OREGON DEPARTMENT OF FISH AND WILDLIFE REPORT ON STOCK ASSESSMENT METHODOLOGY REVIEW

The Oregon Department of Fish and Wildlife (ODFW) proposes review of a fishery-independent visual survey methodology for nearshore groundfish species by the Pacific Fishery Management Council's Scientific and Statistical Committee (SSC). The purpose of the review would be to determine whether results produced using this method can be used in future stock assessment models to better inform management. This report provides content requested by the SSC subsequent to ODFW's September 2017 report first presenting this proposal.

The Research and Data Needs sections of many recent stock assessments[1] for nearshore and other stocks have included recommendations for a fishery-independent survey in untrawlable habitats. Reports by Stock Assessment Review Panels and the Center for Independent Experts have echoed these recommendations, noting the need to adequately survey populations (or portions thereof) that are not available to the current survey sampling gear in order to understand scale and trends in abundance, and to avoid reliance on fishery-dependent Catch Per Unit Effort (CPUE) indices. To date, data informing the scale of nearshore population sizes is lacking. The proposed methods and data focus on providing fishery-independent estimates of absolute abundance for coastal benthic fish species, with the primary purpose of informing scale in stock assessments. For species with insufficient data to generate robust estimates of absolute abundance, these methods may still produce useful indices of relative abundance.

Since 2000, ODFW's Marine Resources Program has conducted remotely operated vehicle (ROV) video transect surveys of untrawlable nearshore rocky reefs to assess the distribution and density of demersal fishes and invertebrates as well as their associated benthic habitat structures. ODFW requests that the SSC review the ROV program's methods and data to determine if they can provide suitable inputs for groundfish stock assessments, and provide advice for improving the methods and data to best support future assessments.

Data acquisition methods:

1. *Fish density*. Fish density data were derived from a series of ROV surveys of separate nearshore reef systems conducted between 2010 and 2017 (Appendix 1). Additional survey data exist for the 2000-2009 period, but the current proposal incorporates only data collected with high-definition cameras in recent years. Belt transects targeted untrawlable habitat in each reef system following either a completely random or depth-stratified random sampling design. Randomly placed transects were excluded if they contained insufficient coverage of rock habitat. Transects occurred at water depths of approximately 18-45 m and were 500 m long. Transect width was determined by measuring the on-screen width of paired scaling lasers at 30 s intervals. Video was reviewed for quality factors and data extraction was restricted to imagery meeting quality standards. For fish observed near the lasers, total length was estimated

[1] 2015 Black Rockfish, 2015 China Rockfish, 2015 Oregon Kelp Greenling, 2015 Canary Rockfish, 2017 Blue and Deacon Rockfishes, 2017 Yelloweye Rockfish, 2017 Lingcod

within coarse bins (0-10 cm, 10-30 cm, 30-60 cm, > 60 cm). For surveys conducted after 2015, stereo video was used to provide more precise length estimates for suitably positioned fishes.

2. Species currently under consideration include nearshore benthic fish such as yelloweye, quillback, China, and canary rockfishes, lingcod, and kelp greenling.

3. *Substrate data.* Substrate data were taken from the Oregon State University Active Tectonics and Seafloor Mapping Lab's Surficial Geologic Habitat (SGH) map that provides statewide GIS data coverage for Oregon waters, though with varying degrees of resolution and accuracy. The great majority of ROV transects were conducted in regions with high-resolution multibeam bathymetry data (obtained from the same source), which covers approximately 75% of the reef area deeper than 10 m in state waters. For these regions, predictive habitat variables used in subsequent distribution modeling analyses were derived from the bathymetry, such as depth, slope, habitat complexity, and bathymetric position index.

Abundance estimation methods:

We define three regions of the Oregon coast (north, central, and south, with transitions at Pacific City and Coos Bay) and estimate total abundance within each region for the area extending from the inshore limit of available multibeam bathymetry, generally near 10 m depth, to the offshore limit of state waters (which varies in depth from approximately 50 - 90 m). Regions could be further subdivided if data show distinct geographic breaks. The excluded inshore area contains valuable habitat but is generally inaccessible to fisheries and fishery-independent surveys, and lacks substrate and multibeam bathymetry data. Abundance is estimated separately for the three coastal regions by each of the following three parallel approaches, similar to the strategies employed by Young and Carr 2015 [2].

1. *Simple extrapolation across total reef area.* Density is calculated for each surveyed transect as total individuals divided by total swept area. Mean density (± SD) across all transects is multiplied by the total area of comparable reef, as determined by analysis of existing substrate and bathymetry data. Reef is defined as mapped substrate that includes at least cobble or larger grain sizes. An example of the sampling variability observed at this level of data aggregation is provided in Appendix 2.

2. *Extrapolation across substrate-specific areas.* Mean density (± SD) within each substrate category (boulder, cobble, bedrock, etc.) is multiplied by the area of similar substrate. Sample units are created from sub-segments of transects within substrate types. Potential non-independence of adjacent sub-segments of transects is assessed, and mitigating approaches are employed where appropriate (e.g. instituting a buffer zone of unused data between segments). An example of the sampling variability observed within substrate categories is provided in Appendix 3.

3. *Modeled abundance based on habitat suitability.* Within the footprint of the multibeam bathymetry raster, derived habitat predictor variables (see above) are used to spatially model species densities using a generalized additive model (GAM). Sample units are sub-segments

of transects with observed fish presence, and an equal number of randomly selected sub-segments without observed fish presence. The model output includes a continuous raster of density and a second raster of standard deviation. Reef boundaries are overlaid on the modeled output and provide the area by which to multiply the density raster to find abundance.

Within each of the three coastal regions, for each species, the appropriate combination of these three approaches will be evaluated to generate a comprehensive abundance estimate (e.g. potentially summing a GAM-based abundance estimate for the footprint area of the multibeam bathymetry survey, with a reef-based extrapolation for the remaining area that lacks multibeam data). Selection of the final components to include in each region's comprehensive estimate would depend on the robustness of the GAM approach for each species, and the details of the substrate mapping in each region. For example, in the north coast region the extensive multibeam coverage and the sampling extent allow primary reliance on the GAM output, whereas in the south coast region, significant gaps in multibeam bathymetry will require a substantial component of reef-based extrapolation.

Detectability

Semi-pelagic schooling fish such as black, blue and Deacon rockfish are currently excluded from analysis (although they are presented here in Appendices for comparative reference) because ROV observations of suspended schools are sometimes limited to the lower portions of the schools, and schooling behavior can be problematic for generating counts from moving-platforms. For solitary benthic species, we have no explicit data on detectability except for qualitative observations, generated over 17 years of video review, as to the occurrence and behavior of the target species. Except for certain cryptic species such as cabezon, we assume that detectability is close to but less than 1 (i.e. a few fish are missed during review, or are hidden among rocks, or flee the ROV). Considering that we are also excluding the shallow zone < 10 m depth, we are implicitly generating a conservative yet still informative total abundance estimate.

There is very little evidence from external studies (e.g. ODFW's video lander experiments, or other published work) to suggest a detectability > 1 for nearshore solitary benthic species. Quantitatively determining species-specific differences in detectability potentially deriving from varying behavioral interactions with the ROV could be approached by examining distance to observed individuals. This would require intensive processing with our new stereo imagery in future surveys. The issue of detectability is currently addressed by several data processing protocols, including an intensive data quality assessment that eliminates segments of transects that fail to provide adequate visibility, benthic coverage, and ROV orientation. Video review protocols also enhance consistent detectability by constraining the area of the screen reviewed to a defined polygon that represents a close, well-lit, non-obscured region.

External studies are currently examining detectability by ROVs in other systems (e.g. NMFS Untrawlable Habitat Strategic Initiative), and we may be able to extract some relevant data to inform quantification of detectability. For cryptic species like cabezon, the implications of likely lower detectability would make our abundance estimate a minimum abundance estimate of stock size, which could be used as a relative abundance index if detectability remains relatively stable over time.

ODFW is prepared to describe these methods and data in detail for SSC review, and is open to exploring alternative recommendations for modeling approaches (e.g. explicitly incorporating the covariance structure in the transect data using a spatio-temporal approach such as VAST). ODFW is prepared to work with the SSC in any way necessary to facilitate the review, and appreciates consideration of this proposal by the SSC and the Council. We are hopeful that results of this visual survey approach will contribute to reducing some of the uncertainty associated with stock abundance estimates and trends in future nearshore stock assessments.

[2] Young, M., and M.H. Carr. 2015. Application of species distribution models to explain and predict the distribution, abundance and assemblage structure of nearshore temperate reef fishes. Diversity and Distributions 21: 1428–1440.

Appendix 1

Number of ROV transects conducted at each reef system during the focal period 2010-2017. All transects are nominally 500 m in length. Prior ROV survey data (not considered in the current analysis) exist at Siletz Reef (2001, 2002, 2008), Orford Reef (2006), and Redfish Rocks (2008).

* At Cape Perpetua, the same transects within this region's limited rocky reef area have been targeted since 2000 to create an irregular time series, with 1-6 days sampling in all but 4 years between 2000 and 2017.

	2010	2011	2012	2013	2014	2015	2016	2017
North Coast								
Cannon Beach			5					
Nehalem Reef			7					
Cape Kiwanda			9					
Cape Meares			7					
Central Coast								
Cascade Head Marine Reserve			16	10		4	3	11
Cavalier Reef			16				4	14
Schooner Creek				10		4	4	15
Siletz Reef	10	9						
Cape Perpetua *	6	6	6			6		6
South Coast								
Cape Arago Reef						19		
Orford Reef	40						23	
Redfish Rocks Marine Reserve	42						35	
Island Rock	3						3	
Humbug Mountain	32						13	

Appendix 2

Example of sampled abundance and variability for the most abundant species in ROV transects in the 2010 Port Orford area survey. Total individuals observed and coefficient of variation of density (CV) are calculated across four separate sites (Orford Reef, Redfish Rocks, Island Rock, Humbug Mountain) using the weighted mean density and standard deviation (weighted by usable transect length) for transects from all four sites combined (n = 117 transects).

Species	Total indiv.	CV (%)
blue/deacon rockfish	4,531	240
black rockfish	2,061	137
kelp greenling	2,006	54
canary rockfish	431	199
lingcod	303	106
China rockfish	93	234
yellowtail rockfish	79	273
quillback rockfish	62	189
yelloweye rockfish	40	277
vermillion rockfish	39	275
cabezon	35	250

Appendix 3:

Example of sampled abundance and variability within substrate categories derived from SGH maps for the most abundant species in ROV transects in the 2010 Port Orford area survey. The second set of columns represents the number of transects (out of 117 total) across four separate reef regions (Orford Reef, Redfish Rocks, Island Rock, Humbug Mountain) that contained each species and substrate combination. Coefficient of variation (CV) is calculated from the weighted mean density and standard deviation (weighted by sampled distance of the substrate per transect) for each substrate-species combination.

	# of individuals observed							# of transects						CV (%)					
Species	bedrock	bedrock mix	boulder	cobble mix	gravel mix	sand-mud	**TOTAL N**	bedrock	bedrock mix	boulder	cobble mix	gravel mix	sand-mud	bedrock	bedrock mix	boulder	cobble mix	gravel mix	sand-mud
blue/deacon rockfish	1,199	564	2,431	127	46	164	**4,531**	51	10	36	19	4	11	162	121	201	136	85	83
black rockfish	1,070	66	538	127	85	175	**2,061**	57	4	36	23	7	15	85	84	108	216	111	106
kelp greenling	624	373	507	197	118	187	**2,006**	64	28	51	34	18	45	41	67	47	68	51	102
canary rockfish	132	51	152	39	21	36	**431**	36	7	23	16	7	8	108	79	177	145	72	84
lingcod	97	50	70	24	27	35	**303**	45	19	31	15	9	21	85	135	86	108	28	67
China rockfish	17	46	26	2	2	-	**93**	10	11	13	2	2	0	111	63	76	30	8	--
yellowtail rockfish	17	7	50	1	1	3	**79**	11	2	10	1	1	1	77	85	71	--	--	--
quillback rockfish	20	18	15	3	3	3	**62**	10	9	8	3	3	3	61	61	62	33	76	29
yelloweye rockfish	4	16	15	2	-	3	**40**	2	6	7	2	0	3	60	59	93	22	--	26
vermillion rockfish	7	11	15	5	-	1	**39**	7	5	7	4	0	1	44	57	112	43	--	--
cabezon	18	5	4	-	3	5	**35**	11	5	3	0	2	4	63	31	125	--	61	65