Identifying VMEs on Cobb Seamount using visual data

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ABSTRACT

We identify vulnerable marine ecosystems (VMEs) on Cobb Seamount by applying a quantitative approach to assessing the Food and Agriculture Organization (FAO) criterion of structural complexity for identifying VMEs (FAO 2009) developed by Rowden et al. (2020). VMEs are identified using visual data as outlined in the North Pacific Fisheries Commission's (NPFC's) framework for identifying data to identify VMEs (See Annex 2.3 in NPFC 2023a and NPFC 2023b). Using Rowden et al.'s (2020) approach, we calculated a VME density threshold of 0.6 VME indicator taxa colonies m^{-2}. Applying our threshold to visual data from autonomous underwater vehicle (AUV) transects on Cobb Seamount, we identify five areas as VMEs ranging in size from 50 – 200 m^2. Using the NPFC's move-on distance of 1 nautical mile following a VME encounter (NPFC 2023a; NPFC 2023b), we propose a fisheries closure area of 1 nautical mile around the identified VMEs to protect them from potential significant adverse impacts (SAIs). We propose two areas as VME protection sites on Cobb Seamount: one in the northwest corner and one in the northeast corner with areas of 24.7 km^2 and 13.7 km^2, respectively.

BACKGROUND

Canada's quantitative and repeatable methodology for identifying vulnerable marine ecosystems (VMEs) in the North Pacific Fisheries Commission's (NPFC's) Convention Area (CA) (Warawa et al. 2022) was endorsed by the NPFC's Scientific Committee in December 2022 (NPFC-SC 2022) and adopted by the NPFC Commission in March 2023 (NPFC 2023c). This working paper applies the adopted methodology to Cobb Seamount in the eastern NPFC CA to identify VMEs where visual data is available.

Canada's method for identifying VMEs is an application of the quantitative approach developed by Rowden et al. (2020), which determines a density threshold of VME indicator taxa above which a VME is present, drawing on FAO's VME criterion of structural complexity (FAO 2009). They identified VME density thresholds for *Solenosmilia variabilis*, a widespread VME indicator species in the South Pacific Regional Fisheries Management Organization (SPRFMO) CA, of 0.11, 0.14, and 0.85 coral heads m^{-2}, at spatial scales of 50 m^2, 25 m^2, and 2 m^2, respectively. They hypothesized that the thresholds used to identify VMEs would likely vary regionally. Hence, we applied their methodology to the Northeast NPFC CA using regional data and VME indicator taxa recognized by the NPFC. See Warawa et al. (2021) and

Warawa et al. (2022) for NPFC working papers describing previous iterations of Canada's approach to identifying VMEs.

METHODS

Study area

We applied the quantitative method to identify VMEs on Cobb Seamount, which is in international waters, close to Canada's domestic waters (Figure 1). This seamount lies in the eastern part the NPFC CA. Cobb Seamount is a 27 million year old symmetrical and terraced guyot with a centrally located pinnacle and an area of approximately 824 km^2 (Budinger 1967) that rises from a base of 2,743 m to within 24 m of the water's surface (Parker & Tunnicliffe 1994). Cobb Seamount was discovered in 1950 and has been the site of biological, geological, and oceanographic research, as well as several commercial fisheries, including for sablefish (*Anopoploma fimbria*). The Canadian commercial Sablefish fishery has been active in the area since the 1980s using mainly longline trap and some longline hook and line gear.

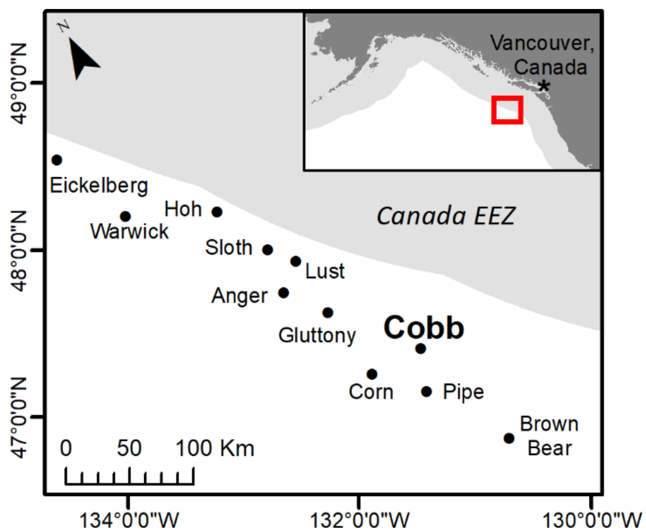

Figure 1. Study area map of Cobb Seamount and surrounding named seamounts. The inset map shows the location of the Cobb-Eickelberg seamount chain in the eastern north Pacific Ocean, just outside of Canada's Exclusive Economic Zone shaded in grey.

Data and data processing

Visual data were collected from Cobb Seamount in 2012 in a scientific survey to characterize the benthic community structure (Curtis et al. 2015). Photos were taken using a SeaBED-class autonomous underwater vehicle (AUV) deployed by the National Oceanic and Atmospheric Administration (NOAA), capable of diving to 1,400 m. We used the fully annotated dataset created by NOAA, which consisted of data extracted from 2,614 AUV photos. Photos were taken from four transects with an average length of 1805 m and ranging from 435 – 1154 m in depth (Figure 2). Discernable taxa, including corals, sponges, other invertebrates (but not brittle stars or snails), and fishes were identified and counted (Curtis et al. 2015).

To process the AUV data for analysis, transects were divided into area-standardized segments of 50 m^2 by grouping adjacent photos until a combined area of 50 m^2 was reached. Rowden et al. (2020) suggest that observations made at spatial scales between 25 m^2 and 50 m^2 result in more stable and reliable density estimates because they are more likely to capture whole coral reef patches. The area of each photo varied depending on the distance between the AUV and the seafloor when the photo was captured. We omitted transect segments from our analysis if they were 10 % smaller or larger than our target area (50 m^2) to prevent a large variation in the actual final segment size. This resulted in the removal of 5.6 % (13 out of a total of 234) of transect segments. Each 50 m transect segment group was composed of 5 – 12 AUV photos, depending on the area covered by each photo in the grouping.

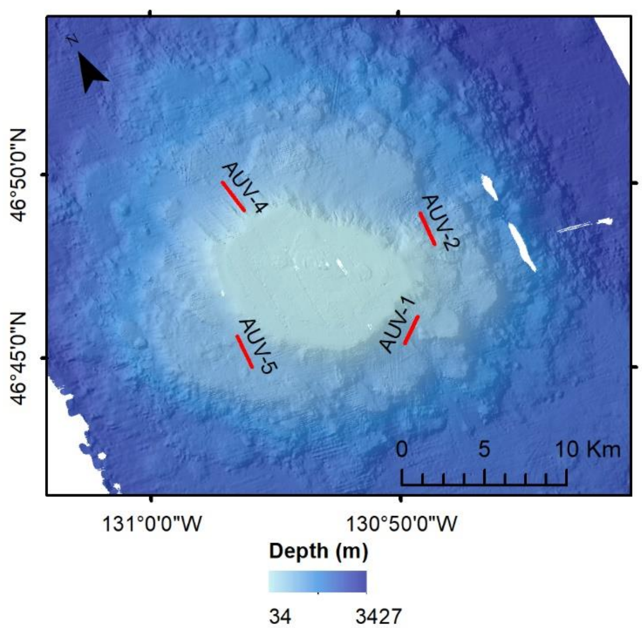

Figure 2. Bathymetry map of Cobb Seamount showing the locations of four AUV transects (red) from the 2012 Cobb Seamount Survey (see Curtis et al. 2015 for more details).

Threshold estimation

Generalized additive models (GAMs) fitting associated taxa richness (dependent variable) to VME density (independent variable) were used to estimate the VME thresholds after Rowden et al. (2020). Final model selection was based on the lowest Akaike's Information Criterion (AIC) score, while maintaining low standard error values. The GAMs were fit using a gaussian distribution and an identity link function. Depth was included as predictor variable in order to account for any differences in taxonomic diversity related solely to the changes in depth (e.g. decreases in overall diversity at deeper depths as observed by other studies and meta-analysis (Costello and Chaudhary 2017, Davies and Guinotte 2011 , Georgian et al. 2014). Transect was included as a random effect in the model to account for the potential dependence of observations taken from the same transect (see Figure 2). The number of basis functions or inflection points in the smooth terms (k) was assessed to ensure dimension choices were adequate. Model accuracy was estimated using the adjusted R^2 values and model fit was compared using AIC score. The final model formula is shown below, where bs="re" indicates the variable treated as a random effect and s indicates a cubic spline smoother:

Species richness ~ s(VME density) + s(depth) + s(transect, bs="re")

We calculated the VME density threshold from the GAM using the same four methods outlined in Rowden et al. (2020) and used the average as the final threshold value. The methods include: (1) the point of intersection of linear regressions using the initial and final 5% of data, (2) the point of intersection between a linear regression using the initial 5% of data and the maximum cumulative species richness value, (3) the point on the curve that is closest to the top right corner (0,1), and (4) the point on the curve that maximizes the distance between the curve and the line between extreme points (Youden Index). See Figure S2 in Rowden et al. 2020 for a visual explanation of these methods using hypothetical curves.

Identifying VMEs

We identify areas as VMEs that meet the FAO VME criteria of structural complexity (FAO 2009), where visual data report VME indicator taxa in densities equal to or greater than our regional VME density threshold.

Areas for protection

Fishery closure areas of 1 nautical mile were drawn around areas identified as VMEs to prevent Significant Adverse Impacts (SAIs) to those VMEs.

RESULTS

VME density threshold

The density of VME indicator taxa was calculated for n = 221 50-m^2 segments of the AUV transects on Cobb Seamount. The number of associated species (richness) ranged from 2 to 16 per 50-m^2 transect segment, with a mean of 7.4 (SD = 2.5). The density of VME indicators ranged from 0 to 1.16 colonies m^{-2}, with a mean of 0.15 colonies m^{-2} (SD = 0.19).

Assessment of GAM fit showed the model performed well with an adjusted R^2 of 0.46 (Table 1). The final average density threshold is 0.6 VME indicator taxa colonies m^{-2} (SD = 0.1, lower 95% CI = 0.5 and upper 95% CI = 0.7) (Table 2).

Table 1. Results of GAM used for identifying the VME density threshold in Cobb Seamount visual data. Estimated degrees of freedom (edf), F statistic and p-value are given for each model term.

Term	*edf*	*F*	*p-value*
VME density	*1.41*	*1.61*	*0.14*
Depth	*5.19*	*12.72*	*<0.001*
Transect	*2.78*	*3.00*	*<0.001*
Adjusted R^2	*0.46*		
Deviance explained	*48.6 %*		
AIC	*949.58*		

Table 2. VME indicator taxa density threshold results in VME indicator taxa colonies m⁻² with reported average and standard deviation.

Threshold Methods	Threshold Results
1	0.53
2	0.74
3	0.61
4	0.52
Average	0.60 (SD = 0.1)

Identification of VMEs

Only 4.5% of the 50 m^2 transect segments (10 of 221) had VME density values above the threshold of 0.6 VME indicator colonies m^{-2}. This resulted in five VME areas identified as VMEs. VMEs ranged in size from 50 - 200-m^2 and ranged in depth from approximately 500 m to 1150 m (Figure 3). VMEs were identified on two out of the four AUV transects on Cobb Seamount. The largest VME areas occurred in the deepest areas of transect AUV 4. VMEs on transect AUV-4 included colonies of gorgonian corals (290 colonies) with some black corals (45 colonies) and a few glass sponges (13 colonies), while the VME on transect AUV 2 consisted of mainly black corals (30 colonies) and only one gorgonian and one glass sponge. The total area assessed for VMEs in this study was 0.011 km^2 and the total area identified as VMEs was 0.0005 km^2, resulting in 4.5% of assessed area identified as VME.

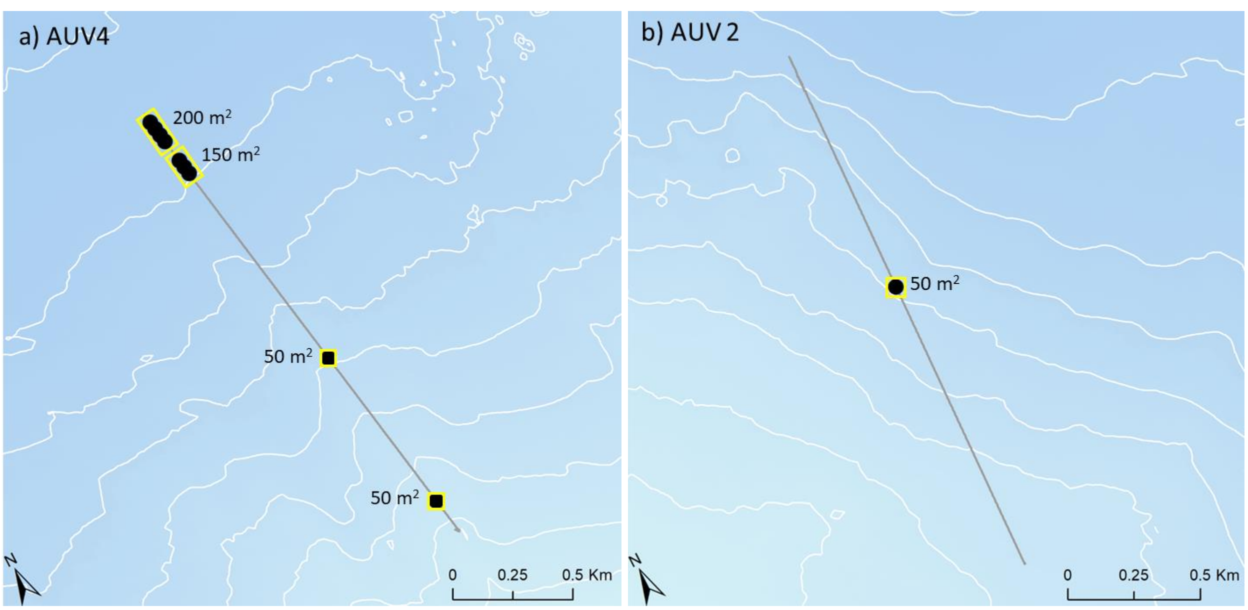

Figure 3. VMEs identified on Cobb Seamount on transect AUV 4 (a) and AUV 2 (b). Yellow boxes surround spatially adjacent transect segments (black dots) grouped into VME areas ranging in size from 50 – 200

m². *White lines are 100 m depth contour lines and grey lines are AUV transect lines (see Curtis et al. 2015).*

Protection from SAIs

Two areas are proposed to protect VMEs on Cobb Seamount, based on a 1 nautical mile fisheries closure area around the identified VMEs. The northwest protection area (transect AUV 4) is 24.7 km^2 (3.6 km east-west by 6.5km north-south) and the northeast protection site (transect AUV 2) is 13.7 km^2 (3.6 km east-west by 3.6 km north-south) (Figure 4). The coordinates for protection area vertices are provided in Table 3.

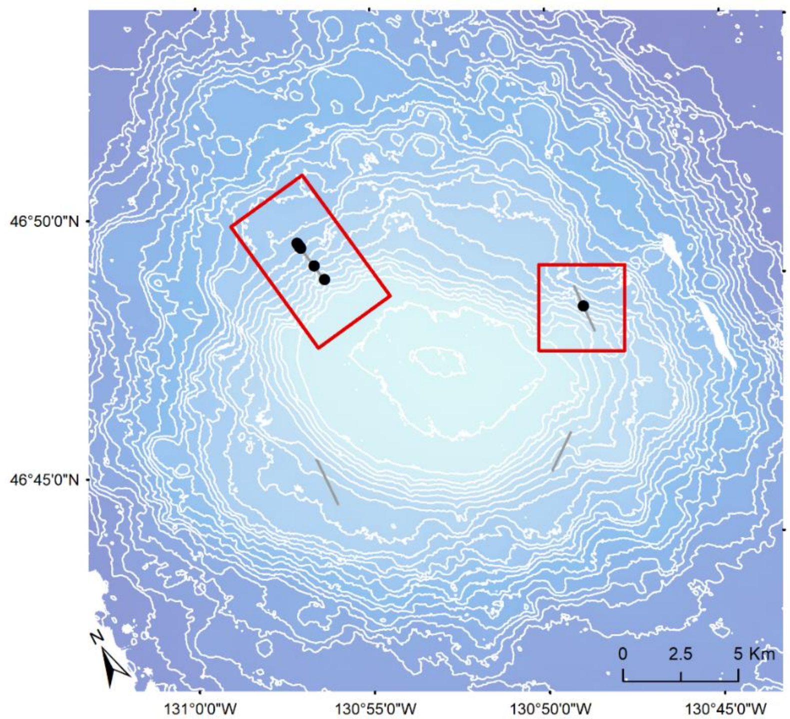

Figure 4. Proposed areas for protection at VME sites on Cobb Seamount. Black dots represent areas identified as VMEs using visual data collected with NOAA's AUV (transect lines in grey) (Curtis et al. 2015). Red rectangles represent the proposed area for fisheries closure based on 1 nm move-on distance following VME encounters (NPFC 2023a; NPFC 2023b).

Table 3. Coordinates (decimal degrees) of bounding box vertices for the proposed areas for VME protection on Cobb Seamount

Area	Latitude	Longitude
Northwestern Cobb Seamount	46.8178 N	130.872 W
	46.7703 N	130.861 W
	46.8277 N	130.825 W
	46.7802 N	130.814W
Northeastern Cobb Seamount	46.7759 N	130.735 W
	46.7675 N	130.694 W
	46.7482 N	130.756 W
	46.7399 N	130.716 W

The proposed fisheries closures will overlap with an area that has produced 15% of the historical (2006-2020) sablefish landings from Cobb Seamount (9% and 6% for the northwestern and northeastern areas, respectively).

CONCLUSION

We identify five 50-m^2 areas as VMEs on Cobb Seamount based on the visual surveys with NOAA's AUV as described in Curtis et al. (2015). To protect these areas from SAIs we propose a fisheries closure area surrounding the VMEs of 1 nautical mile, based on the NPFC move-on rule (NPFC 2023a; NPFC 2023b). This results in two VME protection sites on Cobb Seamount.

Relatively few studies have attempted to quantify a threshold of either habitat suitability or abundance that qualifies a site as a VME, presenting a significant challenge for generating effective spatial management from modeling results. The threshold we calculated (average of 0.6 m^{-2}, 95% CI range of 0.5-0.7) is a reasonable estimate based on comparison to previous work (e.g. Rowden et al. 2020, 0.11 colonies m^{-2} at the 50m^2 spatial scale), as well as a decision flow chart derived from expert opinion (Baco et al. 2023).

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