Comparison of data filtering methods for indices of abundance from a recreational fishery survey

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Abstract

This is the abstract.

Keywords: keyword1, keyword2

1. Introduction

Integrated fisheries stock assessment models utilize a variety of data sources to develop the most complete picture of the stock and current status in relation to management thresholds. Catch data is a primary input to stock assessments and informs the overall magnitude of the stock. Catch data are often input with the assumption that the removals are known with absolute precision, i.e., there is no error associated with removals. Fisheries survey and catch data are used to develop standardized indices of abundance that inform fisheries stock assessment models (Maunder and Punt, 2004). A standardized index of abundance informs the model on the size of the population during a particular year or years, either as an absolute value or a relative value. An absolute index of abundance is an estimate of the true density of fish in a particular area and is most commonly estimated from visual survey data. An absolute index is oftentimes input as a single year due to the high cost associated with determining total fish abundance within an area (Love et al., 2009).

More often, an index of abundance is a relative measure of the population and requires a time series to inform the stock assessment model. An index of relative abundance assumes that changes in the index are proportional to changes of abundance in the population (Harley et al., 2001). Fishery-independent data collected from standardized survey designs provide a more unbiased estimation of the trend in a fisheries population. However, fishery-independent surveys are costly, labor intensive and often require a long time series to be considered informative in fisheries stock assessments. When fishery-independent data are not available, stock assessment scientists make use of the best available data, which may often only include fishery-dependent data.

Catch per unit effort (CPUE) is a common metric available from fisheries and collected on surveys. Depending on the stock assessment model and the available data for a particular fish stock, an index of stock status can have a large influence on end year estimation of stock status (find examples).

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[1] This is the first author footnote.

[2] Another author footnote, this is a very long footnote and it should be a really long footnote. But this footnote is not yet sufficiently long enough to make two lines of footnote text.

[3] Yet another author footnote.

There are both advantages and disadvantages that must be considered when using to fishery-dependent data. Fishery-dependent data are collected directly from the the fishery and are less costly than the whose operations are not constrained by sampling designs, but dependent on the behaviors of the captain and vessel and, in the case of recreational trips, customer preference.

Fishery-dependent data are only collected from areas legally open areas can be collected, i.e., areas closed to fishing are not sampled. In California, this includes a network of marine protected areas (MPAs), rockfish conservation areas (RCAs) developed based on depth closures, and varying seasonal and depth closures that vary temporally and spatially along California's coastline. Fishery-independent surveys are conducted using a scientific study design and, depending on the study, are not always confined to the same regulations as the commercial and recreational fishing sectors. In an ideal situation, both fishery-dependent and fishery-independent surveys would used to inform the stock assessment model.

Fishery-dependent surveys sample the fishing fleets and are subject to potential sampling biases. The sampling is dependent on the fishing boat's behavior, which is to maximize catch. Sampling of the fishing fleet is often opportunistic based on the availability of samplers and the availability of trips to sample. Sampling the fisheries can also be constrained to the current regulations, which may prohibit the retention of a species or fishing at certain depths, i.e., California Department of Fish and Wildlife has varying spatial and temporal depth and season closures implemented through six management regions. There is also a fairly new network of Marine Protected Areas (MPAs) designated from 2007-2012 that prohibit recreational fishing, and are therefore areas no longer sampled by the recreational fishing fleet. However, the advantage to fishery-dependent sampling the reduced program cost compared to a more intensive fishery-independent survey.

The Pacific Fishery Management Council manages groundfish off the West Coast of the United States under the Groundfish Fishery Management Plan (FMP). The FMP includes 64 species of rockfish, _____ of which do not have full stock assessments. Many of these species, especially those nearshore, are assessed using multiple assessment models to represent areas with distinct fishing histories, communities regulations. Along the U.S. West Coast, even if the stock assessment is categorized as data rich, oftentimes the only index of abundance available is from a fishery-dependent CPUE time series of observed recreational angler catch rates (Cope, 2013).

A common characteristic of ecological data is a high proportion of zero observations across samples and the question as to whether the sampling occurred within the species' habitat and the species was not observed or if the sampling occurred outside of the species' habitat (structural zeroes). Fisheries survey data are often subset to exclude structural zeroes using the Stephens-MacCall method (2004), which models the probability of observing the target species given the other the presence/absence of other species. However, the onboard observer survey collected location-specific information on each observer fish encounter. To subset the onboard observer survey data and exclude structural zeroes, we used the positive catch locations as a proxy for suitable habitat.

We evaluated data from a recreational onboard observer program, which collects location- and species-specific CPUE information from the commercial passenger fishing vessel (CPFV; also know as party boat) fleet (Monk et al., 2014). The data are collected at the level of a fishing drift and fine-scale habitat data are available for a large fraction of California state waters. To determine the impact and effect of developing indices with data from known fishing locations mapped to rocky reef habitat to indices without known habitat information, we used the same data set to develop standardized indices of relative abundance based on three different data filtering methods. The three data treatment methods included an aggregation of the catches at the drift-level data to a trip, treating the drift-level data as if specific locations were not available, and lastly filtering the drift-level data based on known locations. In addition, for the model filtered based on known rocky reef substrate, we weighted the index by area of habitat within pre-defined regions.

cut from another place: The onboard observer data provide a high-resolution of catch, effort and the ability to map the fishing drifts to fine-scale habitat data. This paper explores methodological differences in data *treatment to see what we gain by having the high-resolution habitat data and using that as a mechanism to filter out trips that are not targeting the species of interest*

This paper explores methodological differences in data treatment to determine changes in trends in indices and the associated error among three alternative assumptions and data filtering strategies. All of the methods described below started with the same subset of drifts from the onboard observer data, restricted to state waters and the years 2004-2016. In the case of application to stock assessments, all potential data are explored, which may be why trends in indices differ in this paper than what has previously been published in stock assessments. Since the most recent stock assessments in 2021, the data have undergone a major quality assurance effort by the authors.

2. Methods

2.1. Survey Data

The California Department of Fish and Wildlife (CDFW) began a fishery-dependent onboard observer survey of the Commercial Passenger Fishing Vessel (CPFV or party/charter boat) fleet in 1999. In 2004, the survey became part of the California Recreational Fisheries Survey (CFRS) that includes additional surveys to quantify the catches and effort of the recreational fleet. Sampling effort for groundfish-targeted CPFV trips was distributed in proportion to fishing effort, and approximately 21% of the CDFW observed groundfish trips were north of Point Conception. North of Bodega Bay, California the majority of charter boats are smaller 6-pack vessel that may not have the capacity to carry an observer onboard. In 2001, the California Polytechnic State University Institute of Marine Science, San Luis Obispo (Cal Poly) began a supplemental onboard observer program of the CPFV fleet based in Port Avila and Port San Luis along the Central Coast. Protocols for the Cal Poly survey were the same as the CDFW survey, with the exception that Cal Poly measured retained and discarded fish from observed anglers. The additional of the Cal Poly data to the CDFW survey increases the sample sizes of observed trips out of San Luis Obispo county by an average of 155% from 2004-2016.

On a trip, observers recorded information for each drift, each time lines were in the water. Just prior to the start of each fishing drift, the sampler selected a subset of anglers to observe, at a maximum of 15 anglers per drift. The sampler recorded all fish encountered (retained and discarded) by the subset of anglers as a group. Samplers also recorded the time fished (starting when the captain announced “Lines down” to when the captain instructed anglers to reel lines up), coordinates of the fishing drift (start latitude/longitude and/or end latitude/longitude), and minimum and maximum bottom depth. Fish encountered by the group of observed anglers were recorded to the species level as either retained or discarded, providing a count of each species at a particular location. For these analyses we modeled only the retained catch. The catch and fishing time of an individual angler were not recorded. Additional details can be found in Monk et al. (2014).

We explored the methods described in the following sections to develop indices of abundance for six species or species complexes of management interest: black rockfish (*Sebastes melanops*), blue and deacon rockfish complex (*Sebastes mystinus*, *Sebastes diaconus*), brown rockfish (*Sebastes auriculatus*), China rockfish (*Sebastes nebulosus*), gopher rockfish (*Sebastes carnatus*), and vermilion and sunset rockfish complex (*Sebastes miniatus*/*Sebastes crocotulus*). Two genetically distinct species compose a cryptic species pair that are often visually indistinguishable, or for other reasons, were not recorded separately in surveys or catch histories. Gopher rockfish was assessed as part of a species complex with black-and-yellow rockfish (*Sebastes chrysomelus*) in 2019, but were visually identifiable and the data in this paper represents only gopher rockfish (Monk and He, 2019).

2.1.0.1. Stephens-MacCall Data Filtering.

We used the Stephens-MacCall approach to filter data for the trip-level data and also the drift-level data assuming no location information. To create a trip from the drift-level data, we aggregated the retained fish catches within a trip. The trip-level effort was calculated as angler days, using the average number of observed anglers across all drifts on a trip. The trip-level index used all available data before any filtering was done to exclude individual drifts with missing effort or location data.

The second filtering approach retained data a the drift-level, but assumed no knowledge of the fishing location, besides the port of landing and the data were filtered using the Stephens-MacCall approach.

The Stephens-MacCall (2004) filtering approach was used to predict the probability of encountering the target species, based on the species composition of the catch in a given trip. The method uses presence/absence data within a logistic regression to identify the probability of encountering a target species given the presence or absence of other predictor species. This method is commonly used to filter data that are collected dockside after a vessel returns to port. Prior to applying the Stephens-MacCall filter, we identified potentially informative predictor species, i.e., species with sufficient sample sizes and temporal coverage (present in at least 5% of all trips) to inform the binomial model. The remaining species all co-occurred with the target species in at least one trip and were retained for the Stephens-MacCall logistic regression. Coefficients from the Stephens-MacCall analysis (a binomial generalized linear model) are positive for species that are more likely to co-occur with the target species, and negative for species that are less likely to be caught with target species.

While the filter is useful in identifying co-occurring or non-occurring species assuming all effort was exerted in pursuit of a single target, the targeting of more than one species or species complex ("mixed trips") can result in co-occurrence of species in the catch that do not truly co-occur in terms of habitat associations informative for an index of abundance. Stephens and MacCall (2004) recommended including all trips above a threshold where the false negatives and false positives are equally balanced. However, this does not have any biological relevance and for this particular data set where trained observers identify all fish. We assumed that if the target species was encountered, the vessel fished in appropriate habitat. Stephens and MacCall (2004) proposed filtering (excluding) samples from index standardization based on a criterion of balancing the number of false positives and false negatives from the predicted probability of encounter. False positives (FP) are trips that are predicted to encounter the target species based on the species composition of the catch, but did not. False negatives (FN) are trips that were not predicted to encounter the target species, given the catch composition, but caught at least one target species.

Of interest for the index of abundance is the elimination of trips that had a low probability of catching the target species given the other species caught on the trip. Therefore, we retained all of the trips that caught the target species and those trips that did not catch the target species, but had a probability higher than the threshold balancing the false negatives and false positives. This practice has commonly been used in recent stock assessments of rockfish on the West Coast.

The fe fish. Species that never co-occurred with the target species and species present in fewer than 3% of alull data from 2004-2016 contained 19,425 drifts that aggregated to 2,252 trips that retained at least only trips were excluded from the Stephens-MacCall analysis.

For the drift-level data that assumed no knowledge of habitat information, the Stephens-MacCall filter was applied with each individual drift as a sample. Species that never co-occurred with the target species and those present in fewer than 1% of all drifts were removed to reduce the number of species to those that were informative.

CPUE angler day for the drift level no habitat

2.1.0.2. Habitat-informed Data Filtering.

This paper limited the data to observations within California state waters north of Point Conception ($34°27'N$), which were mapped at a resolution of 2 m by the California Seafloor Mapping Program (CSMP). Rough and smooth substrate was identified by CSMP using two rugosity indices based upon bathymetric data, surface:planar area, and vector ruggedness measure (VRM). We considered areas identified as 'rough' as reef habitat. Individual reefs at the finest scale were defined as raster cells of rough habitat greater than

200 m apart. The distance was chosen based on evidence that a number of nearshore rockfish exhibit site fidelity and a number of tagging studies have recaptured close to original capture sites (Lea et al., 1999; Matthews, 1985; Hannah and Rankin, 2011; Hannah et al., 2012). Contiguous raster cells classified as hard substrate remained as a singular reef, regardless of size. Reefs were further defined with a 5 m buffer to account for potential error in positional accuracy. The area of a reef was calculated to exclude portions of the reef that extended outside of California state waters (further than 3 nm from shore). The mapped area does not include the white zones close to shore. Individual fishing drifts were assigned to reefs based on the recorded start location, given that the drift end locations were not always recorded.

2.1.0.3. Indices of Abundance.

Standardized indices of abundance were generated for each data filtering method and an area-weighted index was developed from the drift-level habitat data. All indices were modeled using Bayesian generalized linear models (GLMs) and the delta method (Lo et al., 1992). The delta method models the data with two separate GLMs; one for the probability of encountering the species of interest from a binomial likelihood and a logit link function and the second GLM models the positive encounters with either gamma or lognormal error structure.

The response variable for the positive models was angler-retained catch per unit effort. Year was always included in model selection, even if it was found to not be significant, because the goal of the index of abundance was to extract the year effect.

Covariates for the trip-level data and drift-level data without habitat included wave (a 3-month aggregated period of time) and county of landing. Covariates considered for the drift-level data with habitat filters included, aggregated reef area and wave. Each drift-level index with habitat information was also modeled to include a year/reef iteration and weighted based on reef area.

Year was always included in the trip-level data were 3-month wave and county of landing. Covariates considered for the drift-level data included, region, 3-month wave, and xxxx.

The gamma or lognormal error distribution was chosen via maximum likelihood AIC from the full model with all covariates. Model selection for the binomial and positive observation models were also selected using AIC and unless very different predictors were selected, the same predictors were used in each of the two Bayesian models. The Bayesian models were run with 5,000 iterations and uninformative priors. Posterior predictive model checks were examined for both the binomial and positive observation models. including xxxxxxx. We constructed the final year index by multiplying the back-transformed posterior draws from the binomial model with the exponentiated positive model draws, and taking the mean and standard deviation for each year.

The area-weighted index was developed by extracting the posterior draws of from each year and area combination of the binomial and positive posterior predictions, and then summing across the product of the posteriors weighted by the fraction of total area within each reef.

To better compare the resulting indices across the three data filtering methods and the area-weighted index, each index was scaled to its mean value.

Versions of the indices filtered based on habitat were approved by the Pacific Fisheries Management Council's Science and Statistical Committee for use in the 2013 stock assessments and have been used all of the stock assessment process since. Comparisons should not be drawn between the indices presented here and the stock assessment documents as the indices in this paper were simplified to develop direct comparisons among methods.

3. Results

3.1. Reef Delineation and Sampling Effort

At the finest scale, a total of 108 individual reefs of rocky habitat were defined in California state waters from Point Conception to the California/Oregon border. After exploratory analyses and considering the the availability of data, the reefs were grouped into eight regions. The areas of the Farallon Islands off the coast of San Francisco and the deeper areas of Monterey Bay were aggregated for modeling due to the deeper areas fished within these two regions and the nature of depth as an important descriptor of nearshore rockfish distributions. The rocky reef habitat was aggregated to ensure adequate samples for modeling the indices of abundance. The region defined from the California/Oregon encompasses 49% of the total rocky habitat in state waters by area, but only 12% of the observed drifts fished in this area. Each of the four remaining nearshore regions San Francisco to Point Conception averaged 11% of the available habitat, with the number of drifts from Big Sur to Point Conception increased by 155% with the inclusion of data from Cal Poly's onboard observer program.

The regions of rocky habitat were further aggregated depending on available data for each species in order to model the GLM with positive encounters. Black rockfish is distributed more towards the north and reflected in the aggregation of data from Santa Cruz and south, whereas brown rockfish is distributed across the coast, but not as common in all areas.

3.2. Data Filtering

Trip level data resulted in xxxx trips

The data contained a total of 19,425 fishing drifts and after removing drifts with missing effort information (time fished or observed anglers), 19,180 remained. To further remove drifts that may not accurately define a successful fishing drift or data errors, the upper and lower 1% of the recorded fish time and observed anglers were removed. This resulted in fishing drifts lasting between three and 96 minutes fished with three to 15 observed anglers, reducing the data to 18,591 fishing drifts.

For indices incorporating habitat information, we filtered the data on depth to retain 99% of drifts, which resulted in a depth cutoff of 46.6 fathoms and retained 18,405 drifts. We did not use depth as a predictor in the indices. The fishery was closed deeper than 40 fathoms for the entire time period from 2004-2016, and the additional 6 fathoms is within the scope of error given the rugous bottom habitat.

The distance from rocky reef composed the last filter for indices including habitat. Using the drifts with the target species, we retained 90% of drift from the cumulative frequency of distance to rocky habitat. The cutoff for blue, China and gopher rockfish was six meters, eight meters for vermilion rockfish, 14 meters for black rockfish and 16 meters for brown rockfish.

The percent of the samples retained for each data method differed by species, but followed the general trend that the lowest percent of samples were retained from the Stephens-MacCall filtering at the drift level, ranging from 12% of samples retained for China rockfish and 54% for blue rockfish. A much higher percent of samples were retained both from the other two methods, with an average of 83% of drifts retained when habitat was included as a filter. The species retained for the trip-level and drift-level Stephens-MacCall filtering were similar across species

For the drfit level data, the Stephens-MacCall data does retain drifts off the reefs

Data filtering for the indices with data aggregated to the trip-level and using the status quo of retaining all positive observations resulted in a high proportion of positive samples (0.70 - 0.86) for all species.

The Stephens-MacCall data selection met c differences and similarities

Indices and how they differed by species

Changed in the CV (error) among the four indices for each species

4. Discussion

Lots to discuss!

When filtering and modelling data for a stock assessment, additional filtering steps would be taken, such as excluding areas where species are rare, e.e., south of Santa Cruz for black rockfish. However, this is also a function of the lower sampling rates along the coast north of San Francisco.

These models also do not account for distance to the nearest port, which has been shown to significantly impact the access to fish as well as historical fishing pressure....In addition, in 2004 the CDFW implements spatial and temporal closures to the recreational nearshore groundfish fishery. There are currently XX management areas and recreational fishing is restricted shoreward of 20 fathoms in the northern regions of the state to a deep as 40 fathoms in areas north of Point Conception.

The CRFS onboard observer program prioritizes trips with groundfish target species. There is not a mixed fishery in California north of Point Conception. The main bottom fish target is sanddabs

The recreational fishery in southern California is more of a mixed fishery and a trip is often not purely groundfish.

This is one

The high proportion of retained drifts across species when using habitat as a data filter indicates that hate majority of drifts occurred over, or very close to, rocky habitat.

Oftentimes a captain will position the vessel adjacent to rocky habitat so that the current allows the vessel to drift over the rocky habitat.

The fishery-dependent indices of abundance undergo higher levels of scrutiny during stock assessment reviews due to the nature of the data being driven by fisher behavior. The one fishery-independent survey for nearshore groundfish in California north of California tends to have similar trends to the fishery-dependent indices for the shallower nearshore species like gopher and China rockfish.

Both blue and black rockfish have high affinity to rocky habitat, but occur higher off the bottom and are both schooling species. It is not uncommon to have a a drift dominated by blue rockfish.

However, the Stephen-MacCall approach does not account for this by modeling presence/absence.

The choice of a threshold value to use as a data filter from the Stephen-MacCall method should be reviewed to determine how sensitive an index of abundance is to that method. The

Recent studies have identified the need to investigate the assumptions and uncertainty in relative indices of abundance from visual surveys (Bacheler and Shertzer, 2015; Campbell et al., 2015) and simulation studies (Siegfried et al., 2016).

Prioritize data for stock assessments (Magnusson and Hilborn, 2007).

Stock synthesis weighting of indices based on CVs - is the CV tighter for the fishery-independent survey to give it have an edge over the onboard observer survey?

CDFW sampler manual - "10 anglers should be the target number of observed anglers"

encompass the entire range of the species. However, the point of the exercise is to compare the two methods and these surveys are sampling the same habitats in the SCB

accepted for management (China, gopher/black-and-yellow, vermilion/sunset, blue/deacon, black, lingcod - cite assessments).

The characteristics and classification of the rocky habitat are not yet avaialble and this results all rock types treated as equ

Survey indices can be either absolute or relative. In the case of an absolute index of abundance, the entire population within the sampling area is accounted for and the index also provides information on the density of the fish species within that area as well as aid in scaling the population size within the stock assessment model. Most indices of abundance are relative due to the fact that the entire population within the survey area was not observed. Estimates of absolute abundance are difficult to obtain, especially for cryptic rockfishes. The cowcod (*Sebastes levis*) stock assessments is one of the only West Coast stock assessments that has incorporated an estimate of absolute abundance, derived from a visual survey (Love et al., 2009) add assessment. The majority of stock assessments include one or more index of relative abundance.

Data were limited to the California coast north of Point Conception ($34°27'N$). The composition of the fish communities in southern California differ, and the recreational fisheries are fundamentally different, with a higher percentage of trips targeting mixed species and pelagic and highly migratory species, as well as more limited access to rocky habitat nearshore. Point Conception is a biogeographic break (citation) and a number of stock assessments In addition, complete habitat data are not available for areas in southern California. The data were also temporally restricted to the years 2001-2016. Earlier and more recent data were excluded to preserve a dataset with the most consistent gear and depth regulations.

Composition data from recreational surveys had the largest impact on simulation results, but individual survey components did not have individual effects on benchmarks (Siegfried et al., 2016).
The onboard observer surveys decrease the amount of uncertainty, but relative to a fishery-independent survey, is still high….

A key assumption of the onboard observer programs is that fishing behavior remains the same when observers are not onboard the vessel. If a captain only fishes particular locations or targets a different suite of species when an observer is onboard the vessel, additional bias is introduced in the data

5. Tables

Table 1: The fraction of samples retained to develop indices of abundance after the filtering steps for each method from the where the trip level data started with 2,252 samples, the drift level (no habitat) started with 19,425 samples and the drift level with habitat started with 18,405 samples.{#tbl-samplesize}

Species	Trip level	Drift level (no habitat)	Drift level (habitat)
Black rockfish	0.408	0.252	0.886
Blue rockfish	0.871	0.538	0.830
Brown rockfish	0.490	0.243	0.855
China rockfish	0.515	0.121	0.808
Gopher rockfish	0.755	0.401	0.787
Vermilion rockfish	0.821	0.382	0.799

Table 2: The average fraction of positive observations across years after applying each filtering method.{#tbl-percentpos}

Species	Trip level	Drift level (no habitat)	Drift level (habitat)
Black rockfish	0.753	0.557	0.158
Blue rockfish	0.916	0.699	0.444
Brown rockfish	0.727	0.605	0.160
China rockfish	0.699	0.552	0.083
Gopher rockfish	0.843	0.648	0.310
Vermilion rockfish	0.869	0.623	0.295

Table 4: Area of rocky habitat in state waters aggregated to levels modelled for each species. The shaded blocks for each species indicate which areas ere aggregated to ensure appropriate samples sizes to explore an area-weighted index.

<table>
<tr><th>Rocky Reef Desginations</th><th>Blue rockfish & Vermilion rockfish</th><th>Black rockfish</th><th>Brown rockfish</th><th>China rockfish</th><th>Gopher rockfish</th></tr>
<tr><td>California border to San Francisco</td><td>439.546</td><td>439.546</td><td>439.546</td><td rowspan="2">547.970</td><td rowspan="4">685.573</td></tr>
<tr><td>San Francisco to Santa Cruz</td><td>108.424</td><td>108.424</td><td rowspan="2">158.676</td></tr>
<tr><td>Deeper rocky habitat</td><td>50.252</td><td rowspan="4">340.291</td><td>50.252</td></tr>
<tr><td>Moss Landing to Big Sur</td><td>87.351</td><td rowspan="2">177.775</td><td>87.351</td></tr>
<tr><td>Big Sur to Morro Bay</td><td>90.424</td><td rowspan="2">202.688</td><td>90.424</td></tr>
<tr><td>Morro Bay to Point Conception</td><td>112.264</td><td>112.264</td><td>112.264</td></tr>
</table>

Table 3: The average Coefficient of Variation (CV) for each index of abundance.

Species	Trip level	Drift level (no habitat)	Drift level (habitat)	Drift level Area-weighted
Black rockfish	0.671	0.364	0.449	0.443
Blue rockfish	0.257	0.099	0.142	0.134
Brown rockfish	0.858	0.679	0.240	0.242
China rockfish	0.151	0.233	0.301	0.320
Gopher rockfish	0.626	0.138	0.183	0.179
Vermilion rockfish	0.238	0.133	0.178	0.152

6. Figures

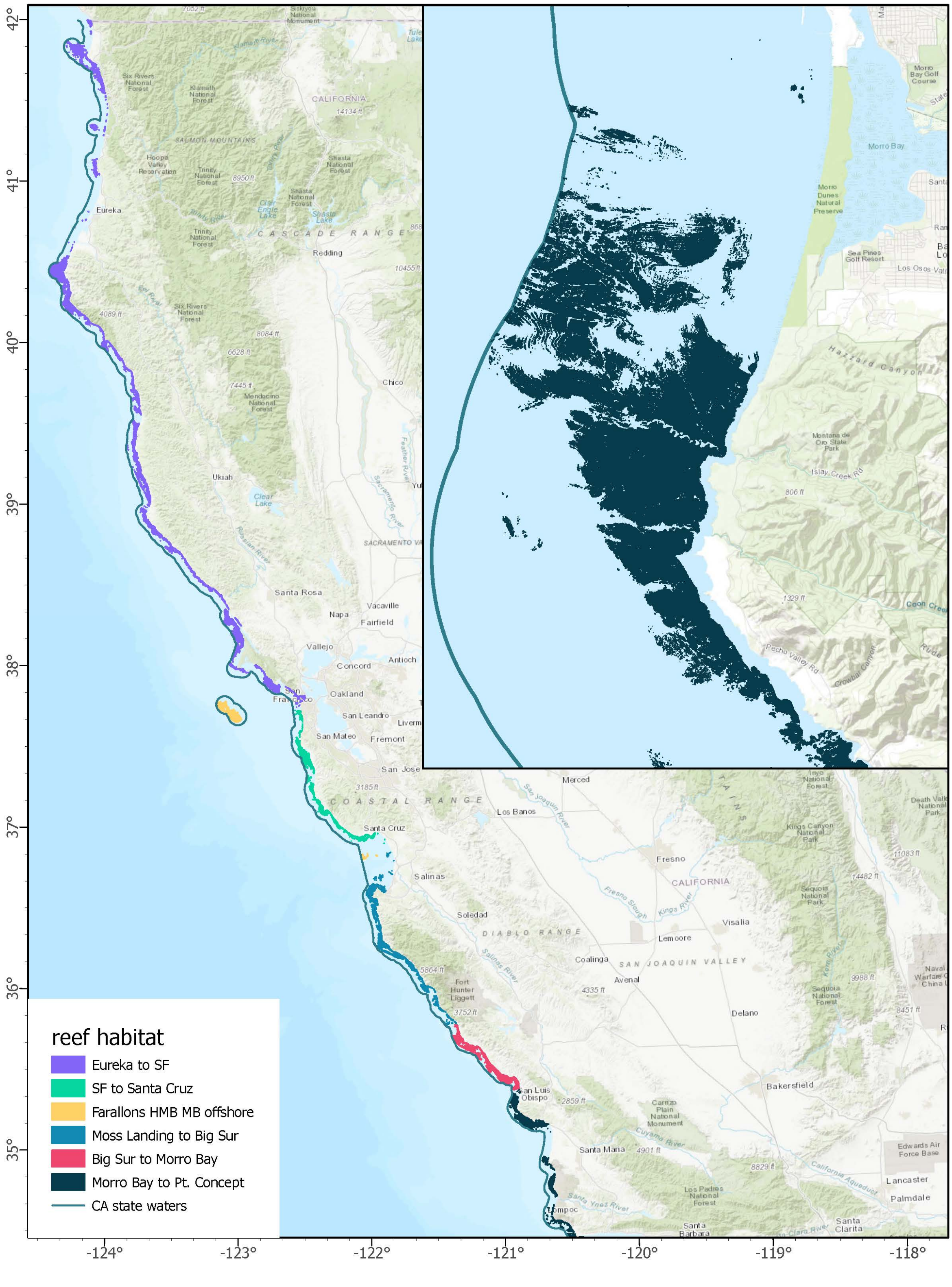
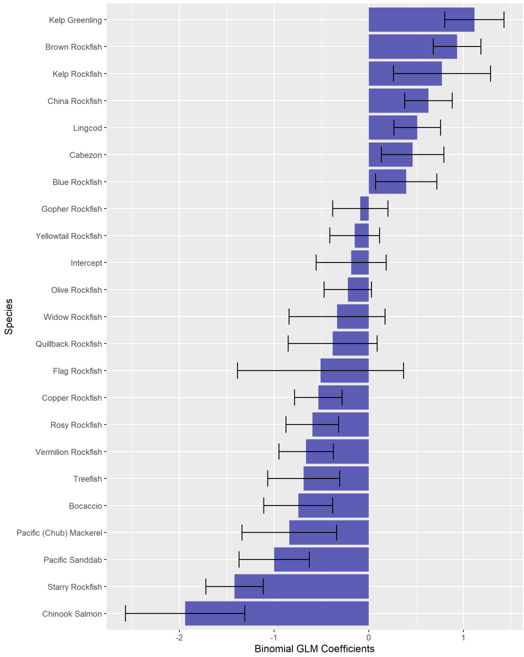
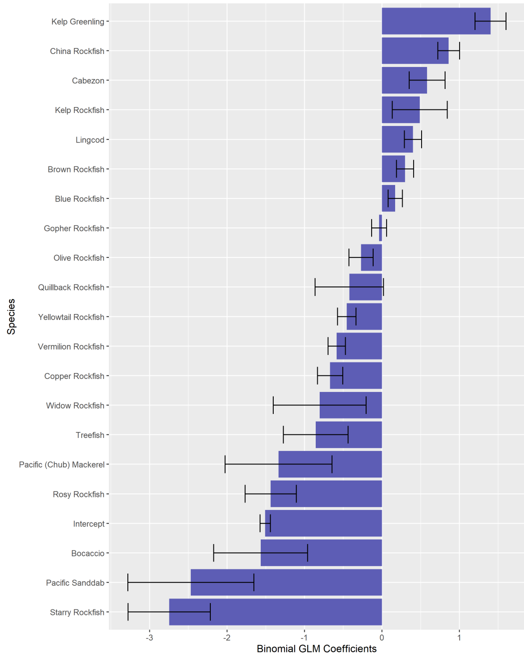


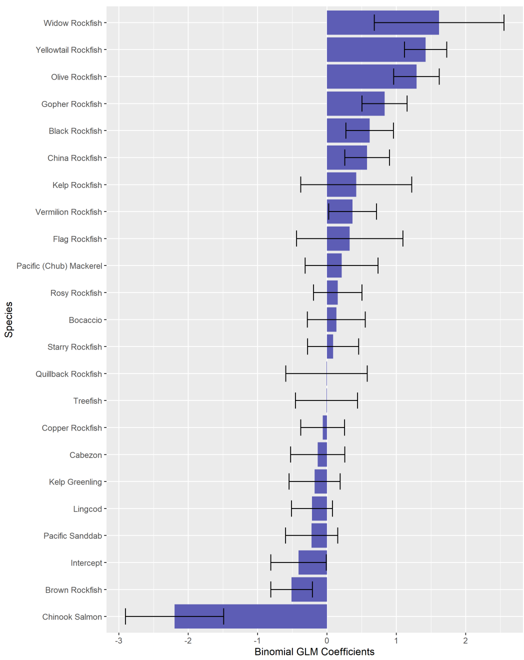
Figure 1: An example of the mapped rocky habitat in California state waters north of Point Conception and an inset of the state showing the 3 nm state water boundary



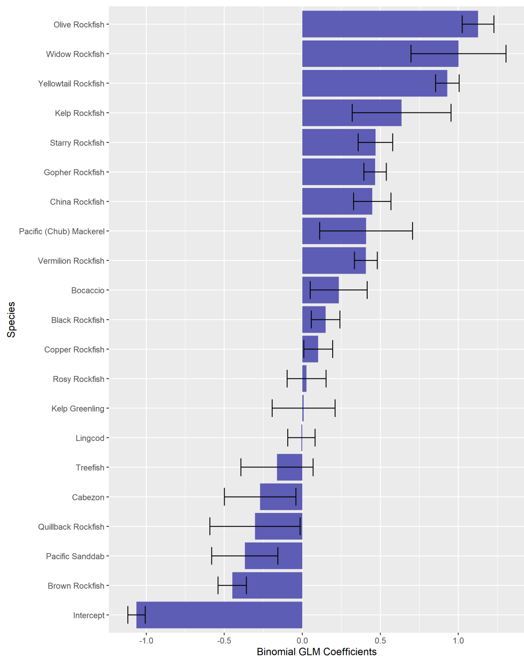
(a) Black rockfish trip level



(b) Black rockfish drift level

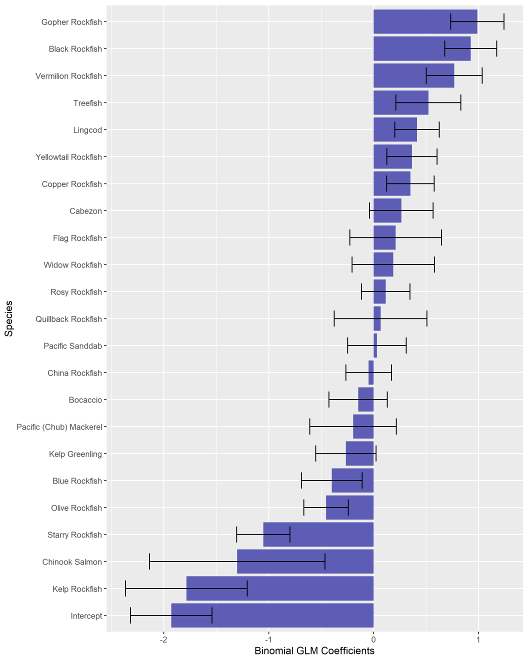


(c) Blue rockfish trip level

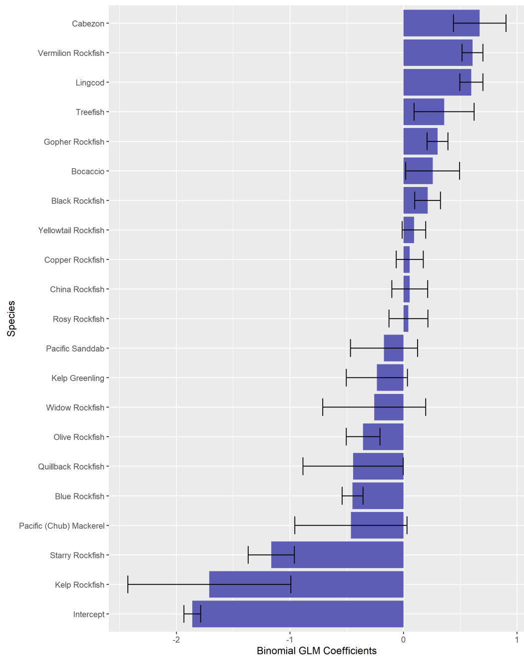


(d) Blue rockfish drift level

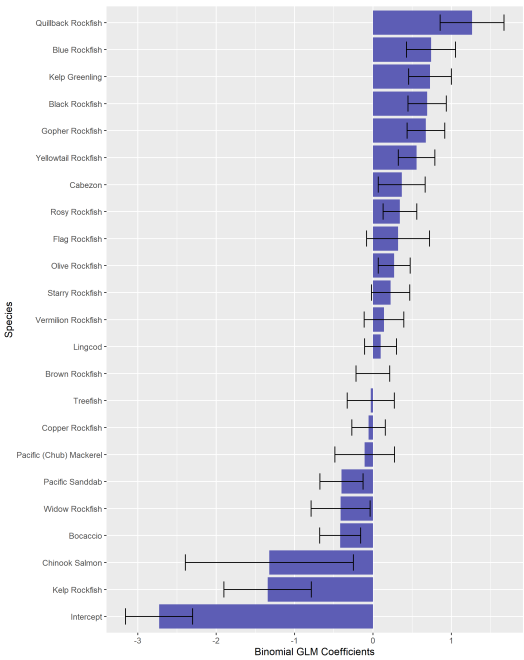
Figure 2: SM figure 1



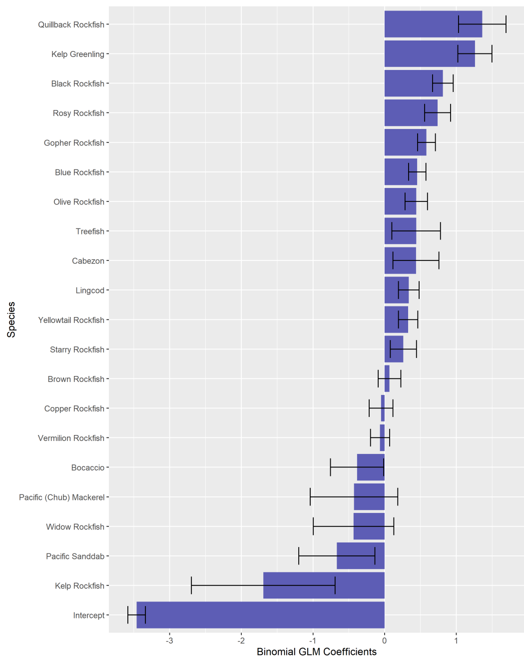
(a) Brown rockfish trip level



(b) Brown rockfish drift level

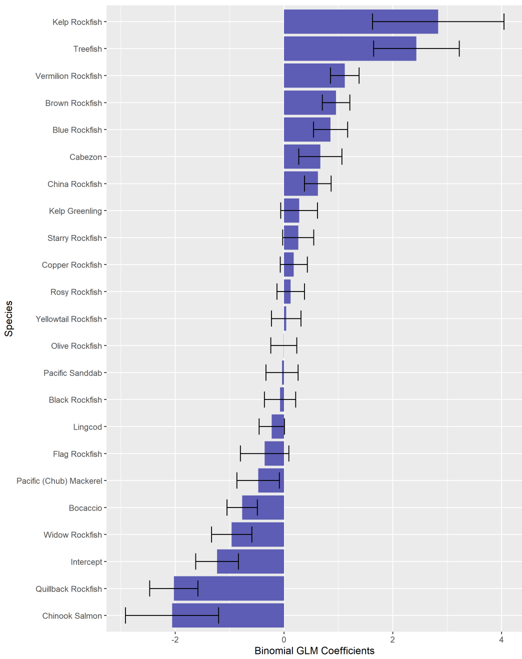


(c) China rockfish trip level

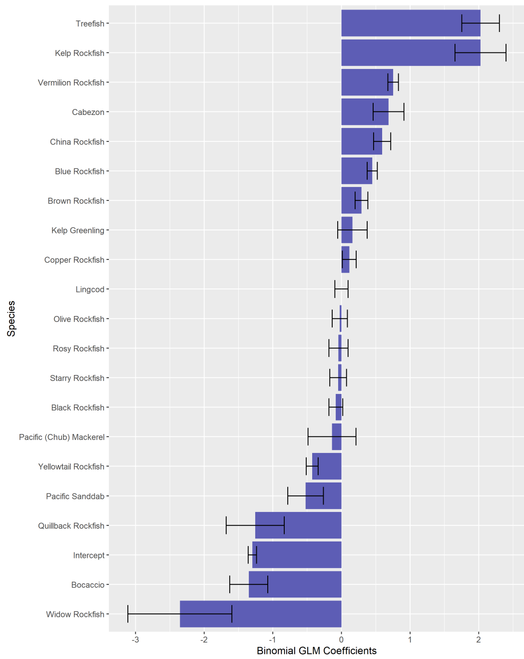


(d) China rockfish drift level

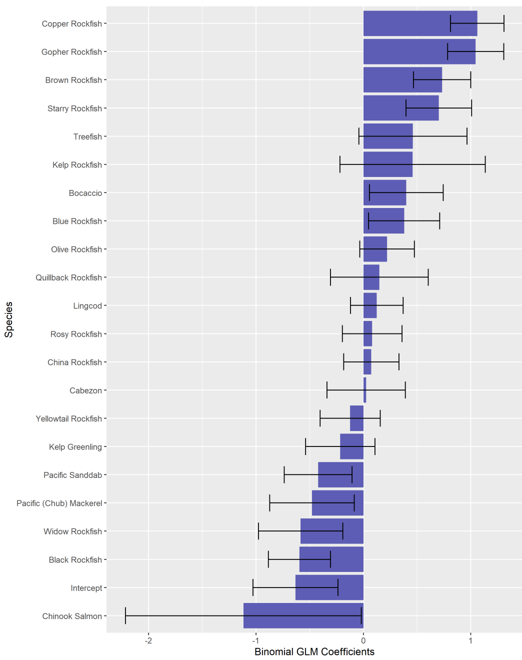
Figure 3: Sm figure 2



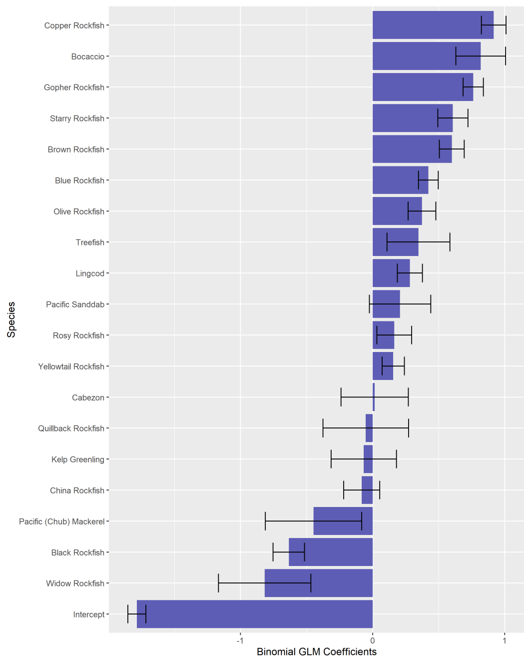
(a) Gopher rockfish trip level



(b) Gopher rockfish drift level



(c) Vermilion rockfish trip level



(d) Vermilion rockfish driftlevel

Figure 4: SM3

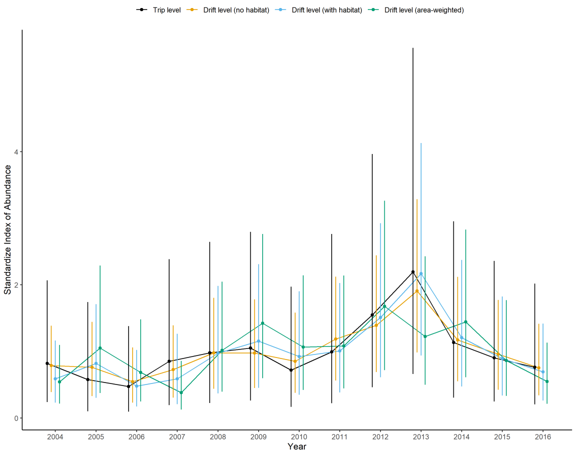


Figure 5: Black rockfish

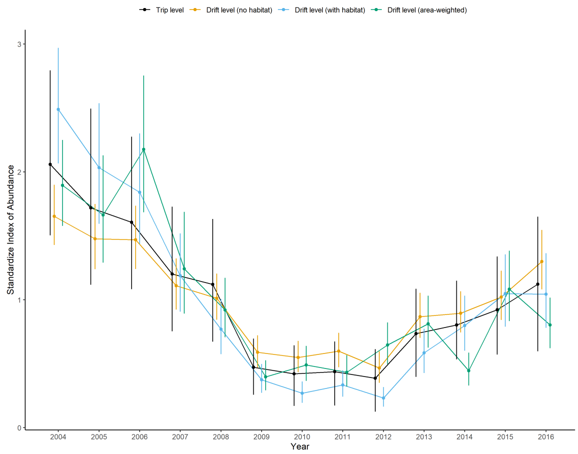


Figure 6: Blue rockfish

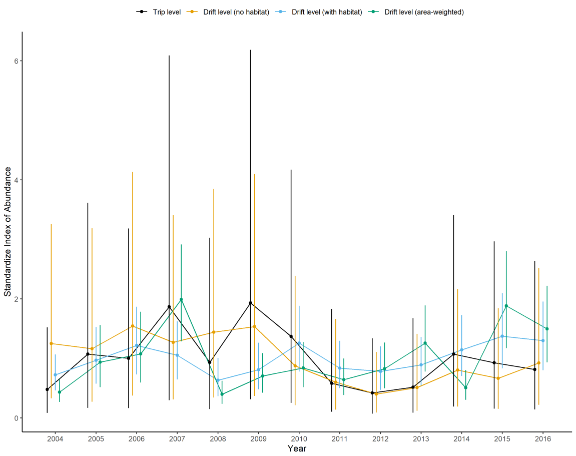


Figure 7: Brown rockfish

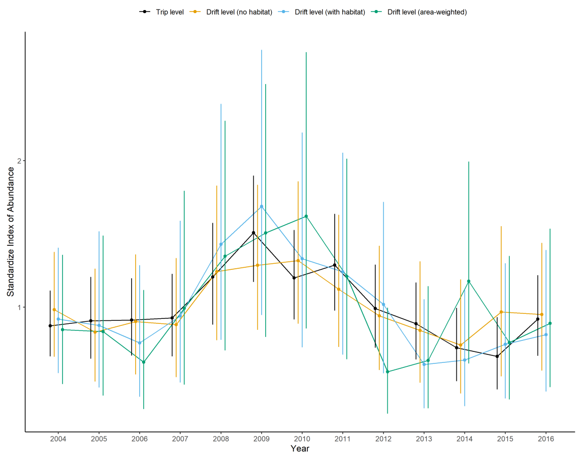


Figure 8: China rockfish

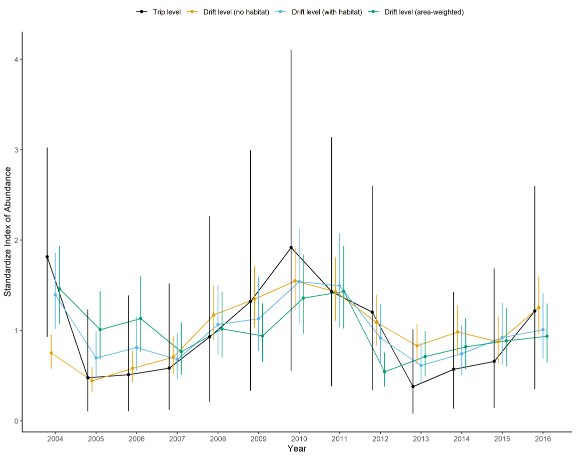


Figure 9: Gopher rockfish

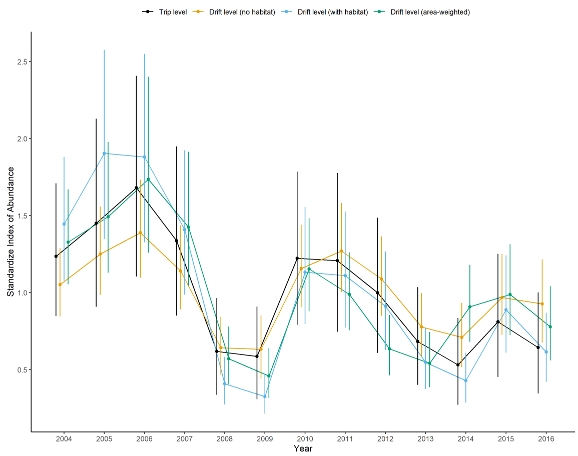


Figure 10: Vermilion rockfish

Indices of abundance for four iterations...

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