**Pelagic juvenile (age-0) rockfish abundance index**

*Data*

The Fishery Ecology Division of the Southwest Fishery Science Center has conducted a standardized pelagic juvenile trawl survey (the Rockfish Recruitment and Ecosystem Assessment Survey, RREAS) during May-June every year since 1983 (Ralston et al. 2013; Sakuma et al. 2016; Field et al. 2021). A primary purpose of the survey is to estimate the abundance of pelagic juvenile rockfishes (*Sebastes* spp.) and to develop indices of year-class strength for use in groundfish stock assessments on the U. S. West Coast. This is possible because the survey samples young-of-the-year rockfish when they are ~100 days old, an ontogenetic stage that occurs after year-class strength is established, but well before cohorts recruit to commercial and recreational fisheries. This survey has encountered tremendous interannual variability in the abundance of the species that are routinely indexed, as well as high apparent synchrony in abundance among the ten most frequently encountered species (Ralston et al. 2013, Schroeder et al. 2019). Past assessments have used data from this survey to provide indices of year-class strength (as relative age 0 abundance), including assessments for Canary rockfish (Langseth et al. 2023), Blue/Deacon Rockfish (Dick et al. 2017), Widow Rockfish (Adams et al. 2019), Bocaccio (He et al. 2015), Shortbelly Rockfish (Field et al. 2007) and Chilipepper Rockfish (Field 2015).

Historically (1983-2003), the survey was conducted between 36°30' and 38°20' N latitude (the ‘core area’ from approximately Carmel to just north of Point Reyes, CA). However, starting in 2004 the spatial coverage of the RREAS expanded to cover from the U.S./Mexico border to Cape Mendocino. Additionally, since 2001 data are available from comparable surveys conducted by the Pacific Whiting Conservation Cooperative (PWCC) and the NWFSC (2001-2009), which later evolved into the NWFSC “Pre-recruit” survey (2011-present) for waters off of Oregon and Washington (Field et al. 2021). Coastwide data have revealed both spatial differences in species composition (e.g. north and south of Point Conception) and interannual shifts in the distribution of most pelagic juvenile rockfishes (Ralston and Stewart, 2013; Field et al. 2021). As the core area index seems to have failed to capture the magnitude of the 1999 year class for most stocks, the recommendations from the juvenile rockfish survey workshop held in 2005 were to use only the coastwide data (since 2001) for juvenile indices rather than the longer-term ‘core area’ indices unless a convincing case could be made otherwise. Here we used data from 2001 to 2024, the period for which we have coastwide coverage. On account of the COVID-19 pandemic, sampling in 2020 was very limited and restricted to the historical core area (Santora et al. 2021), so this year is excluded in all models. Note that in the years 2010 and 2012, sampling did not span the entire coastwide spatial domain, with data sparse or lacking from northern CA, OR, and WA. The year 2022 lacks sampling in northern CA. These years were included in the models for coastwide stocks (e.g., widow and chilipepper), but 2010 and 2012 were excluded for the yellowtail rockfish northern index. Assessors may want to consider a sensitivity with these years excluded, particularly for species with a more northern distribution.

Catch per tow was adjusted to a common age of 100 days to account for interannual differences in age structure (Ralston et al. 2013), as has been done for prior assessment indices using this dataset.

Data from these surveys also supports process studies seeking to better understand the oceanographic processes leading to strong or weak year classes in adult groundfish populations. Survey data also provide insights into the drivers and consequences of climate-driven shifts in both the abundance and spatial distribution of other epipelagic micronekton, such as krill, coastal pelagic species, and mesopelagic fishes, as well as many of the seabirds and marine mammals that prey upon them. Such data are routinely reported in the CCIEA and other ecosystem status reports. More details about all of these research efforts can be found on the [project storymap page](https://storymaps.arcgis.com/collections/af0fa37db2bf4f1cadb024ec0ffbdfb5).

*Model*

For the index model, we first examined species occurrence in samples across the entire survey domain. If there was evidence of a hard range boundary (e.g. the species was never observed south of Point Conception), then we excluded the regions where the species was never observed. Depending on the geographic scope of assessment, we may also have applied other geographic subsettings, e.g. only CA waters. If there were years in the final geographic domain with no or very sparse sampling, those years were also excluded.

Since catch (and sampling) varied over space and time, we modeled catch using a spatial GLM with the package sdmTMB (Anderson et al. 2022). The 100-day standardized catch per tow was modeled as a function of fixed year effects along with Julian date (GAM smoother with k=4) to account for seasonality, a spatial random field, and IID spatiotemporal random fields. If there were years with sufficient sampling but where no fish of the focal species were caught, then we modeled year effects instead using time-varying (random walk) intercepts. This allowed us to retain these years, which are informative about abundance being relatively low (the fixed year effect model is unable to estimate an index and associated uncertainty for years with no positive catches). Prior testing indicates that for years with positive catches, there is little difference between these two model structures, and that for years without positive catches, the time-varying intercept model produces low index values of reasonable magnitude.

We fit the model using 3 different error structures: tweedie, delta-lognormal, and delta-gamma. In all rockfish species examined so far, dharma quantile residuals from model simulations suggested that tweedie distribution was the best, so this is the model we proceeded with. The tweedie model also best reproduced the observed proportion of zeros in the data based on simulations from the fitted model. For all species except yellowtail (see below), the Julian date effect showed a decline in catch towards the end of the sampling season, as juveniles begin to settle out of the water column.

For the index, predictions from the model were made for all active sample stations within the geographic domain, for the mean Julian date, for each year. Predictions were added together for each year to produce the index. Active stations are those regularly and consistently sampled, and are located on a semi-regular grid spanning the sampling region. Previous work has found that interpolating to a finer spatial grid has little impact on the resulting index.

*Modeling methods specific to individual species (2025 models):*

Widow rockfish: A coastwide index was generated with no spatial subsetting (all data from CA, OR, and WA were used). There were no years with zero positive catches (excluding 2020).

Yellowtail rockfish: Two indices were produced for yellowtail: a coastwide index with no spatial subsetting (all data from CA, OR, and WA were used), and a northern index using only data north of 40-10. For the coastwide index, there were no years with zero positive catches (excluding 2020). For the northern index, years 2010 and 2012 were excluded due to insufficient data, and there were 5 years (2002, 2003, 2008, 2009, 2011) with no positive catches of yellowtail. Thus, the northern model used the time-varying intercept formulation. The delta-lognormal and delta-gamma versions of the northern model did not converge. In both the coastwide and northern models, the relationship with Julian date was linearly increasing rather than declining at later dates.

Chilipepper rockfish: Two indices were generated for chilipepper rockfish: One using data since 2001 (same as the other coastwide indices generated), and once using historical data back to 1984 (1983 was excluded because no chilipepper were caught that year). For both time periods, a coastwide index was generated with no spatial subsetting (all data from CA, OR, and WA were used). For the index using the historical data, which before 2001 was only collected in central CA, this involved extrapolation to regions outside of central CA. For both models, there were no years with zero positive catches (excluding 2020 and 1983).

Canary rockfish: We used data from 35–48.2°N latitude (just north of Point Conception to La Push, WA). Canary rockfish were never caught south of 35°N. There were no years with zero positive catches (excluding 2020).

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