The following supplements accompany the article

Spatial analyses reveal conservation benefits for cold-water corals and sponges from small changes in a trawl fishery footprint

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Supplement 1 – Data inputs for maximum entropy species distribution models

Occurrence records. The occurrence records of corals and sponges used in this study were obtained from catch records of the Fisheries and Oceans Canada (DFO) groundfish trawl surveys (Olsen et al. 2009), and from DFO invertebrate general status report (P.D. Boutillier & G. E. Gillespie unpubl.). The location of catch records from trawl surveys were based upon the start point of trawl tows with a target bottom time of 20 minutes (Olsen et al. 2009). The DFO invertebrate general status report is compiled from 37 different sources that include other DFO research surveys (eg. tanner crab survey and shrimp trawl survey), private collections and museum records (eg. Royal Ontario Museum, Royal British Columbia Museum). The Alcyonacea model had the least number of occurrence records (n = 74), while the Hexactinellida model had the most occurrence records available for model fitting (n = 154) (Table S1.1). Records dated as far back as the 1960s, although the majority of occurrences were recorded since the year 2000.

Environmental predictors. The environmental predictors were selected among all available, relevant predictors within our study area (Fig. S1.1, Table S1.2). We began with 19 environmental predictors and removed highly correlated predictors until 10 were selected for inclusion in final models. We assessed correlation using Pearson's correlation coefficient (r) and removed predictors with $|r > 0.8|$. All the removed predictors were related in terms of the environmental variable that was represented. For example, maximum temperature was highly correlated with summer temperature. When two variables were highly correlated, we preferentially retained maximum, minimum or ranges of environmental variables, while discarding seasonal variables.

A number of physical oceanographic variables were based on a tidal circulation model of the eastern North Pacific (Foreman et al. 2008). These variables included seasonal, maximum, and minimum bottom temperature and salinity, bottom tidal speed, and summer and winter non-tidal currents. These predictors were calculated at variable resolutions from 100 m in coastal channels up to 70 km in the deep ocean. Temperatures and salinities were estimated from conductivity-temperature depth, bottle expendable bathy-thermograph and Argo data from NOAA, Marine Environmental Data Service and Institute of Ocean Sciences archives (Foreman et al. 2008). Average summer and winter non-tidal currents are based on monthly mean values from the National Centers for Environmental Predictions (NCEP).

Depth was obtained from an integrated 100 x 100 m^2 bathymetric grid (E. Gregr, unpublished data) derived from Fisheries and Oceans Canada and National Oceanic and Atmospheric Administration source data. Slope was calculated from depth using the terrain() function from the “raster” package in R (Hijmans & van Etten 2013; R Core Team 2013), which uses the eight neighbouring cells to calculate slope in degrees.

Chlorophyll *a* bloom frequency was calculated using the algal_1 band from the Medium Resolution Imaging Spectrometer (MERIS) of the European Space Agency Environmental Satellite (ENVISAT) for spring 2007 to 2011 (E. Gregr, unpublished data). This variable represents the number of months in which each grid cell was classified as undergoing chlorophyll *a* blooms ([*chla*] > 2.0

mg/m^3) from March 18th to June 21st in 2007 to 2011. Therefore, values range from 0 to 20, with a value of 20 representing blooms occurring every month within this range.

Maximum entropy model settings. The Maxent models were created using the default settings of the Maxent species distribution modeling software, version 3.3.3k (Philips et al. 2006). These settings included: a) number of randomly selected background points = 10,000; b) default prevalence = 0.5; c) output = logistic; d) feature selection = auto; e) regularization parameter = 1. These default settings were shown to be appropriate for a similar set of species distribution models for coral groups in the Pacific region of British Columbia (Finney 2009).

TABLES AND FIGURES

Table S1.1. Presence record data inputs for the Alcyonacea, Hexactinellida, Pennatulidae and Halipteridae species distribution models.

Species	Source	Year range	Number Occurrences
Alcyonacea	DFO Groundfish trawl survey	1987-2011	63
	DFO Invertebrate database	1960-2006	11
Hexactinellida	DFO Groundfish trawl survey	2005-2011	89
	DFO Invertebrate database	1976-2000	65
Pennatulidae	DFO Groundfish trawl survey	2000-2011	62
	DFO Invertebrate database	1960-2011	60
Halipteridae	DFO Groundfish trawl survey	2003-2011	62
	DFO Invertebrate database	1966-2008	52

Table S1.2. Environmental predictors that were considered within the study area. Highly correlated predictors |r > 0.8| were removed from the final species distribution models.

Environmental Layer	Units	Source	In final model
Depth	Meters	Fisheries and Oceans Canada and National Oceanic and Atmospheric Administration bathymetry	Yes
Slope	Degrees	Calculated from depth using terrain() function in R raster package	Yes
Chlorophyll-a bloom frequency	Frequency of blooms during spring months from 0-20	Medium Resolution Imaging Spectrometer (MERIS)	Yes
Flow – summer (non-tidal)	Meters/second	Foreman et al. 2008	Yes
Flow –winter (non-tidal)	Meters/second	Foreman et al. 2008	Yes
Tidal flow	Meters/second	Foreman et al. 2008	Yes
Salinity range	PSU	Foreman et al. 2008	Yes
Salinity summer	PSU	Foreman et al. 2008	No
Salinity winter	PSU	Foreman et al. 2008	No
Salinity fall	PSU	Foreman et al. 2008	No
Salinity spring	PSU	Foreman et al. 2008	No
Salinity max	PSU	Foreman et al. 2008	No
Salinity min	PSU	Foreman et al. 2008	Yes
Temperature range	Celsius	Foreman et al. 2008	No
Temperature summer	Celsius	Foreman et al. 2008	No
Temperature winter	Celsius	Foreman et al. 2008	No
Temperature fall	Celsius	Foreman et al. 2008	No
Temperature spring	Celsius	Foreman et al. 2008	No
Temperature max	Celsius	Foreman et al. 2008	Yes
Temperature min	Celsius	Foreman et al. 2008	Yes

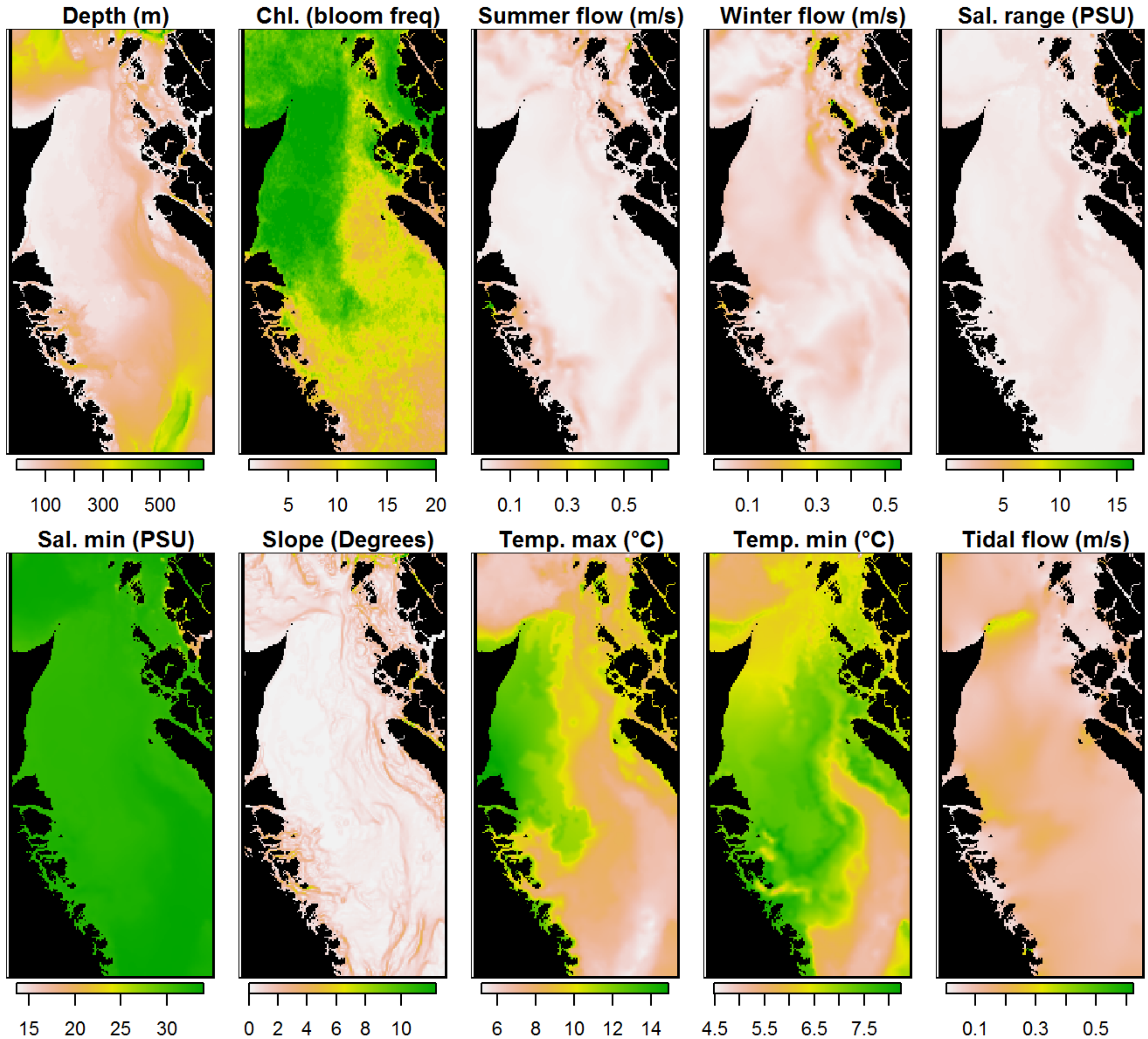

Figure S1.1. Environmental predictors included in the final species distribution models.

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Supplement 2 – Effects of alternative thresholds for species distribution models on predicted trade-offs

The selection of a threshold for presence-absence conversion of species distribution models is an important decision that determines the extent of predicted presence locations (Jiménez-Valverde & Lobo 2007; Liu et al. 2013). For our analysis, we did not convert to binary presence-absence values, but instead applied a threshold that transformed low habitat suitability index (HSI) values to zero in order to prioritize conservation towards areas that are most likely to contain corals and sponges. However, if this threshold is set too high, then areas containing corals and sponges may have HSI transformed to zero, resulting in false negative prediction errors. Therefore, we examined how alternative threshold methods, including not applying any threshold, affected the predicted trade-offs between landings value and protection of coral and sponge habitat.

We compared three threshold methods: the maximised sum of specificity plus sensitivity (SSS) threshold, the least presence (LP) threshold, and no threshold. The LP threshold is equal to the lowest HSI where a presence records occurs, and is therefore a conservative threshold without false negative prediction errors, but with a high probability of false positive errors (Liu et al. 2013). The SSS threshold is the value that maximises the sum of specificity and sensitivity, which are the proportions of pseudo-absence records and presence records that are correctly predicted, respectively (Jiménez-Valverde & Lobo 2007). The SSS threshold may result in false negative errors, but is more robust than LP because the rate of false positive errors is lower (Jiménez-Valverde & Lobo 2007; Liu et al. 2013). Thresholds were applied separately to the model predictions for the Halipteridae and Pennatulidae families, and then HSI values in each grid cell were summed and rescaled between 0 and 1. See Table S2.1 for the threshold values obtained for each model.

RESULTS

Results described here are based on landings value averaged over all years (1996-2011) and including Pennatulacea as a conservation target. Landings values remained at their total values in the absence of closures up to conservation targets of 0.7 regardless of the threshold method used (Fig S2.1). The proportion of landings value remaining open was higher for the SSS threshold compared to the LP threshold for conservation targets above 0.8, but slightly lower for conservation targets of 0.75 and 0.8. The LP threshold resulted in larger areas being closed over the entire range of conservation targets because the predicted extent of suitable coral and sponge habitat was greater. For example, using the LP threshold with a conservation target of 0.99 resulted in 95.8% of the study area being closed and landings value being reduced to 51.6% of the total compared to 77.2% of the study area closed and 63.0% of landings value remaining using the SSS threshold. Using no threshold resulted in similar trade-off predictions to the LP threshold; the proportion of remaining landings value did not differ by more than 1% over the entire range of conservation targets between no threshold and the LP threshold.

Table S2.1. Threshold values, and mean and median habitat suitability indices for the species distribution models.

Model	Sum of sensitivity plus specificity (SSS) threshold	Least presence (LP) threshold	Mean HSI value	Median HSI value
Alcyonacea	0.256	0.039	0.130	0.0405
Hexactinellida	0.336	0.014	0.176	0.0739
Pennatulidae	0.284	0.043	0.149	0.0630
Halipteridae	0.295	0.044	0.190	0.0959

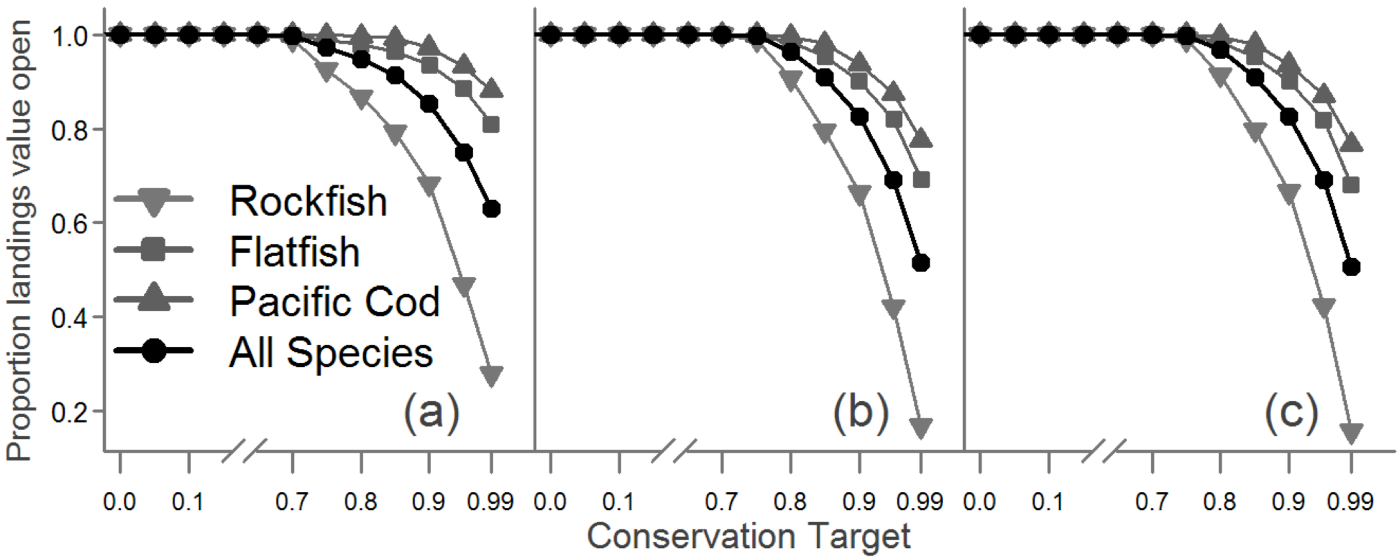

Figure S2.1. Proportion of the total landings value within areas open to trawling as a function of the conservation target for protection of coral and sponge habitat. Panel (a) uses the sum of specificity and sensitivity (SSS) threshold to convert low habitat suitability indices to zero; panel (b) uses the least presence (LP) threshold; panel (c) does not use any threshold.

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