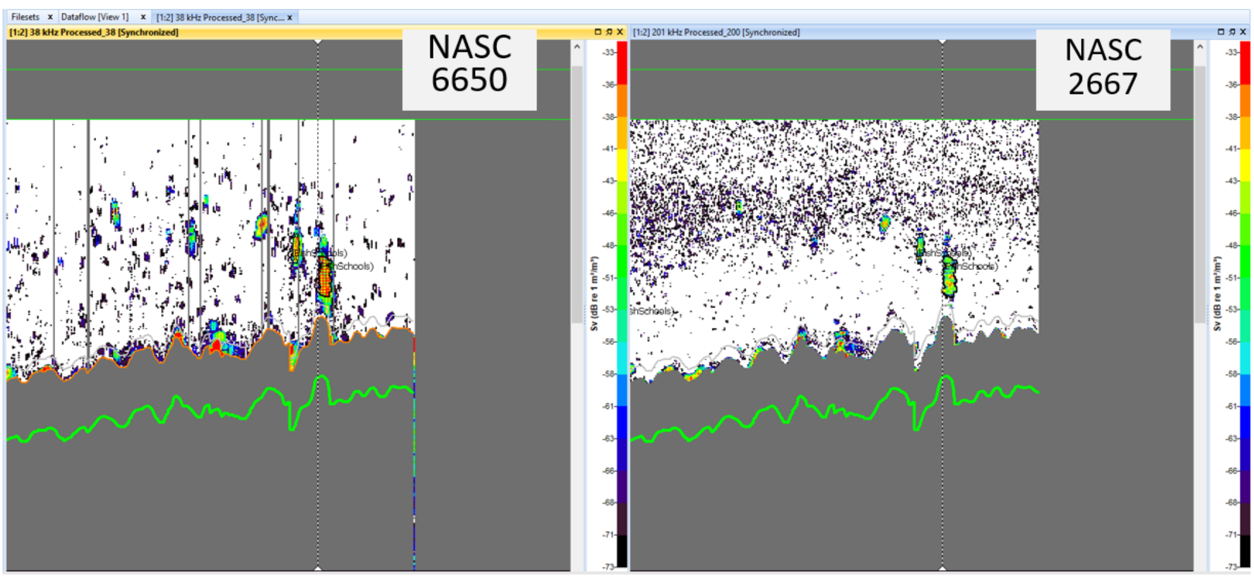

Figure 6. High density example echogram; the integrated school is located next to the vertical dotted line.

This comparison brought to light that it would be beneficial to measure the TS values of the individual fish targets (tracks) in the 38 kHz data.

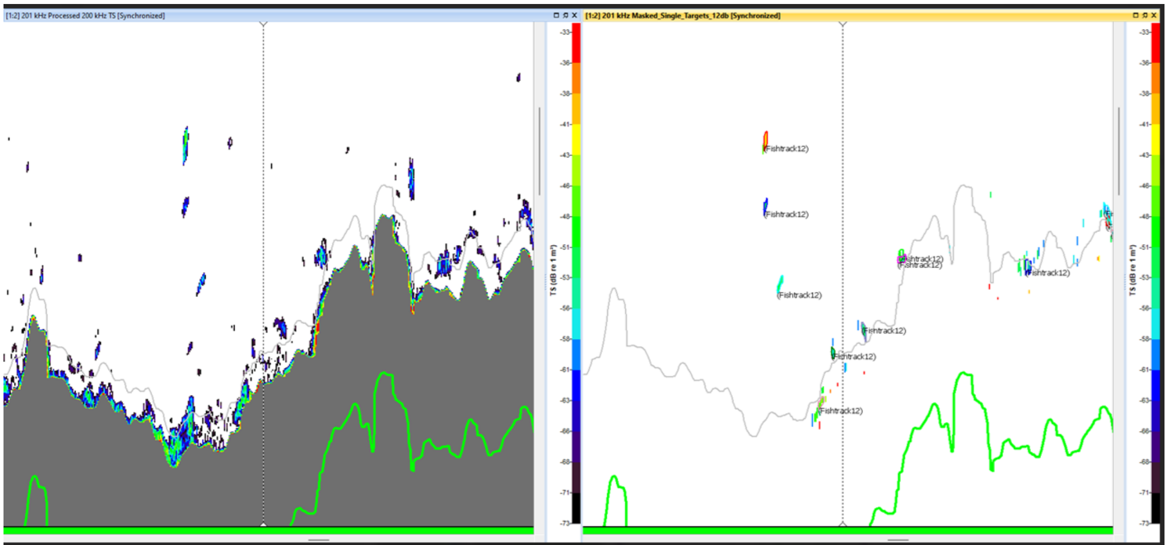

Figure 7. Example echogram, showing single targets in the form of fish tracks.

Evaluation of the association between data from the two transducers (38 and 201 kHz) visualized in x-y plots of the NASC and Sv values (Figure 8). NASC from the 201 are not equivalent to NASC values from the 38. The relationship is closer to 1:1 when visualizing mean Sv values. Differences from the 1:1 line in the Sv data may be due to pulse duration and frequency differences. This analysis brought to light the need for in-situ data collected from a Simrad narrow split-beam system that could be compared to the BioSonics data, which will be included in the recommendations for the future.

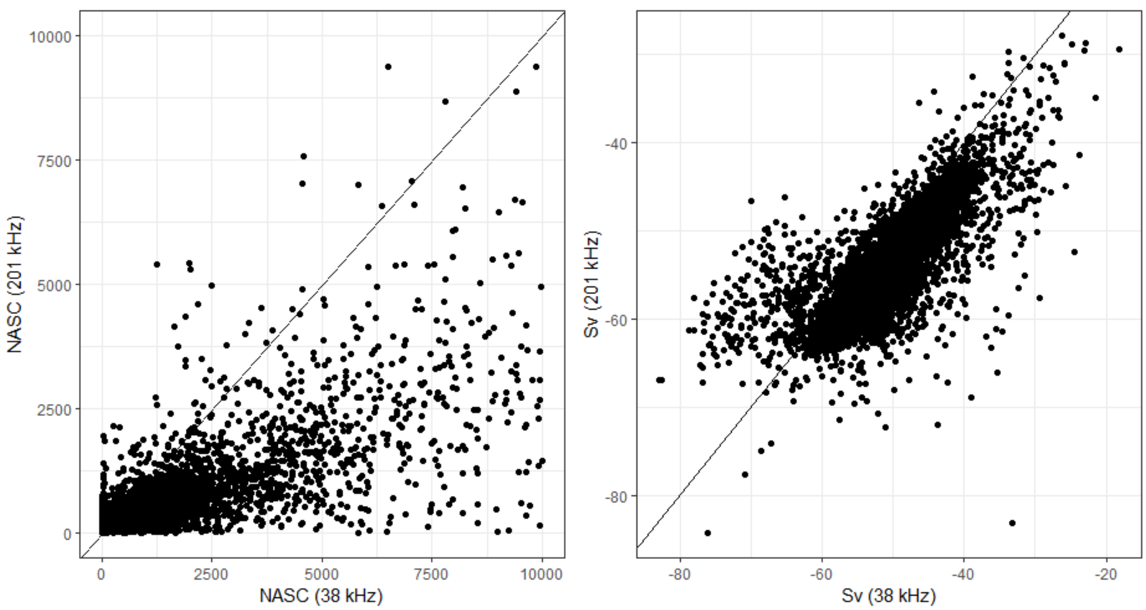

Figure 8. Comparison of NASC and Sv between the two transducers (38 and 201 kHz) visualized in x-y plots of the NASC and Sv values.

Conclusion: As identified by the proponents, given the higher NASC values and greater stability from 38 kHz transducer compared to the 201 kHz for the reasons described above, future research should work towards using the 38 kHz on single targets to better inform the relationship between fish length and target strength. Moreover, the survey would benefit from a split-beam system that would be more appropriate for these types of schooling rockfish.

Request 4: What is the best regression fit for the data in Request 1?

Rationale: To understand the best local target strength model.

Response from ODFW: We fit a range of hypothetical target length models (in the form 20*log10(Length)-b20) with b20 values ranging from -75 to -50 in 0.1 increments. We then compared the log likelihood to the goodness of fit to a 1:1 line to determine which of the models was the best fit. We identified a b20 value of -71.5. This model was named Andre Best Fit in Requests 1 and 2.

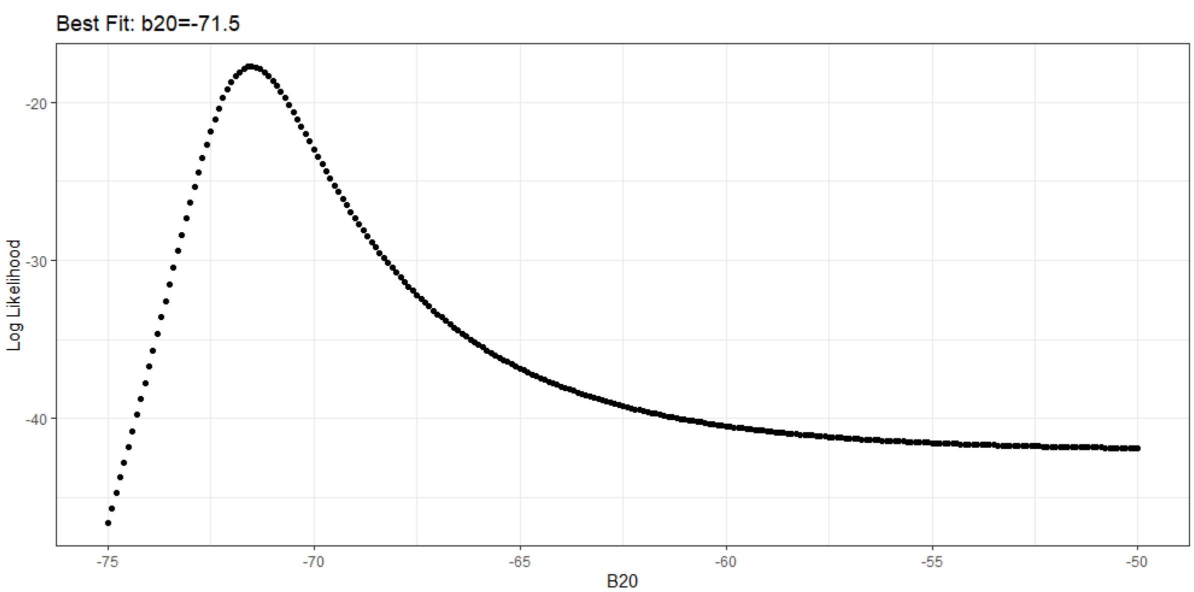

Figure 9. Best fit line created in response to Andre Punt's Request to compare in-situ and ex-situ b20 values with a hypothetical b20 value. This is known as the Andre Best Fit value in other responses in this document.

Conclusion: This best fit results in a lower value of b20 than those derived from the literature but should continue to be explored as a potential alternative in the remaining requests related to comparing target strength models.

Request 5: Review the ICES report and identify alternative target strength equations and ideally apply them to the calibration survey data in requests 1 and 2.

Rationale: To evaluate alternative target strength models.

Response from ODFW: We have reviewed the ICES report and have added b20 values taken from Gauthier and Rose 2001 and Reynisson 1992 (-68.1 and -71.3 respectively). The resulting x-y plots (Figure 1), and density (Table 1) are presented in responses to Request 1.

Conclusion: Consider these alternative target strength models in responses to Request 1.

Request 6: Plot residuals against mean length.

Rationale: To evaluate fits to target strength.

Response from ODFW: A selection of video drops that were associated with acoustically identified fish schools was made (n=26), and the mean length of fish observed in these drops was plotted against the density from the camera minus the density from the acoustics (Figure 10). An added LOESS line was typically above 0 indicating a higher density of fish in the camera than the acoustics but overall, lines were somewhat flat. No distinct trend was observed, suggesting residuals were not associated with length of the fish. We hypothesize the poor target strength to video relationship is not due to the use of mean length from the video data.

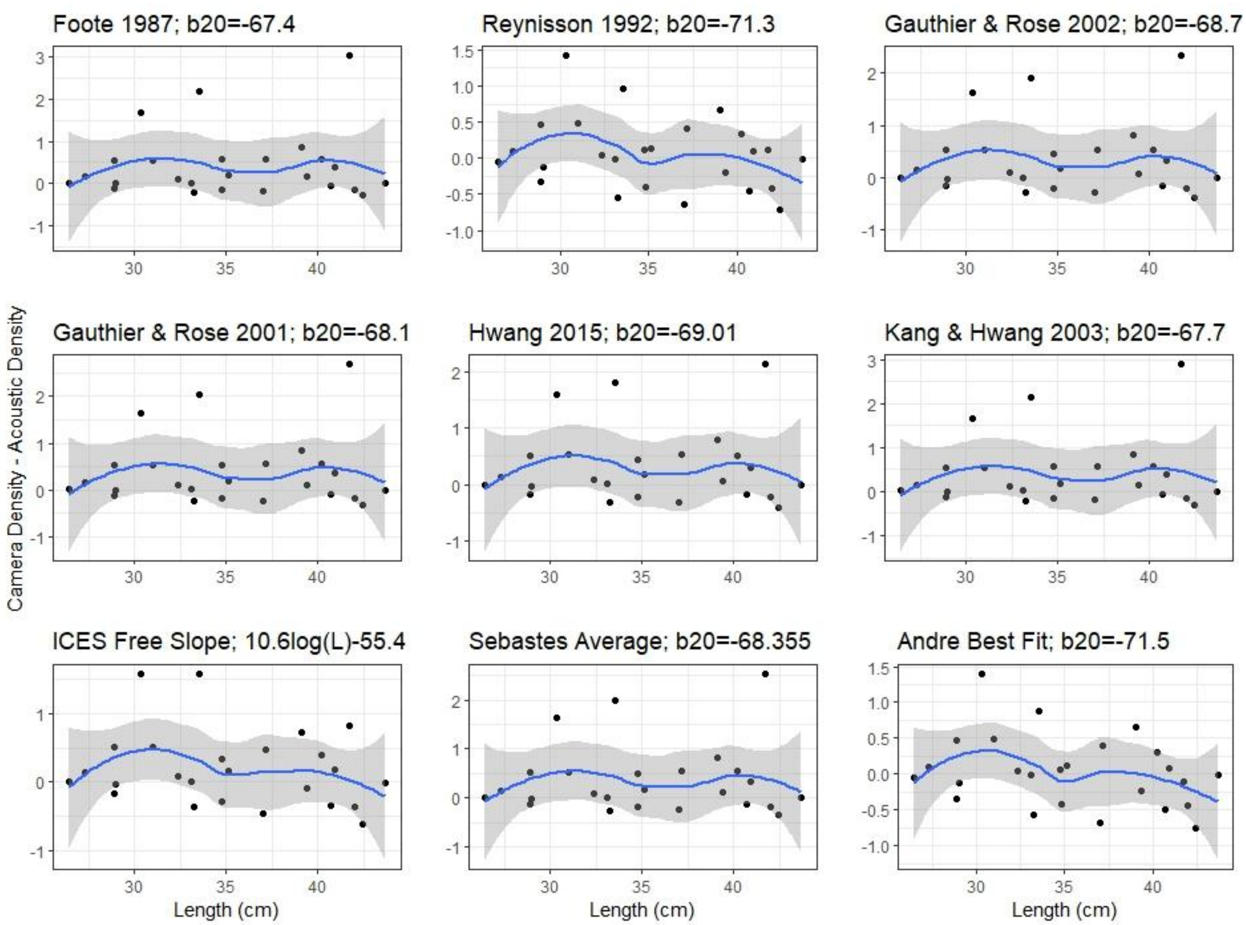

Figure 10. Mean length of fish observed in video drops conducted within 10 m of an acoustically observed school plotted against the residuals (density from the camera minus the density from the acoustics).

Conclusion: The panel agreed that the fish length does not appear to be the cause of the poor target strength to video relationship.

Request 7: Plot residuals against numbers of observed fish.

Rationale: Both mean length and numbers of fish contribute to bias and variation in camera-acoustics density estimates and this plot could help determine what is contributing to the fits.

Response from ODFW: The mean count of fish observed in the video drops associated with 10 meters of an acoustically identified fish school were plotted against the density from the camera minus the density from the acoustics (Figure 11). For most target strength length relationships, an initial rise in the difference was observed, followed by a flattening and then a final rise at the end. Although for the Reynisson and Andre Best Fit plots, the relationship remains relatively flat at higher densities.

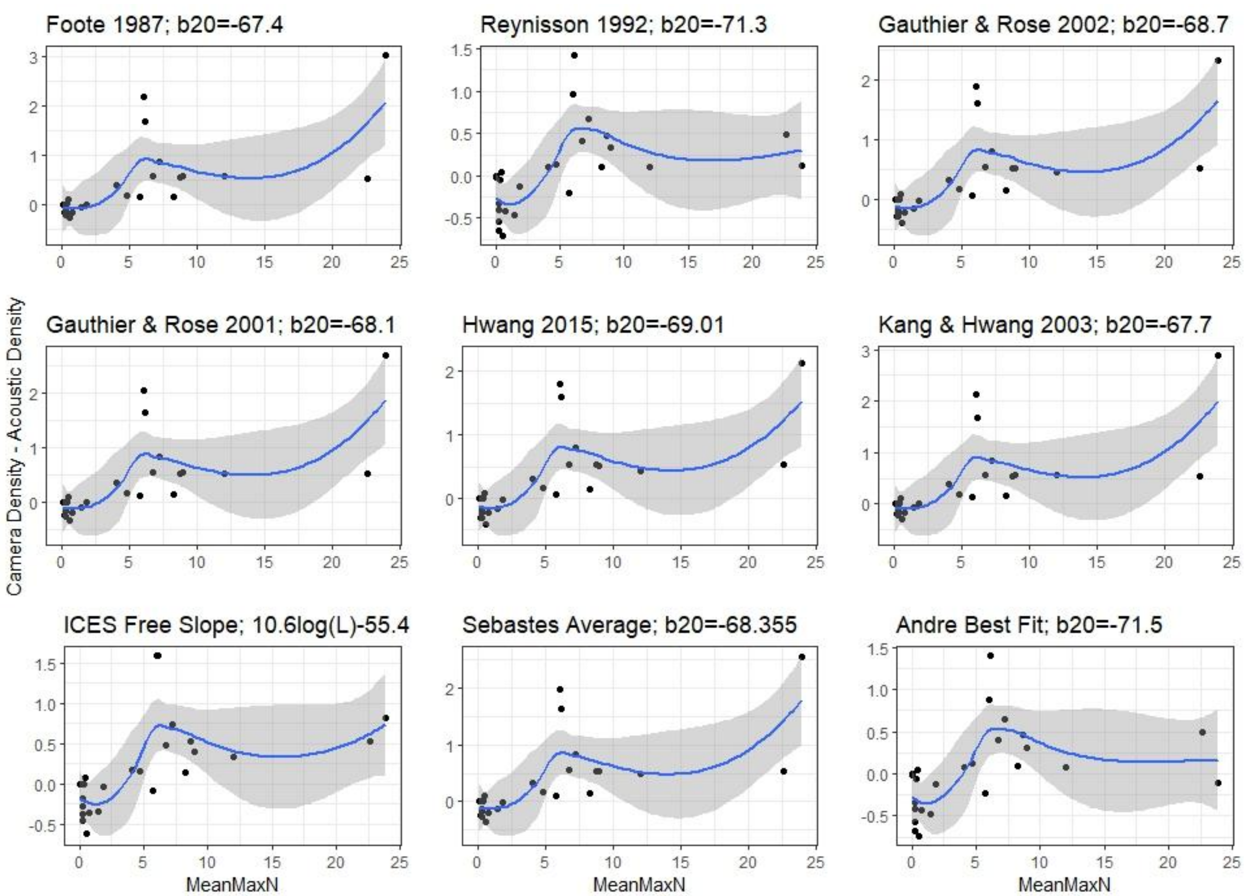

Figure 11. Mean count of fish observed in video drops within 10 m of an acoustically observed school plotted against the residuals (density from the camera minus the density from the acoustics).

In an attempt to see if count was potentially associated with length, we also plot mean length versus mean count (Figure 12). While the confidence intervals around the data are large, the LOESS line does not depict any strong trends.

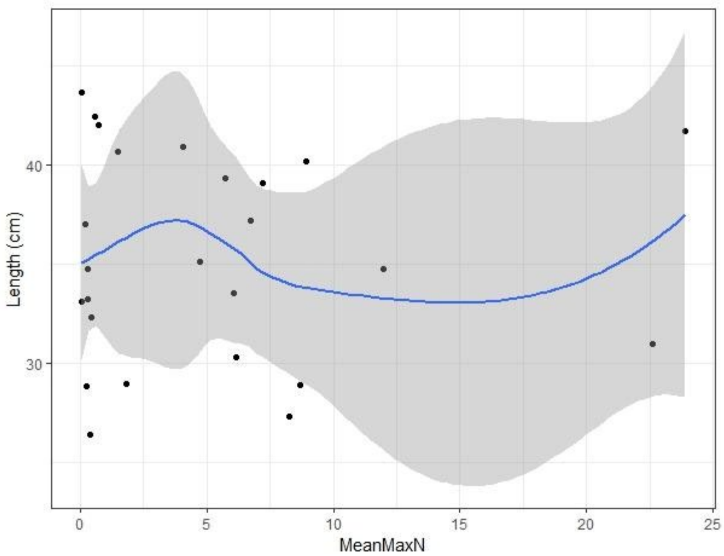

Figure 12. Mean length versus mean count to test relationship of count to length.

Conclusion: While the relationship of residuals with mean Max N remains relatively flat even at higher densities indicating, there was discussion of the potential for fish at the periphery of the school being in lower densities than the center of the school primarily observed by the drop camera, which may contribute to the discrepancy in target strength to video relationship.

Request 8: Examine the ICES free slope model based on rationale from requests 1 and 2. Plot residuals according to Requests 6 and 7.

Rationale: To explore the impact of length on a target strength model.

Response from ODFW: The requested Free Slope b20 model was plotted and displayed in Requests 6 and 7. For completeness we have also included these models in Request 6 and 7. We have also updated the results from Request 1 and present them here (Figure 13). The use of a 10.6 log rather than 20 log relationship appears to be better. The R^2 for the 20 log models was 0.8055 whereas the r^2 for the 10.6 log model was 0.7786. The density from this model is presented in Request 9. Based on the high density estimate and the lower r^2 we do not think the Free Slope model is the best model going forward.

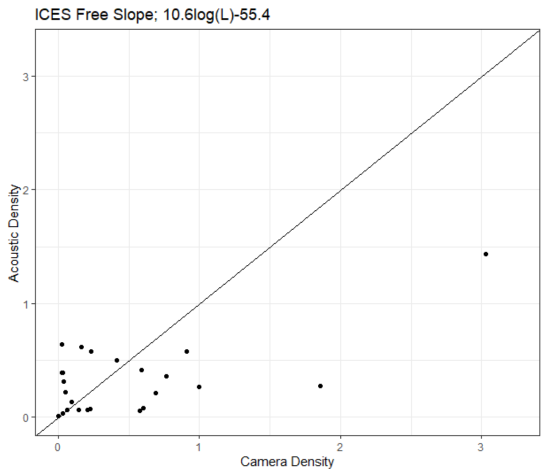

Figure 13. Comparing density from 38 kHz transducer to camera-derived densities using b20 value derived from the ICES Free Slope model. These data were generated during the survey presently being reviewed (2021 Statewide Black Rockfish Survey).

Conclusion: The panel agreed that the Free Slope model does not appreciably improve target strength to video relationship and should not be considered further.

Request 9: Apply the corrected values from Hwang et al. 2015 and provide a revised average target strength model.

Rationale: This will address the error in the previous exploration.

Response From ODFW: We have revised the plots from Request 1 with the correct TS relationship from the Hwang model (now 69.01 in Figure 14). We also corrected the *Sebastes* average, to be an average of Hwang 2015 and Kang and Hwang 2003. Despite the error in the presentation, we verified that in our report the correct 69.01 b20 value was used in the development of the population estimates.

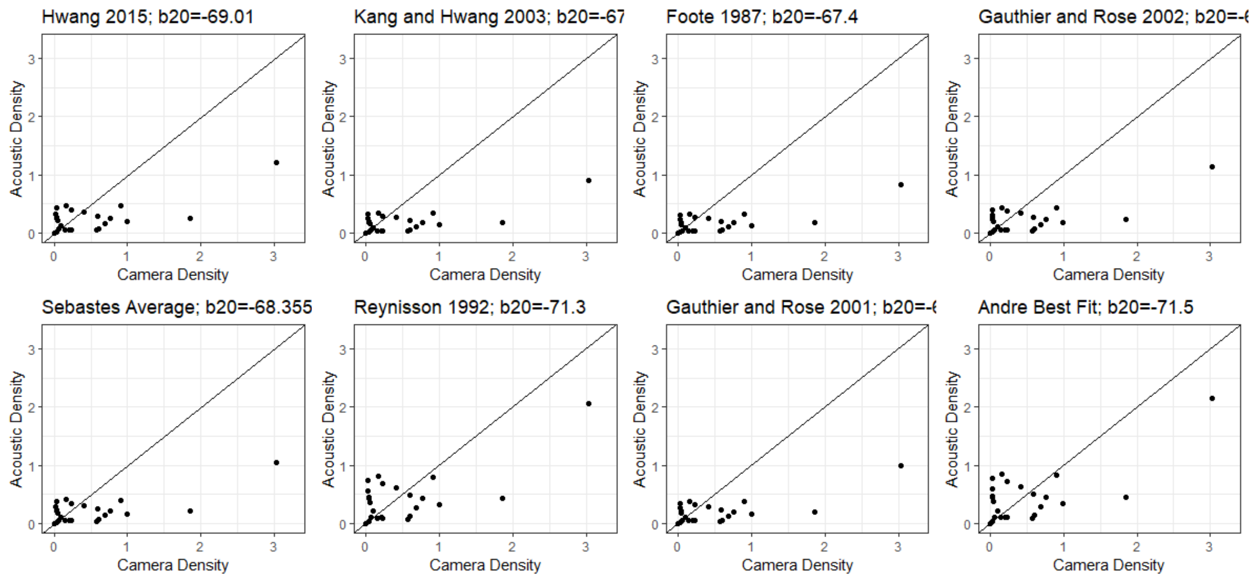

Figure 14. Revised x-y plots (from Request 1) after correcting b20 value to 69.01 in Hwang 2015 and in Sebastes Average.

We also provide an updated table of the density values (from Request 2) given this b20 correction (Table 2). Given that Hwang 2015 has the smallest b20 value, and Kang and Hwang 2003 have the largest b20, we proposed using the Sebastes Average method derived in our 2021 ICES paper because it represents an average of ex-situ target strength values from two species that are physically and ecologically similar to our focal species in this study.

Table 2. Corrected density and standard deviation values after changing Hwang 2015 and Sebastes Average b20 values.

Paper	b20	Density	Standard Deviation
Andre Best Fit	-71.5	0.0415	0.113
Reynisson 1992	-71.3	0.0397	0.108
Hwang 2015	-69.01	0.0234	0.0638
Gauthier and Rose 2002	-68.7	0.0218	0.0594
Sebastes Average	-68.355	0.0201	.0549
Gauthier and Rose 2001	-68.1	0.019	0.0517
Kang and Hwang 2003	-67.7	0.0173	0.0472
Foote 1987	-67.4	0.0162	0.044
ICES Free Slope	-55.4	0.0284	0.0773

Conclusion: The revised values for Hwang 2015 do not appear to appreciably improve the target strength to video relationship. Of the values presented, the average b20 of Hwang 2015, Guthier and Rose 2002, Guathier and Rose 2001 and Kang and Hwang 2003 were considered to provide the most reasonable proxy for use in the interim given the intermediate density values and their basis, which was further evaluated in Request 10.

Request 10: Produce a new average between the target strength b20 values (mean and standard deviation) provided in Kang and Hwang 2003, Hwang 2015, Gauthier and Rose 2001, and Gauthier and Rose 2002.

Rationale: These values are more likely for the species surveyed in the ODFW program.

Response From ODFW: We have created an average of b20 values from Kang and Hwang 2003, Hwang 2015, Gauthier and Rose 2001, and Gauthier and Rose 2002. The average b20 value is -68.3775 +/- 0.59. Going forward we will use this relationship and its associated standard deviation in the calculation of population estimates.

Conclusion: The Panel supports this approach as the best way forward at this point. Additional references and information will be sought out from Korean scientists. If additional plausible target strength values are found in gray literature, the b20 value and its standard deviation should be updated. The strong preference of the Panel would be to conduct in situ target strength studies on the rockfish species in this survey rather than using values from other species and regions.

Biomass Estimation Methods

Design-based Methods

The design-based estimates of population size in numbers and biomass were derived using acoustic data on schools and single targets along with video counts and length estimates by species. The latter were used to derive species relative densities by length category separately for schools and single targets, and "background" densities for each survey pass. These compositions were calculated statewide and also by dividing the state into three regions, rather than using the data on a transect level.

During survey design, habitat was divided into two categories. Following the fieldwork, habitat was then expanded to three categories, "Hard", "Gravel" and "Soft", with the less favored "Gravel" habitat removed from the "Hard" category. Transects were analyzed based upon acoustic data into sections with schools, with single targets but no schools (both with 35m buffers from observed fish), and "background" with no acoustic observations of fish. The volume within one meter of the bottom was treated separately as a near bottom exclusion zone due to the bottom "dead zone" for acoustics.

Population areal densities in both numbers and biomass were derived by species or complex. For areas with acoustic observations, areal densities were calculated for both the volume of water above the exclusion zone and for the exclusion zone, with the latter relying on data from schools only. Population density estimates were based on echo integration of schools and counts for individual fish, with length and species compositions derived from video for each of those two categories. The proportion (by species) of schools within exclusion zones was based on forward and downward camera data for schools. For background areas, densities were based on counts and compositions which both came from video data alone.

Total numbers for each survey, habitat and volume outside of the background areas were dependent upon the assumed target strength to length relationship. Conversion of numbers at each length to biomass depended upon length-weight relationships for each species or complex from hook and line sampling.

The majority (~3/4) of the biomass for both black and blue/deacon rockfish was estimated to be above the exclusion zone, with most of the remaining biomass estimated to be in the exclusion zone, and very little in the background areas.

Hypoxia is not directly considered in the design-based approach.

Model-based Methods
Model-based biomass estimates were derived for each species by fitting spatiotemporal hurdle models using sdmTMB. Biomass densities in 50 m bins along acoustic transects were modeled as a function of covariates (habitat, hypoxia, depth, and hour of the day), separately for each survey pass and with pass as a random effect. Model selection with AIC was used to select the best-fit model among all potential combinations of the covariates.

A triangular mesh was developed for interpolation, which included a shoreline barrier to prevent biomass from being estimated on land. This configuration in sdmTMB required assuming isotropy in the model, which is probably not an ideal assumption given the structure of the coastlines and depth contours. The assumption of isotropy vs anisotropy should be further explored when that functionality in the sdmTMB package becomes available.

The spatial GAM model fit to the near bottom oxygen data from the CTD casts was used as a covariate in the model-based biomass estimate. Hypoxia was included in the model because a tagging study on blue/deacon rockfish showed behavioral differences in normoxic and hypoxic conditions. Under hypoxia (<2.5 mg/L), fish moved slower, disaggregated, and stayed shallower, lessening the diel vertical migrations they exhibited under normoxia. Substantial hypoxia was observed in deeper depths in the northern portions of the survey area. While differences in fish behavior were evident using the threshold of 2.5 mg/L to define hypoxia, the Panel suggested that future research should also explore the sensitivity of the different assumptions of that threshold value to ensure the value used is biologically meaningful.

The best-fit model selected includes all potential covariates (depth, hour of day, habitat, and hypoxia), although models with and without hypoxia performed similarly. Relationships between the covariates and biomass density were mostly as expected, with greater densities at shallower depths, over hard and gravel substrates, and during morning and early evening hours. Hypoxic conditions were associated with greater biomass densities.

A prediction grid was developed to extrapolate biomass densities using depth and habitat information on a 50 m grid statewide. Habitat type in each grid cell (hard, gravel, or soft) was extracted from the SGHv4 product and determined by majority cover. Resulting mean biomass estimates by species and region were presented with their associated uncertainties. Only pass 1 values were presented and recommended by the proponents due to very high CVs estimated for pass 2 data.

Model-based estimates presented were almost double the design-based estimates for both black and blue/deacon rockfish, and the CVs were substantially lower. The Panel and proponents discussed several potential explanations for these results and made several requests for further analysis.

Discussion and requests for biomass estimation methods.

Request 11: Apply the model without the hypoxia term. Use just the black rockfish data on the first pass.

Rationale: To evaluate the comparability of model-based and design-based estimates (noted there are minor differences in AIC scores for models including and excluding hypoxia).

Response from ODFW: The sdmTMB package is no longer working on ODFW computers and we are working to solve the issue. We are working with the technology department and the developers of the package to try and come up with a solution. However, since we were unable to answer the question that was posed, we looked at the data we did have to try and understand what might be happening.

Because we have abundance estimates from the southern extent of our survey (Coos Bay to the California Border) and since we did not observed hypoxia in this area during the survey, we could hypothesize that if the effect driving the large difference between the design-based and model-based estimate was hypoxia, then these two estimates for southern Oregon should be similar. However, as shown in the table below this is not the case (Table 3). When sdmTMB is running again we will be able to better understand what is driving this difference. These sdmTMB data are from the model runs conducted prior to the upgrade that occurred in response to technological problems outlined above.

Table 3. Comparison of black rockfish counts from the south region (region without hypoxia on pass1). Counts were derived from the design-based versus the model-based (sdmTMB) methods.

Method	Count	Standard Deviation	CV
Design	8,196,634	5,854,201	71
sdmTMB	14,079,245	1,100,146	8

9/30/2022 Update: ODFW staff got sdmTMB up and running on a personal computer. It is worth noting, doing so required updating many of package dependencies as well as sdmTMB had version changes from those used in our report. We reran the fit (changes in how matrices are dealt with required a new fit to be generated) with and without hypoxia and predicted the number of fish statewide. We observed there was little difference between population estimates generated from current model fits that included or excluded hypoxia. However, and more surprising, there was a very large difference in the resulting estimate from the estimate presented during the review in the report and the presentation. To the best of our knowledge the only change was the versions on the primary package and its dependencies. More work is required to assess the utility of using a species distribution model.

Table 4. Comparison of coastwide black rockfish counts from pass. Counts were derived from the model-based method including and excluding hypoxia as a variable in the model, predictions from the current run and the run in the report (row 2 and 3) denote the large discrepancy in results. Ultimately, more work is needed to determine the validity of a similar model.

sdmTMB Model	Count	Standard Deviation
Hypoxia excluded	13,622,206	953,554
Hypoxia included	13,491,995	944,439
From Report (with hypoxia), exact same fit as row 2	19,739,531	1,334,337

Conclusion: The Panel concurs with the proponents that more analysis and model exploration is needed to better understand the sdmTMB model-derived biomass estimate. It appears that the inclusion of hypoxia in the model is not strongly influencing the number of fish estimated. However, that the updating of the sdmTMB and its dependent packages resulted in substantial differences in counts suggests that more work and verification is needed before a model-based biomass estimate can be endorsed.

Request 12: Provide an explanation of what is being plotted when evaluating random effects.

Rationale: To gain a better understanding of the analytical results.

Response From ODFW: We spoke with the developers of sdmTMB and there was confusion with a plotting function when making that figure. When sdmTMB is up and running (see Request 10) we will redo it and provide the plots. The data will be on the 0-1 scale for presence-absence and density for the gamma.

9/30/2022 Update: After correcting the problem identified in the sdmTMB package that was identified yesterday we have recreated the random effects model outputs but excluded hypoxia (Figures 15-17). Figure 15 shows the spatial estimate of just the fixed effects in the model. The binomial plot is presented on the probability scale but the values are quite low due to the fact that most values were near zero. The gamma plot is on the density (number of fish per m2) scale. Figure 16 shows the spatial random effects for the model. Figure 17 shows the combined spatial random effects and the fixed effects. Obviously, the random spatial fields are having a large influence on the model. As described in Request 10 more work is needed to ascertain if these models are a viable solution going forward. In particular, better understanding of what is driving these spatial fields is required.

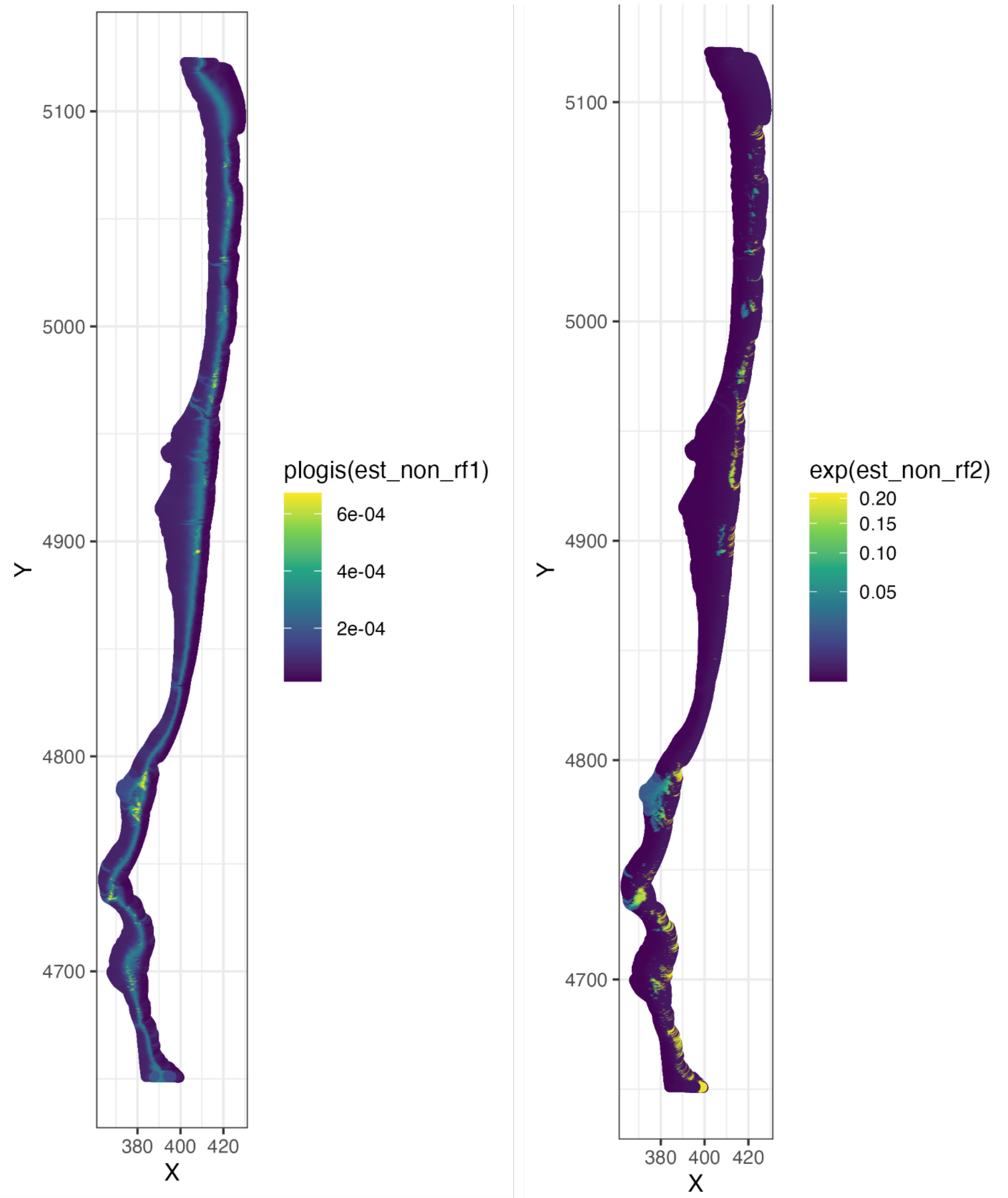

Figure 15. Predicted fixed effects for the binomial (left) and gamma (right) models for black rockfish for pass 1. Binomial data are presence-absence, the model response values are quite low hence the color bar scale.

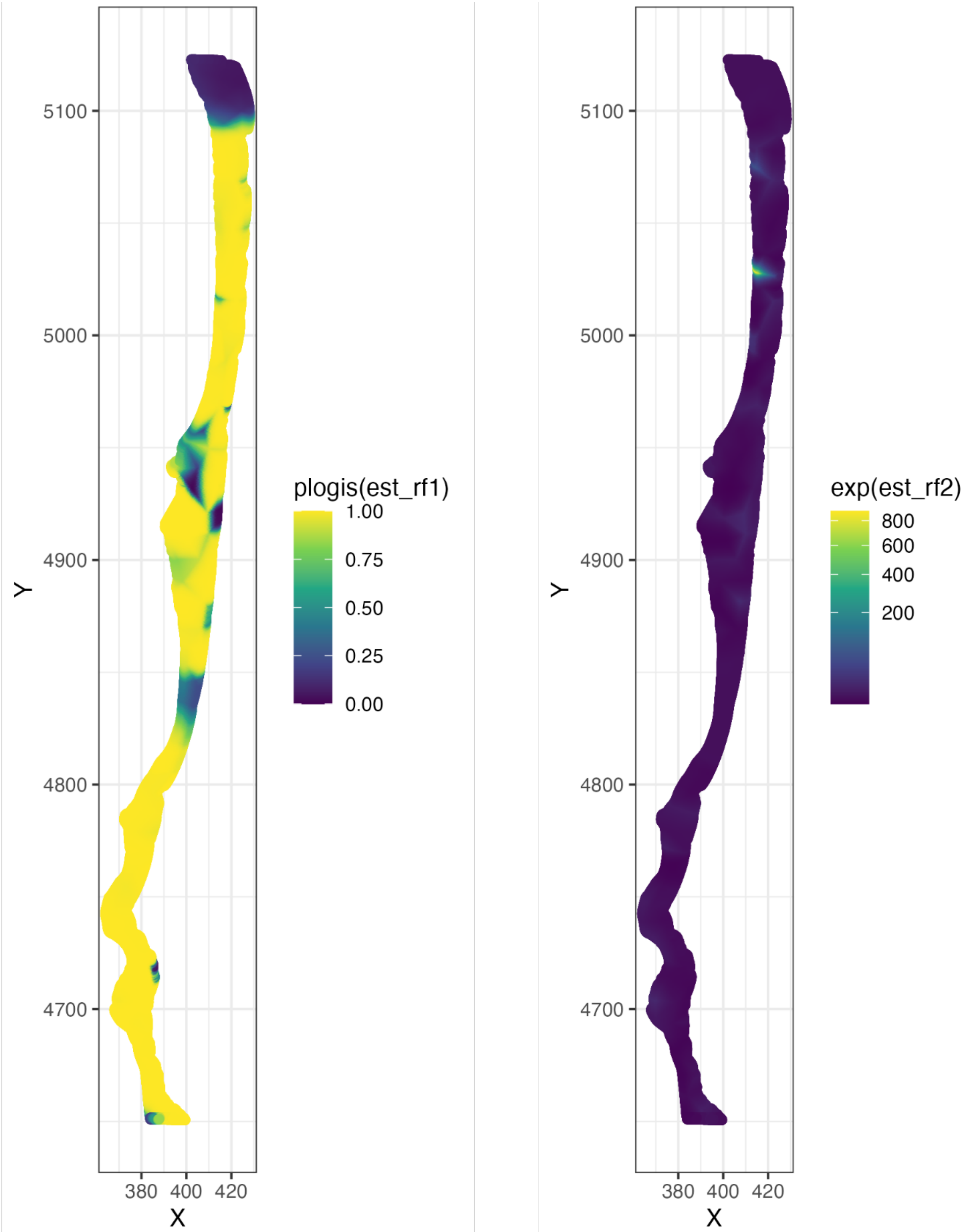

Figure 16. Predicted spatial random effects for the binomial (left) and gamma (right) models for black rockfish for pass 1.

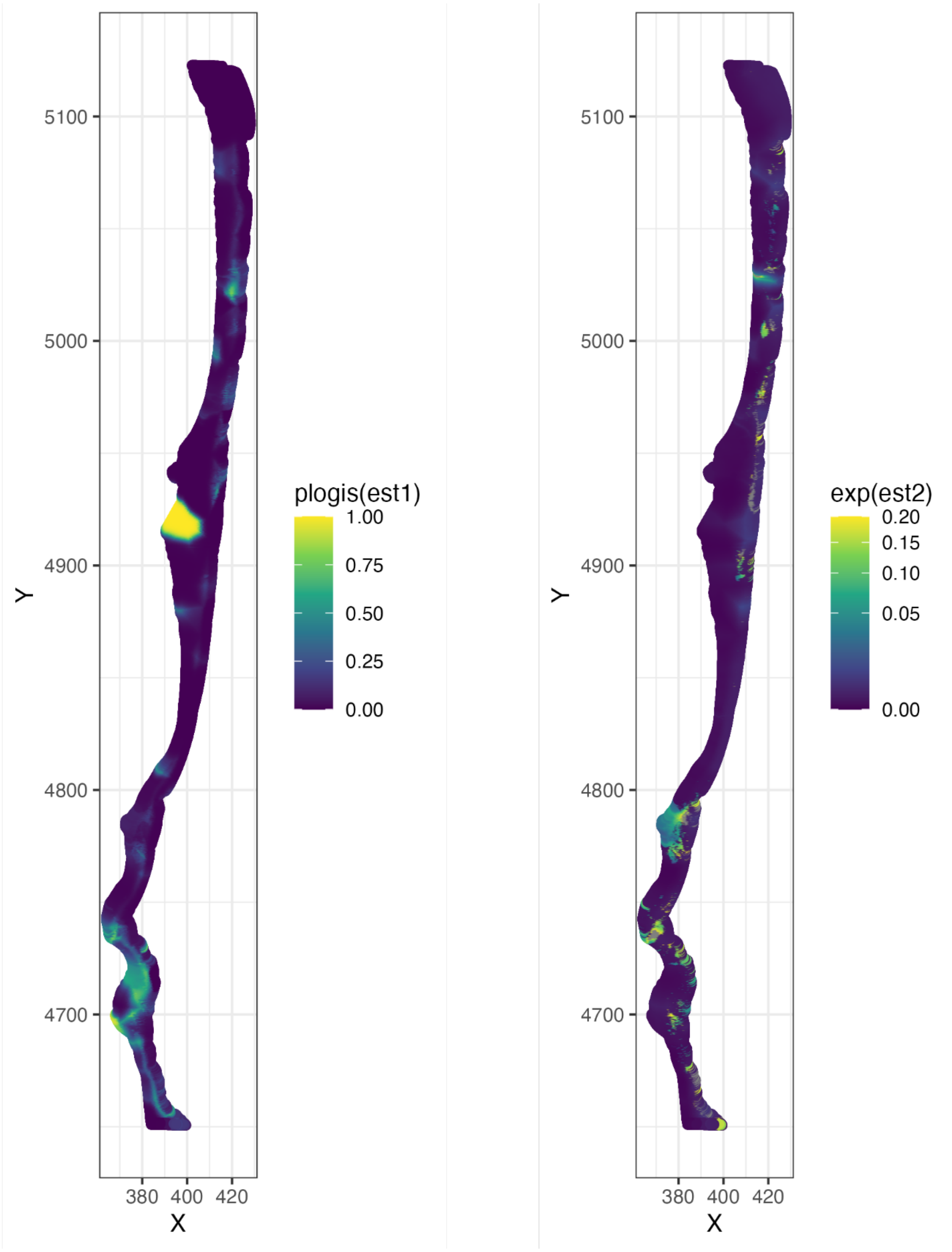

Figure 17. Predicted spatial estimates (combining spatial random effects and fixed effects) for the binomial (left) and gamma (right) models for black rockfish for pass 1.

Conclusion: The Panel agrees with the components that more model exploration is needed to understand the factors driving the spatial patterns observed in the random effects. Comparing design-based and model-based biomass estimates at the transect level may be one way to better understand the differences between the two methods and the patterns observed in the spatial random effects.

Request 12: List the sources of variance not included in density estimates.

Rationale: To better understand why the CVs are so low in the density estimates.

Response from ODFW: Sources of variance in the three main data components of the 2021 black rockfish video-hydroacoustic survey are provided below (Table 5). These identifications were generated in a single night during the survey review and thus additional sources are undoubtedly unidentified.

Table 5. Sources of variance that may or may not be quantifiable.

	Quantifiable	Not Quantifiable
Acoustics	Uncertainty in TS-length model selection	Calibration (Factory Calibration vs. Sphere Calibration In-Situ)
	Survey vessel	Uncertainty due to existing limits of habitat data resolution
		Increasing uncertainty in lobes of 38 kHz data
		Extrapolation of data from 1-2 m off bottom into the 0-1 m off bottom (exclusion) zone
Video	Length measurement error	Detection differences uncertainty
Habitat Data		Assumption that occurred in the development of the habitat data which is used for the expansion.
All Data Sources		Limited time series

Conclusion: The identified quantifiable and unquantifiable sources of variance may contribute to the low CVs, though the Panel acknowledges that accounting for them may not be possible at present.

Request 13: Calculate the total numbers and biomass estimated and the standard deviations (SD) by assuming the above exclusion and within-exclusion areas are fully correlated. Add the SDs above and the SD within plus the variance of the background; take the square root to estimate the SD.

EQ1: $(\mathrm{Var}(X+Y+Z)=\mathrm{Var}(X)+\mathrm{Var}(Y)+2\mathrm{Cov}(X,Y)+\mathrm{Var}(Z))$.

EQ2: $(\mathrm{Var}(X+Y+Z)=\mathrm{Var}(X)+\mathrm{Var}(Y)+2\mathrm{sqrt}(\mathrm{var}(X)*\mathrm{var}(Y))+\mathrm{Var}(Z))$.

Rationale: To provide a better characterization of uncertainty in total abundance estimates based on the transect design (ignoring other sources of uncertainty) under simple assumptions regarding correlation.

Response from ODFW: Using the first provided equation, we calculated the biomass and uncertainty estimates for a "combined" area where density of all three regions were combined. In the original calculations using EQ1, we conducted the analyses at the transect level so we could calculate a covariance matrix (Table 6, Row 4).

After discussing this result with the review panel, it noted the request was to just use the already presented standard deviations from the report and presentation. A clarification was made and calculations conducted using EQ2 (Table 6, Row 5). Based on these analyses it suggests combining the estimates from above, within and the background is a viable solution moving forward and that the combined CVs are reasonable to deal with. These analyses will need to be redone at the point the aggregate TS relationship identified in Request 12 is implemented with its associated uncertainty.

Table 6. Biomass and uncertainty estimates for three acoustic zones defined in the acoustics processing methods and the combined biomass estimates calculated first by including the covariance at the transect level, and again by excluding the covariance factor.

Species	Region	# Fish	# Fish SD	Biomass	Biomass SD	CV
Black	Above	11,328,416	7,689,553	11,372.10	7,719.20	68
Black	Within	2,796,378	2,761,482	2,807.20	2,772.10	99
Black	Background	365,786	461,810	367.2	463.59	184
Black	Combined (using first equation)	14,490,580	11,583,195	14,456.46	11,627.86	80
Black	Combined (using corrected equation)	14,490,580	10,461,233	14,456.46	10,501.54	73

Conclusion: The Panel recommends combining the fish estimated from the background and accepting marginally higher CV that goes along with it.

Application of the ODFW Acoustic/Visual Survey in Assessments

Application of Biomass Estimates Informing Population Scale Versus Constructing an Abundance Index: Absolute estimates of abundance accounting for the associated uncertainty at acceptable levels is the goal of the survey, though the result could also be used as relative abundance estimate with an appropriate catchability (q). Habitat mapping data from side scan sonar collected across all habitat types provides a basis for estimation of catchability given the distribution of sampling. Comparison of absolute abundance estimates to the scale of the biomass from the assessment may provide a useful check on scale. Conflicting results may be a cause for further analysis in the model, and incorporation in the assessment at the outset would allow for age and length composition from the survey to inform the assessment as well. Assessment authors will need to consider the limitations of the survey in applying the data. As a time series becomes available, additional benefit will accrue from both the abundance estimates and the length composition data. Additional funding can be sought for future surveys given the results of this review to provide a time series in the future. ODFW staff working on the assessment STAT can help ensure all needed data are available for use either as a relative index of abundance or an absolute estimate.

Application of Length Composition Data to Inform Population Structure: The greatest number of lengths are provided by the visual survey drop camera observations as opposed to the hook and line portion of the survey. The visual survey is also likely to have greater selectivity across length classes compared to the hook and line data. In addition, hook and line data may be subject to variable selectivity between the two gear types deployed, as observed for blue rockfish. The inability to identify fish to species at small sizes may limit the representation of smaller size classes, and development of selectivity curves may need to address this. Further development of considerations by assessment staff will inform the most appropriate application.

Application of Age Composition and Maturity Data from Hook-and-Line Sampling: The stock assessment team can consider the potential reconciliation between age composition for the hook and line survey vs. length composition from the visual survey when incorporating the data in the model. Comparison of length distributions from schools observed with both gears might provide additional information on the consistency of the composition data from the two data sources.

Comparison of the length at which 50% maturity is reached to the lengths collected in the field may be necessary to evaluate whether a sufficient sample of the smaller fish are collected to capture the age at maturity with the hook and line data. The spawn timing relative to the timing of the survey may affect the ability to determine maturity staging and fecundity estimates given the winter spawning of these stocks and the timing of the survey. The timing of the survey precluded collection of ages during the winter months, but in the future, there may be representation. These are future data needs considerations as the age and maturity data has yet to be worked up for analysis.

Independent Estimates of the Overfishing Limit (BiomassF_{MSY}):* Estimates of biomass can be multiplied by the F_{MSY} proxy to provide an overfishing limit estimate to which a category 2 buffer can be applied to derive an acceptable biological catch to inform harvest specifications. Accounting for a survey catchability less than one may be important as well to account for limitations on representation of biomass in the survey. While theoretically possible, this harvest control rule should be evaluated in a management strategy evaluation and compared to management with the results of a full assessment to account for the performance of this method. An alternative application could entail using annual estimates from the survey to adjust the catch limit after an assessment to adjust the harvest specifications in a subsequent cycle based on more recent results. Further consideration of issues identified in the target strength relationship is advisable before considering an independent estimate including in situ calibrations using a calibration orb and further resolution of appropriate b20 values.

Discussion and requests for application in assessments.

Request 14: Compare length compositions of observed fish in hook and line sampling and video collection at the school level and in aggregate.

Rationale: To evaluate potential conflicts between these data sources to determine best practices for using these composition data in assessments.

Response from ODFW: When we subset the data to include only video drops that were associated with hook and line locations, we found that the number of video-derived length measurements was too small to be compared with the number of hook-and-line lengths and therefore this analysis was not possible.

Conclusion: While this comparison was not possible with paired observations, additional comparisons may be possible by aggregating to a slightly larger spatial scale (e.g., transects). Future research should consider and evaluate the potential for conflicts between hook and line and camera drop observations.

Research and Data Needs

1. There remains a need for in-situ calibration of acoustic systems in marine waters off of Oregon or nearby waters if possible (for example, Puget Sound or Monterey Bay).
2. Using an acoustic system with a narrower beam width could be more optimal, by narrowing the dead zone and enhancing the ability to resolve single fish targets (and thus enable improved target strength analysis, given the conditions of the survey). The current beam is generally too wide to resolve single targets, and results in a larger dead zone (requiring greater extrapolation).
3. There are several approaches that could be used to model and/or conduct in situ target strength work (at 38 kHz) if a better technical system could be put into place to conduct this work. The current approach of using TS estimates of different species, from other ecosystems, is less than optimal.
4. A deeper evaluation of the relationship between video and acoustic measurements, at the appropriate spatial scales, would be beneficial in understanding some of the inconsistencies observed.
5. A comparison of length frequency data from the visual and hook and line survey would be beneficial, particularly with respect to the question of how best to incorporate age data into the stock assessment.
6. There is a need to consider how best to simultaneously incorporate both survey-specific uncertainty and target strength uncertainties into the assessment (e.g., as variance in the q prior to address uncertainty in scale relative to year-specific uncertainty in point estimates).
7. There is some need for additional explorations of the sdmTMB software code (and/or potential package dependencies) and the disparate results observed (with respect to scale) for runs that should have produced identical results.
8. Further exploration of potential seasonal changes in distribution (potentially as interacting with variable impacts of hypoxia among both years and seasons) would be useful in considering issues associated with survey timing.
9. A comparison of model-based and design-based estimates at the transect level may be beneficial as a longer term exploration, in order to better understand what factors may be contributing to the differences among these two types of estimates.

10. Continuing to reach out to researchers who have past or ongoing research experience with respect to estimating rockfish target strengths could help to improve future target strength estimates.

Washington Department of Fish and Wildlife Hook-and-Line Survey Workshop

Survey Design and Operations

Dr. Theresa Tsou (WDFW) and Mr. Rob Davis (WDFW) presented an overview of the Washington Department of Fish and Wildlife (WDFW) Coastal Hook and Line (H&L) Surveys and Dr. Jason Cope (NWFSC) compared the contemporary survey design with historical data used in the black rockfish stock assessment. These H&L surveys are separated into two components, a rod-and-reel survey targeting nearshore groundfish and a setline survey targeting yelloweye rockfish that builds on the International Pacific Halibut Commission (IPHC) setline survey. WDFW began tagging black rockfish for population studies in 1981 and it was these studies along with a STAR panel recommendation from 2007 that ultimately led to development of multi-species H&L surveys that could accomplish three objectives.

1. Continue close monitoring of black rockfish off the Washington coast with expanded geographic coverage.

2. Develop a monitoring program for other nearshore groundfish off the Washington coast.

3. Facilitate research and address data gaps identified in stock assessments and STAR panel reports.

There are multiple challenges to developing surveys of a multi-species groundfish assemblage. Some components are semi-pelagic while other components are demersal, and there are species-specific behaviors that result in widely differing availability to particular angling techniques and hook/bait choices. These factors led WDFW to split this survey into two components: one targeting the semi-pelagic component in the spring and another targeting the demersal component in the fall. In addition to biological considerations, the survey can be based on either a fixed-site or random-site design. Early in the process WDFW chose a fixed-site design due to the lack of high quality habitat maps needed to implement a stratified random design and to minimize cost while taking advantage of limited charter boat availability.

Nearshore Rod and Reel Survey

A coastal survey grid of three-mile resolution which extends from the coast to 40 fm was used to select potential research sites. Sub-cells were selected at a one-mile resolution. Microhabitat preferences were identified including pinnacles for black rockfish and boulders on plateaus for demersal species. Locations with sets that encountered at least one of the focal species were included in selection of survey locations. GPS location within cells was selected as a starting place for drifts. Survey grids are numbered sequentially with 107 random systematic cells and 18 purposive cells for 125 stations. These stations have exact latitudes and longitudes as starting points. Each set is allowed to drift 50 yards from the starting point. Stations were selected to provide a proportional representation of depth across four Marine Areas found in each of 398 1-by-1 km habitat cells. For the demersal groundfish survey only sites with high catch of focal species were included.

Through a series of pilot studies, WDFW selected eight focal species and a standardized methodology for each survey type (semi-pelagic or demersal). The focal species are black rockfish, deacon/blue rockfish, China rockfish, copper rockfish, quillback rockfish, lingcod, kelp greenling, and cabezon. The gears evaluated for deployment in the survey included both setline and rod-and-reel. Setlines caught fewer black rockfish and more diverse assemblages of demersal species, while rod and reel caught more semi-pelagic species. The setline is three times more expensive than rod-and-reel making it infeasible and thus rod-and-reel gear was selected for use in the survey.

The semi-pelagic survey takes place in spring and targets 125 stations using a double shrimp fly bait. The demersal survey takes place in fall and targets 64 stations using a single hook artificial mooching rig. Twenty seven of the fall stations overlap with the spring stations, others are at different locations. For both survey types, five anglers fish four, eight-minute drifts at each station where they are allowed to land as many fish as possible. The angler tracks the amount of time the baits are in the water during each drift. Data is collected as catch by drift and angler. Biological data is recorded for all catch by scientific staff onboard and most fish are released at the site of capture. Environmental variables include wind speed, swell height and direction, tide height as well as CTD at some sites.

The semi-pelagic and demersal H&L survey were initiated in their current forms in 2019. However, sampling was reduced for the semi-pelagic and missed entirely for the demersal survey in 2020 due to Covid-19. The semi-pelagic survey catches substantially more black rockfish and deacon rockfish than the demersal survey. Conversely, the demersal survey catches substantially more quillback rockfish, copper rockfish, China rockfish, kelp greenling, and cabezon than the semi-pelagic survey.

Historical and New Survey Designs

For black rockfish in the semi-pelagic survey, an index standardization was developed using a subset of data in 2015 assessment based on current survey locations. This index trend was then compared with the index trend reported in the 2015 assessment. The trend from 1998-2013 was similar regardless of whether the full dataset or reduced dataset composed of only stations sampled since 2019 were used. This consistent measure of abundance will provide a bridge between survey periods.

The four years of data from the current survey show the CPUE of black rockfish is similar. Across marine areas there are variable trends with no significant year interactions, but depth and area were pertinent factors. Index values for the last three years provide 20% Percent Standard Error (PSE), which is reasonable. The index over the last four years has been produced and is available for use in the next assessment.

Comparing Stratified Random and Fixed-station Survey Designs for Black Rockfish

WDFW initiated an H&L survey targeting black rockfish and other semi-pelagic rockfishes in 2019. That survey used a fixed station sampling scheme rather than stratified random survey design in part due to a lack of habitat mapping to inform sampling locations for random selection on appropriate habitat. This design will be carried forward to the future. The black rockfish index trend comparison above to ensure the site selection maintains a linkage with the historical dataset. The current survey continues to use a subset of locations sampled across time.

IPHC Yelloweye Rockfish Setline Survey

The International Pacific Halibut Commission (IPHC) setline survey has been used as an ad-hoc source of data for an abundance index for yelloweye rockfish assessments in the past. The WDFW seeks to identify sites and seasons for a setline survey focused on yelloweye rockfish. IPHC survey sites with high catch rates for yelloweye rockfish have been identified. An adaptive approach of adding additional sites around higher catch locations in the IPHC survey was implemented to identify locations with the highest catch rates. These locations were added and surveys were conducted in spring and fall as well as summer to determine the best season to catch yelloweye rockfish. Summer provides the highest catch, consistent with the timing of the IPHC survey, and sampling has taken place at the adaptive sites since 2007.

A delta-GLM has been used to develop an index from sites that have been positive in the past. The adaptive sampling at site numbers 1500 and 1082 provide a shorter time series focusing on the highest catch locations. The increased sampling since 2007 was intended to reduce the variance in the index to decrease the CV to acceptable levels, however the CV was found to still be around 0.6 in each year even with the additional sites. A greater number of sampling locations with appropriate habitat for yelloweye rockfish would be necessary to reduce CV of the index to a more useful level. Even so, the gear and habitat selection for the IPHC survey focused on Pacific halibut may not be optimal for sampling of yelloweye rockfish.

Nearshore rocky reef habitat is relatively limited along the Washington coast, with large swaths of sand, and high-resolution side scan sonar mapping of the seafloor is not available to inform site placement. No fishing location is recorded in the recreational survey to inform high catch locations for the survey. Exploration of additional data sources including the hook and line survey data, sampling in yelloweye rockfish closure areas outside the IPHC survey and anecdotal reports of high catch areas met with limited success, with one site identified off of La Push near IPHC site 1077. The hook size or other factors in site selection in the IPHC survey may limit its utility. A pilot study to evaluate use of smaller hooks found catch rates were double those on the IPHC series, but there is a cost associated with deployment of the alternative gear and such a change would result in forgone utility of the early time series due to differences in gear.

The new demersal survey may provide additional data if sites were sampled in deeper waters in habitat with pinnacles or abrupt drop offs with which yelloweye rockfish are often associated. NOAA Charts provide limited resolution of data to identify such abrupt changes in bathymetry and side scan sonar would be beneficial both in this application and in weighting of indices by habitat area useful in other applications. The current depth limit of 40 fm for the demersal survey does not cover the primary depth distribution of yelloweye rockfish nor the full depth distribution of many of the demersal rockfish species such as copper and quillback rockfish and some moderate extension into deeper depths to 60 fm may increase catch rates for yelloweye rockfish and provide more complete coverage of the full depth distribution of deeper nearshore stocks. Expenditure of funds on the demersal survey formerly expended on the IPHC survey to extend the depth of sampling may improve the utility of the survey.

Accepted Practices and Future Research Needs

1. The GFSC agreed that reducing the number of drifts from four per site to three per site is an acceptable practice, especially if additional sites are added. The GFSC also agreed that eliminating the two sites in Marine Area 1 was an acceptable practice given the high cost to benefit ratio, especially if additional sites were added in other Marine Areas.
2. The additional sites to supplement the IPHC setline survey are not informative for yelloweye rockfish abundance given their high CV. An exploration of other ways to obtain information for yelloweye rockfish such as exploring deeper depths in the demersal survey may be warranted.
3. Yelloweye and canary rockfish increase in the deepest depths surveyed in California. A future research need identified is to explore additional sampling in deeper depths (>40 fm). This may be valuable for representing the full depth distribution of the current focal nearshore species as well as allow for representation of additional focal species on the shelf.

Discussion and Requests

Request 1: For the semi-pelagic and demersal surveys, compare the 4-drift CPUE indices and SDs with all sites using 3-drift estimates. Show comparative results for all important species.

Rationale: To evaluate the potential trade-off of reducing drifts/site and adding sampling sites.

Response from WDFW: WDFW provided tables of 4-drift (Table 7) and 3-drift (Table 8) CPUE indices and SDs for a suite of species for the surveys for years where the data is currently available (2019-2022 for semi-pelagic; 2019 and 2021 for the demersal). Differences in both the indices and SDs were small for both surveys across all years.

Table 7. Results of the CPUE index with four drifts for black rockfish.

Year	Mean	logSE	PSE	HPD_lower95	HPD_upper95
2019	4.76	0.18	18.79	3.07	6.52
2020	6.48	0.27	27.51	3.30	9.88
2021	5.52	0.19	19.39	3.61	7.66
2022	3.29	0.19	19.86	2.11	4.59

Table 8. Results of the CPUE index with three drifts for black rockfish.

Year	Mean	logSE	PSE	HPD_lower95	HPD_upper95
2019	4.94	0.19	19.09	3.27	6.85
2020	6.89	0.27	28.18	3.60	10.82
2021	5.69	0.19	19.52	3.63	7.86
2022	3.28	0.20	20.17	2.13	4.65

Conclusion: The panel supports elimination of the fourth drift for the semi-pelagic survey. Such a reduction may not be advisable for demersal species as the CPUE did not decline with drifts as was the case for semi-pelagic species and the fourth drift may provide more robust index estimates with a lower CV given their more dispersed distribution, though for the two available years of data the effect seemed relatively small. The effect of the approximate increase of 20% more sites gained by reducing the semi-pelagic sampling to three drifts can be explored through resampling all sites in considering whether three drifts provides a means of approximating the potential reduction in the CV from sampling more sites. The potential to survey deeper sites for the demersal survey would be a reasonable trade-off for reducing to three drifts.

Request 2: Provide the scaled indices from the IPHC+ yelloweye survey.

Rationale: To evaluate the potential benefits of sampling the extra sites.

Response from WDFW: A scaled plot of the indices was provided and which allowed for a better visual comparison of the survey time series with and without the extra sites, and that from the extra sites alone (Figure 18).

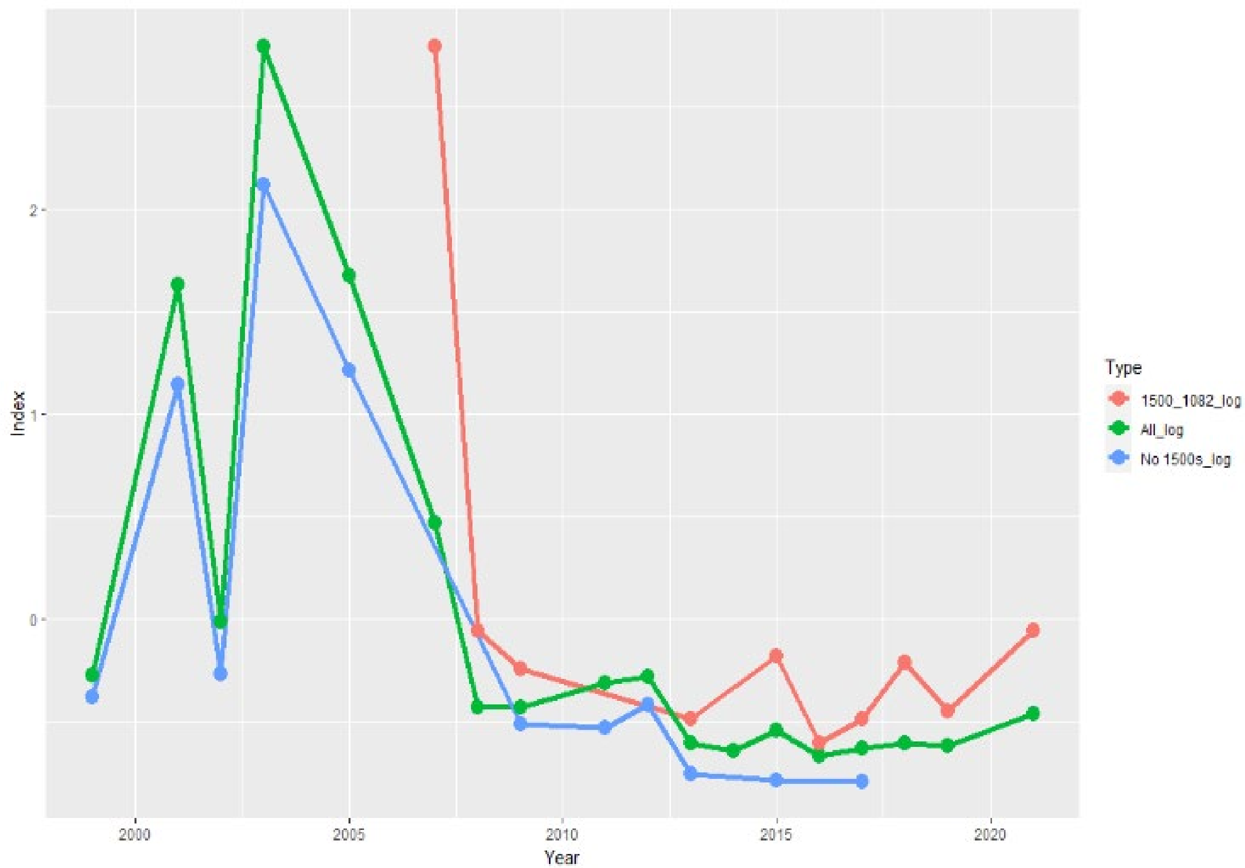

Figure 18. Scaled indices with and without addition of adaptive sampling locations around established IPHC sites.

Conclusion: This did not change the conclusion of the panel. There is not enough data from either the IPHC survey alone, or the enhanced IPHC+ survey to provide an informative index for yelloweye, nor are trends different from the IPHC survey vs. the extra sites.

Workshop Conclusions and Recommendations

1. The number of drifts for the WDFW hook and line survey doesn't appear to have a major impact on results or uncertainty, such that going to three drifts is a reasonable approach moving forward.
2. For the semi-pelagic survey, there is the potential to add more sites if the number of drifts is reduced, which is likely to be a more robust allocation of effort.
3. For the demersal survey, there is an opportunity to survey deeper habitats (50 fm or deeper), which may provide information over greater depth distributions, and potentially to encounter more yelloweye rockfish.
4. For the setline survey, given the uncertainty observed in these data, even with the additional sites the index is not likely to have a great impact on the assessment, unless there is a major increase in the number of yelloweye rockfish observed. An exploration of alternative approaches to surveying yelloweye rockfish is recommended.
5. Continuing to survey marine area 1 is likely not cost effective, relative to the importance of

continuing to survey in other areas. Given the limited contribution of the sites in Marine Area 1 the Panel recommends they be excluded in the future in order to support greater effort elsewhere.

Research and Data Needs

1. As with other hook and line surveys, hook saturation issues (and approaches to modeling those effects) are likely to be important future research needs and should be considered in future investigations and applications of the data.
2. Improved habitat mapping could help inform site selection and ultimately would be beneficial for improving modeling approaches.
3. There could be merit in considering an increase in the number of hooks (or the sequence of hook deployment) used in the demersal survey, although differences among surveys should also be considered. It is possible that this could provide increased catch rates and thus better information for assessments, particularly if this change was done concurrently with other potential changes in the survey design (e.g., deeper habitats).

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