

# Pre-assessment data-workshop for copper rockfish off California in 2023

Dr. Melissa Monk, Southwest Fisheries Science Center  
Dr. Chantel Wetzel, Northwest Fisheries Science Center  
Dr. Julia Coates, California Department of Fish and Wildlife

2023-01-31

## Contents

<b>Overview</b>	<b>1</b>
<b>Summary of the 2021 Assessment</b>	<b>1</b>
Unresolved Questions and Issues from the 2021 Assessments . . . . .	2
<b>Potential Model and Fleet Structure</b>	<b>2</b>
<b>Removal Data</b>	<b>3</b>
Commerical Landings & Discards . . . . .	3
Additional Items for Discussion . . . . .	7
Recreational Landings & Discards . . . . .	7
Additional Items for Discussion . . . . .	10
<b>Indices of Abundance</b>	<b>10</b>
Fishery-Independent . . . . .	10
California Cooperative Fisheries Research Program . . . . .	10
NWFSC Hook and Line Survey . . . . .	11
NWFSC West Coast Groundfish Bottom Trawl Survey . . . . .	13
Additional Data Sources Being Considered . . . . .	13
Fishery-Dependent . . . . .	14
<b>Composition Data</b>	<b>14</b>
Commerical length compositions . . . . .	14
Recreational length compositions . . . . .	17
Potential bias in length sampling with CPFV trip duration . . . . .	19
Survey length compositions . . . . .	23

CCFRP Survey . . . . .	23
NWFSC Hook and Line survey . . . . .	24
NWFSC WCGBT survey . . . . .	27
<b>Biology</b>	<b>27</b>
Maturity and Fecundity . . . . .	27
Length-Weight . . . . .	29
Length-at-Age . . . . .	30
Natural Mortality . . . . .	31

*Disclaimer: All data summaries and exploration presented here are preliminary and may not be indicative of the final data that will be incorporated in the 2023 assessment models*

## Overview

Description of data being considered for use in the 2023 stock assessments for copper rockfish in California. Exploratory analyses are provided that have been used to inform modeling choices and treatment of data.

## Summary of the 2021 Assessment

In 2021, copper rockfish (*Sebastes caurinus*) in California waters were modeled using two area-based models split north and south of Point Conception. The stock status in 2021 was estimated at 18% and 39% of unfished spawning output (millions of eggs) south and north of Point Conception ( $34^{\circ}27'N$ ), respectively.

The final assessment documents can be found online at the Pacific Fisheries Management Council (PFMC) website: South of Point Conception and North of Point Conception

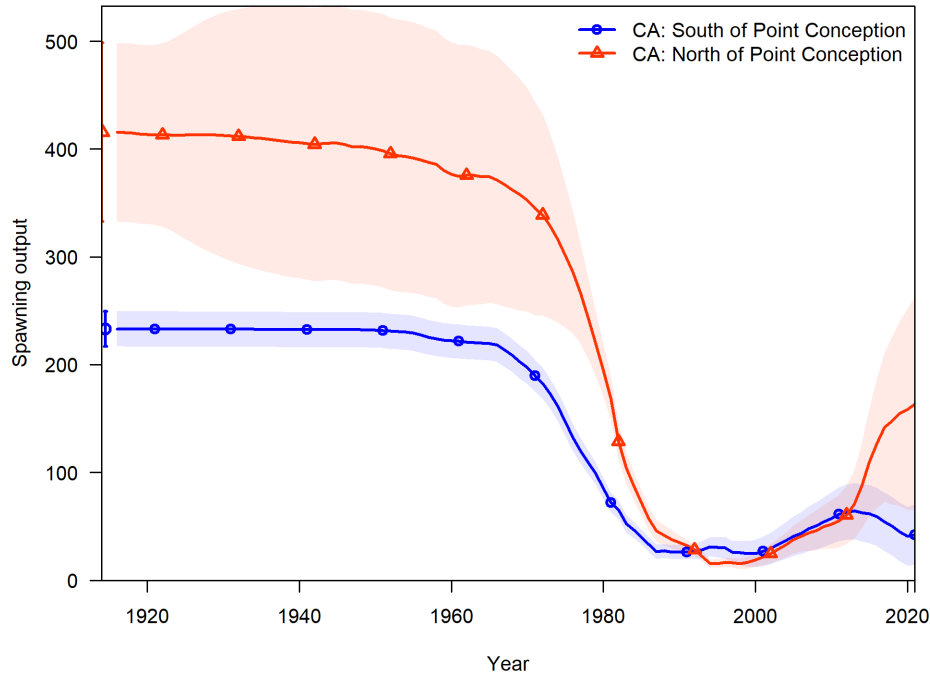


Figure 1: Estimates of spawning output (millions of eggs) from each model area in California from the 2021 data-moderate length-based assessments.

## Unresolved Questions and Issues from the 2021 Assessments

- Growth
  - The length-at-age relationship north of Point Conception was based on age and length data from Oregon and Washington due to a lack of age data from northern California fisheries.
  - The length-at-age relationship south of Point Conception was informed by limited ages from the NWFSC Hook and Line and West Coast Groundfish Trawl surveys.
- There were additional sources of data that were not included in the 2021 length-based data-moderate assessment that may be considered for use in this year's assessments:
  - Onboard Commercial Passenger Fishing Vessels (CPFV) length sample data from 1975-1979 (Collins and Crooke), 1987-1998 (Deb Wilson-Vandenberg), and 1986-1989 (Alley and Ono). These data were explored during mop-up and had limited impact on the model results.
  - California Collaborative Fisheries Research Program (CCFRP) index of abundance and biological samples.
  - CPFV observer index of abundance.
  - RecFIN dockside sampling index of abundance.
  - California Department of Fish and Wildlife (CDFW) remotely operated vehicle (ROV) relative of absolute biomass estimates and ROV length measurements.
  - Any age samples from various sources that may support estimation of growth within the model.

## Potential Model and Fleet Structure

The Stock Assessment Team (STAT) for the assessment of copper rockfish in California waters in 2023 currently plans on retaining the same model areas, split south and north of Point Conception, as were used

in the 2021 assessments. This decision was primarily guided by the distinct differences in the commercial and recreational fisheries seen by area. Additionally, this approach provides the ability to easily account for differences in biological parameters and variable recruitment success in the two areas.

Currently, the following fleet structure is being considered for modeling commercial and recreational fisheries in both area models:

1. Commercial Passenger Fishing Vessel (CPFV, recorded as PC mode in RecFIN),
2. Private Rental (PR mode in RecFIN),
3. Commercial Fleet Landing Dead Fish, and
4. Commercial Fleet Landing Live Fish.

Several factors have influenced the pre-preliminary fleet selection. First, there is a differential in size of fish landed live versus dead in the commercial fishery, particularly north of Point Conception, that supports the need for separate selectivity curves. Second, both the CPFV and PR recreational fleets are expected to have corresponding fishery-dependent indices of abundance for consideration which requires separating these recreational modes into two fleets. Finally, the removals from the recreational man-made and beach/bank modes for copper rockfish are very small and do not justify a separate fleet. The minimal removals from these recreational modes will be added to the PR fleet to account for total mortality.

The commercial lengths by year, particularly when divided into two fleets based on the landed fish condition (live or dead), are limited in recent years for each proposed model area. If there are issues estimating selectivity reliably for all model years, the two commercial fleets may be combined into a single fleet with selectivity estimated by a parameterization that would allow bimodal selectivity (multiple peaks in selectivity at size) using time blocks (e.g., one or more time blocks in recent years when the live fishery developed).

Finally, each model area will have at least one fishery-independent fleet. The CCFRP survey will be included in the model north of Point Conception and potentially south of Point Conception depending upon the sample sizes. For the area south of Point Conception the NWFSC Hook and Line survey will be included as a fleet in the model.

## Removal Data

### Commercial Landings & Discards

Since 1981, landings of copper rockfish have occurred from hook and line, net, pot, shrimp trawl, trawl, troll, and diving gear. The majority of these landings are from hook and line gear across California (south of Point Conception 96% and north 87%). North of Point Conception there are some proportion of landings from trawl gear (8% primarily occurring between 1982-1985) and net gear (4% primarily occurring between 1983-1986). Since 2011, 98% and 96% of the landings south and north of Point Conception, respectively, are coming from hook and line gear.

In recent years, there has been an increase in the proportion of fish landed live for both areas. In recent years, the percentage of copper rockfish landed dead north of Point Conception has been generally less than 50% within each year. Fish landed live are primarily caught with hook and line gear. However, in recent years, north of Point Conception there have been some limited landings of live fish using pot gear.

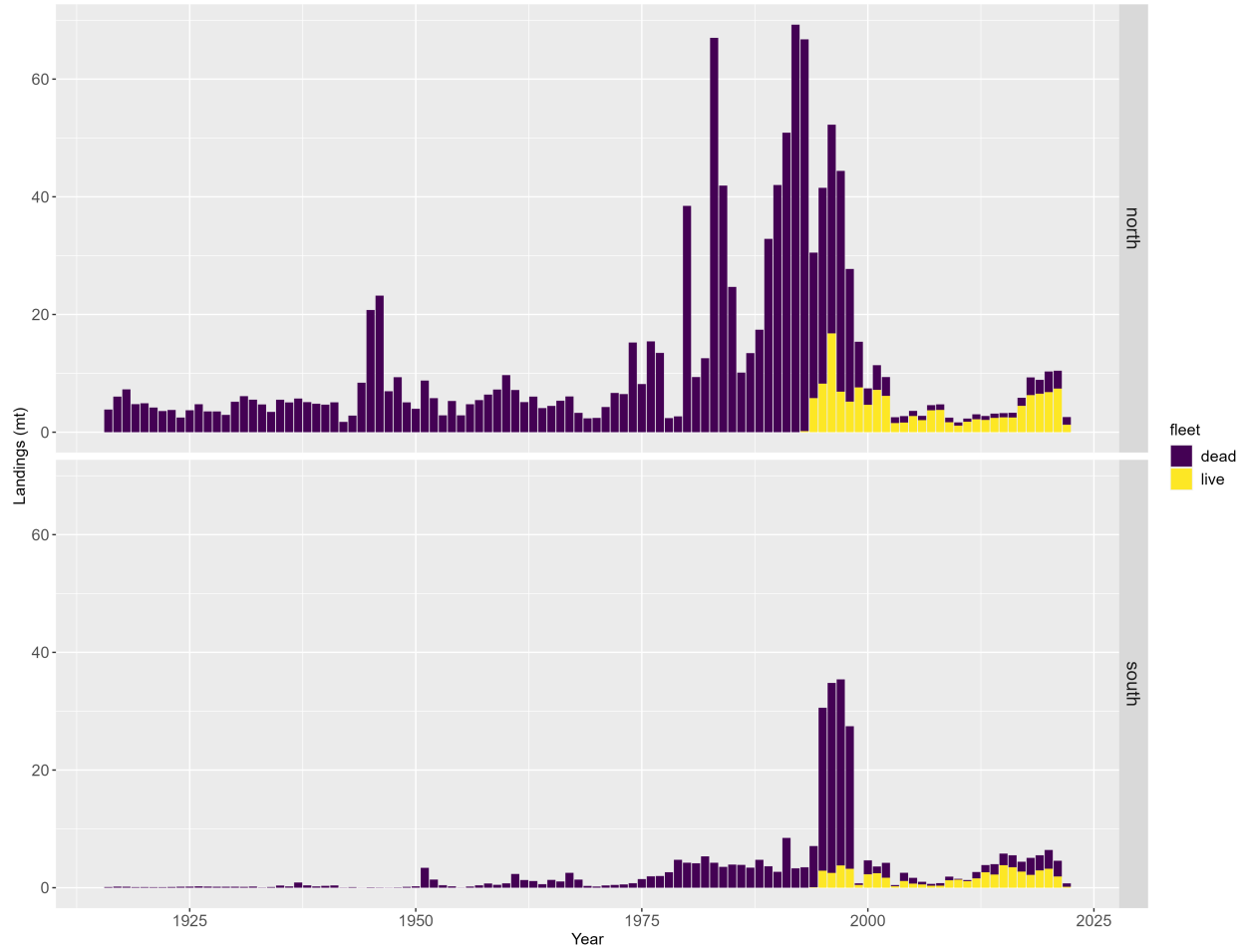


Figure 2: Commercial landings north and south of Point Conception. The landings are separated by fish landed live versus dead. The commercial landings in the south are relatively low (less than 10 mt per year) across the majority of years excluding 1995-1998 when landings ranged from 24 to 32 mt. The commercial landings in the north were higher than those observed south of Point Conception prior to 1995 with catches peaking at 69 mt in 1994 (sources: PacFIN and California historical catch reconstruction).

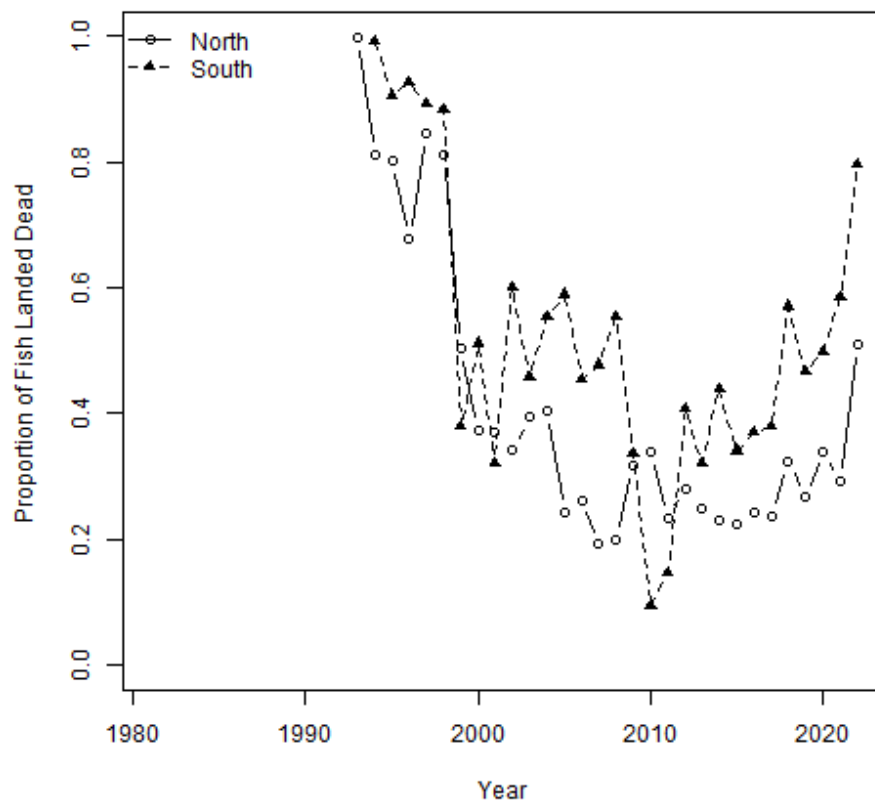


Figure 3: Proportion of commercial landings from fish landed dead north and south of Point Conception in recent years. The proportion of fish landed dead for the north are shown by a solid line with circles and the south by a dashed line with triangles. (source: PacFIN).

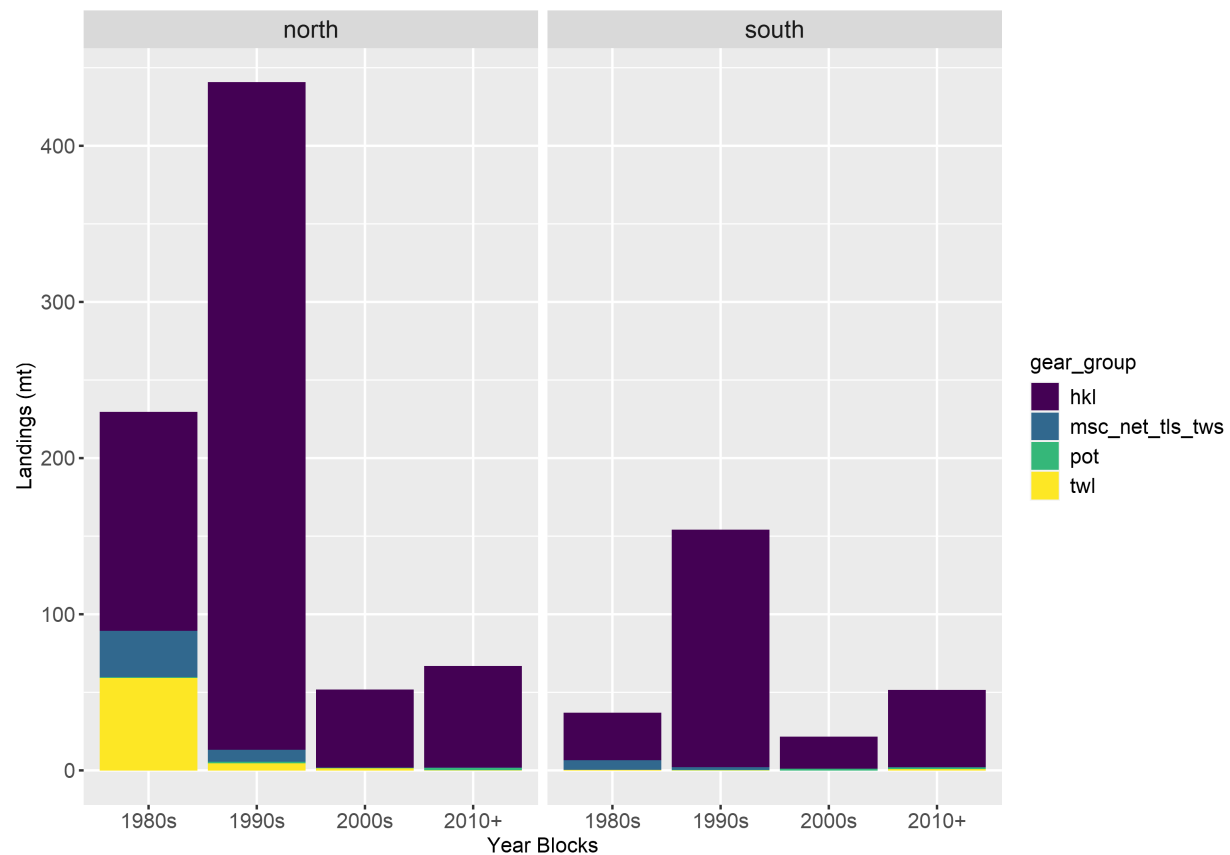


Figure 4: Landings by area, time period (grouped by decade), and gear grouping: hook and line (hkl), diving gear/net/bottomfish troll/shrimp trawl combined (msc\_net\_tls\_tws), pot, and trawl (twl) (source: PacFIN).

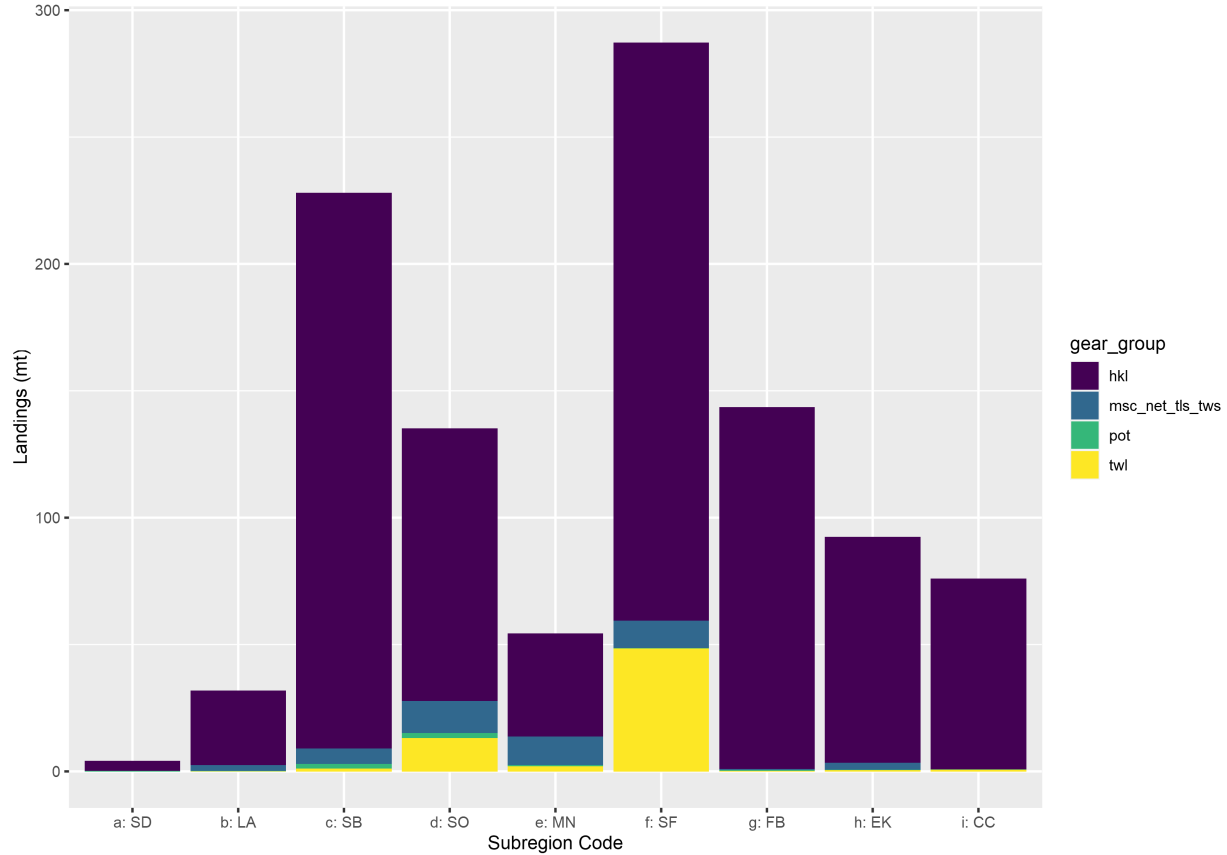


Figure 5: Landings by subregion and gear grouping hook: and line (hkl), diving gear/net/bottomfish troll/shrimp trawl combined (msc\_net\_tls\_tws), pot, and trawl (twl) (source: PacFIN).

### Additional Items for Discussion

Only the commercial landings are shown for each area. Discard mortality across time will need to be considered to determine catches.

- The 2021 assessments assumed a constant discard mortality rate of 4.4% informed by WCGOP data for each area in California.
- The rate of discarding has likely varied across time. Are there particular periods of time when discarding likely increased/decreased?
- Different factors impacting discarding practices by area?

### Recreational Landings & Discards

Copper rockfish is caught by the recreational fishery across California. Historically, landings of copper rockfish were highest in the areas north of Point Conception. In recent years, 1993 onward, the scale of landings of copper rockfish is similar north and south of Point Conception. The proportion of landings by recreational modes (CPFV, private, shoreside) across all years for each area are:

- North of Point Conception:
  - CPFV 34%,



- Private = 66%, and
- Shoreside = 0.2%
- South of Point Conception:
  - CPFV 42%,
  - Private = 58%, and
  - Shoreside = 0%

However, since 1993 the CPFV fleet has accounted for 72% of all recreational landings south of Point Conception (only 40% north of Point Conception).

There are some years with missing and incomplete landings that will need to be determined. The first gap in landings occurs due to a funding lapse in the MRFSS program between 1990-1992. Two methods that have commonly used in other assessments to fill in these missing data are by averaging the landings in 1989 and 1993 and filling in the missing years with the average or by ramping (either up or down) the landings between 1989 and 1993. Both of these approaches result in similar total landings (the sum) for these missing years. The landings for each area prior to and after the missing data years are:

- North of Point Conception
  - 1989: 87 mt
  - 1993: 71.6 mt
  - Average: 79.1 mt
- South of Point Conception
  - 1989: 46.2 mt
  - 1993: 16.4 mt
  - Average: 31.3 mt

The landings for these missing years will be allocated by fleet based on the proportion of landings by mode from the surrounding years.

The 2004 landings, the first years of the CRFS program, are currently not available on RecFIN. These data were available on RecFIN in 2021 for the previous assessments (north = 15.6 mt, south = 13.7 mt). Inquiries have been made about the removal of these data and when the issue is resolved the appropriate landings will be used in the 2023 assessments.

Finally, the landings from 2020 - 2021 are potentially incomplete due to the absence of dockside sampling due to the COVID-19 pandemic. Estimates of landings for these years have been requested from CDFW.

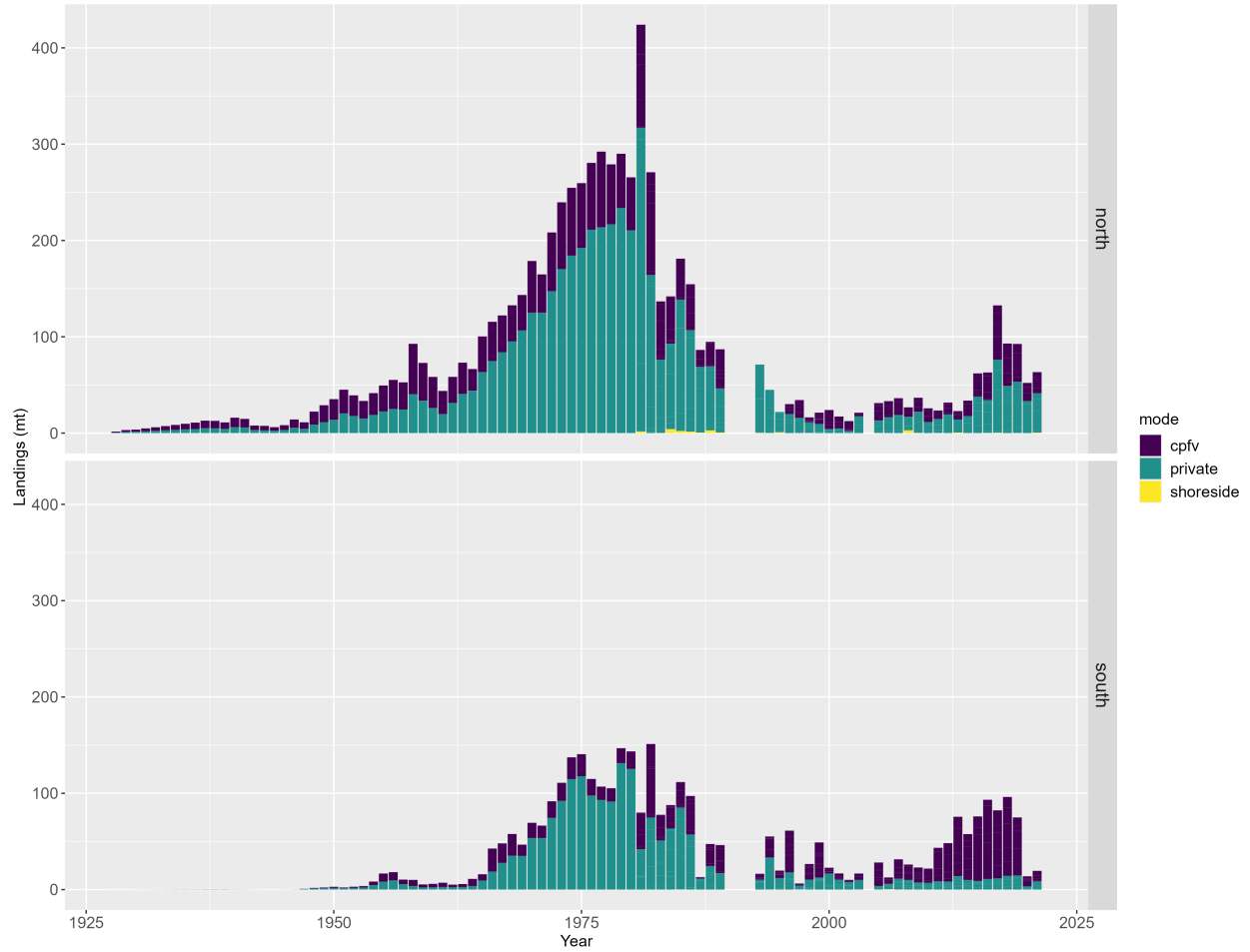


Figure 6: Recreational landings north and south of Point Conception. The landings are separated by private, CPFV and shoreside (beach and bank) modes. The landings from the CPFV fleet predominate the recreational landings in the south since 2004. In contrast, the majority of the removals north of Point Conception arise from the private fleet. Landings between 1990-1992 are missing due to a loss in funding to MRFSS for this period. Landings from 2004 from CRFS were not available on RecFIN. Finally, landings in 2020 and 2021 may be incomplete due to limited sampling during the COVID-19 pandemic. Landings for these years will need to be determined and added (sources: RecFIN and California historical catch reconstruction).

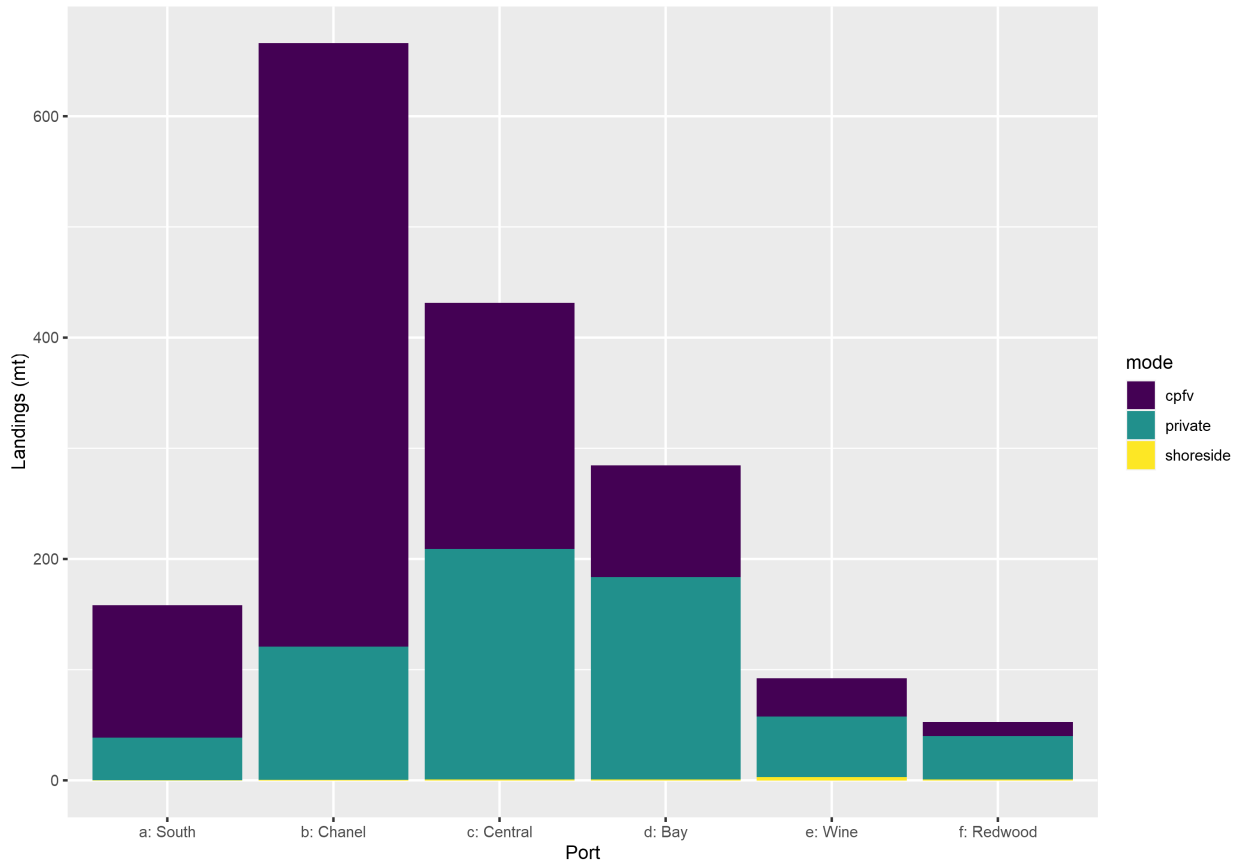


Figure 7: Recreational landings in CRFS by port area and mode between 2005-2021. The landings from 2004 are currently not available in RecFIN and the landings in 2020 and 2021 may be incomplete due to limited sampling during the COVID-19 pandemic. Landings for these years will need to be determined and added (source: CRFS).

### Additional Items for Discussion

Only the recreational landings are shown for each area. Discard mortality across time will need to be considered to determine catches.

- The 2021 assessments assumed only limited discarding prior to 1981 (0.3% discard rate).
- The rate of discarding has likely varied across time. Are there particular periods of time when discarding likely increased/decreased?
- Different factors impacting discarding practices by area?

## Indices of Abundance

### Fishery-Independent

#### California Cooperative Fisheries Research Program

California Collaborative Fisheries Research Program (CCFRP) is a survey that monitors groundfish populations in California's network of Marine Protected Areas (MPAs) and adjacent reference areas. The CCFRP

survey began in 2007 sampling select areas in northern California. In 2017, CCFRP expanded sampling across California. A detailed summary of the program and available sampling data for copper rockfish can be found online.

Copper rockfish have been observed at every monitored MPA along the California Coast at least once. Copper rockfish are most common at the Carrington Point MPA in southern California, followed by the Point Lobos and Piedras Blancas MPAs in central California.

Table 6: Percent of drifts with encounters of Copper Rockfish at each monitoring location (inside and outside areas combined) and year.

YEAR	South Cape Mendocino	Ten Mile	Stewarts Point	Bodega Head	Ano Nuevo	Point Lobos	Piedras Blancas	Point Buchon	Carrington Point	Anacapa Island	Swamis	South La Jolla
2007	-	-	-	-	2%	30%	-	6%	-	-	-	-
2008	-	-	-	-	2%	16%	38%	10%	-	-	-	-
2009	-	-	-	-	2%	30%	54%	4%	-	-	-	-
2010	-	-	-	-	2%	22%	34%	6%	-	-	-	-
2011	-	-	-	-	6%	30%	38%	2%	-	-	-	-
2012	-	-	-	-	8%	26%	44%	6%	-	-	-	-
2013	-	-	-	-	6%	10%	30%	12%	-	-	-	-
2014	-	-	-	-	6%	42%	54%	6%	-	-	-	-
2015	-	-	-	-	6%	34%	-	10%	-	-	-	-
2016	-	-	-	-	8%	46%	46%	14%	-	-	-	-
2017	22%	24%	22%	32%	4%	38%	46%	10%	98%	38%	12%	20%
2018	60%	24%	30%	24%	8%	44%	52%	22%	100%	36%	4%	8%
2019	26%	26%	32%	54%	6%	46%	60%	20%	100%	36%	4%	10%
2020	34%	34%	28%	38%	2%	44%	56%	22%	98%	50%	-	10%
2021	42%	24%	42%	42%	10%	52%	52%	18%	94%	50%	-	18%

## NWFSC Hook and Line Survey

The NWFSC Hook and Line survey begun sampling shelf rockfish over rocky reef habitat within the Southern California Bight in 2004 using rod and reel gear. Since, 2005, sampling has been conducted in late-September through early-October. The minimum and maximum sampling depths are set at 20 fathoms (37 meters) to 141 fathoms (257 meters). Starting in 2014, the survey added sampling sites with the Cowcod Conservation Area (CCA). The depth of sites sampled within the CCA range between 25 - 128 fathoms and the depth of sites sampled outside the CCA range between 20 -141 fathoms.

Between 2004-2021 the NWFSC Hook and Line survey has caught a total of 1,151 copper rockfish. The majority of these observations have occurred outside the CCA (outside CCA = 1,057 and inside CCA = 94). The NWFSC Hook and Line data from 2022 is not yet available and not included in these data summaries.

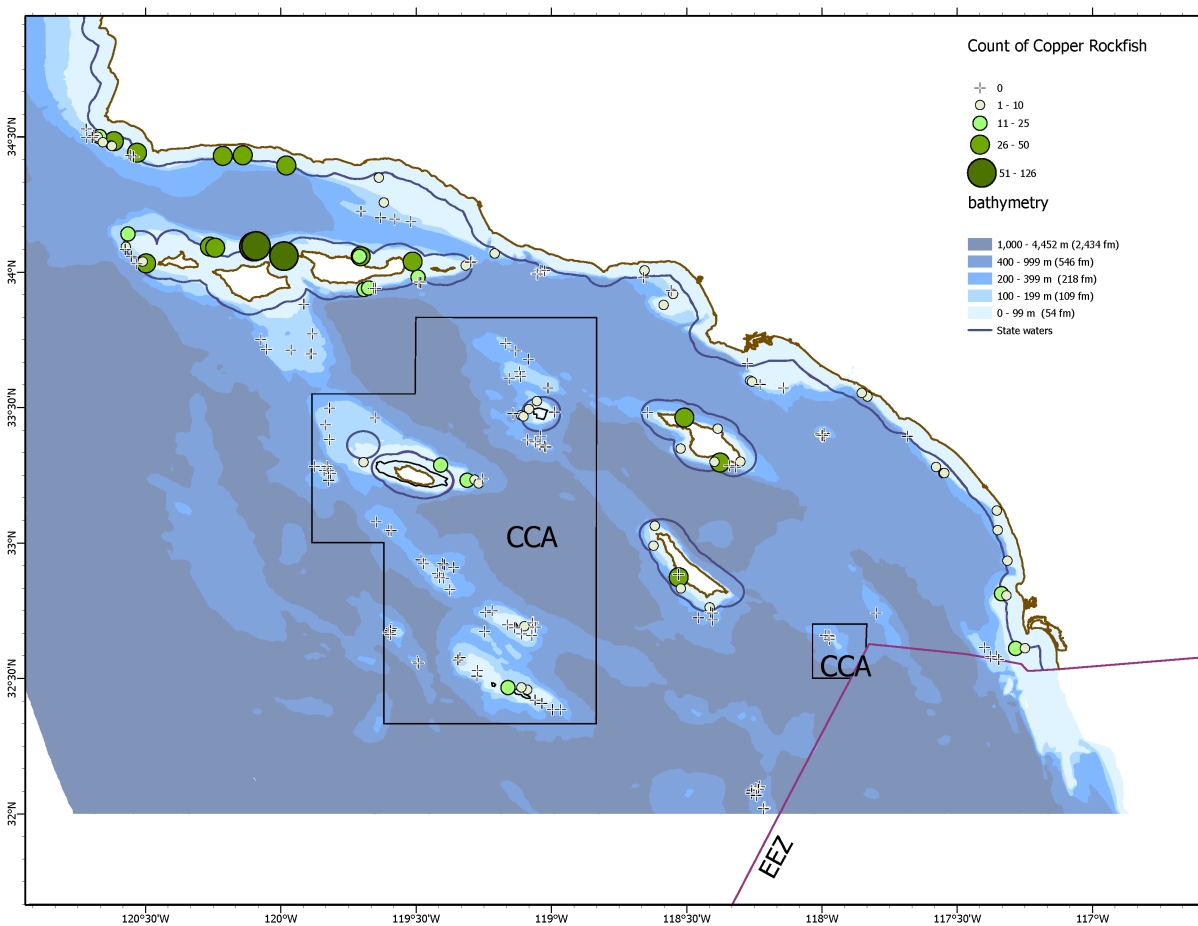


Figure 8: Total number of observation of copper rockfish between 2004-2021 by sampling site inside and outside of Cowcod Conservation Areas (CCA) from the NWFSC Hook and Line survey (source: NWFSC Hook and Line survey).

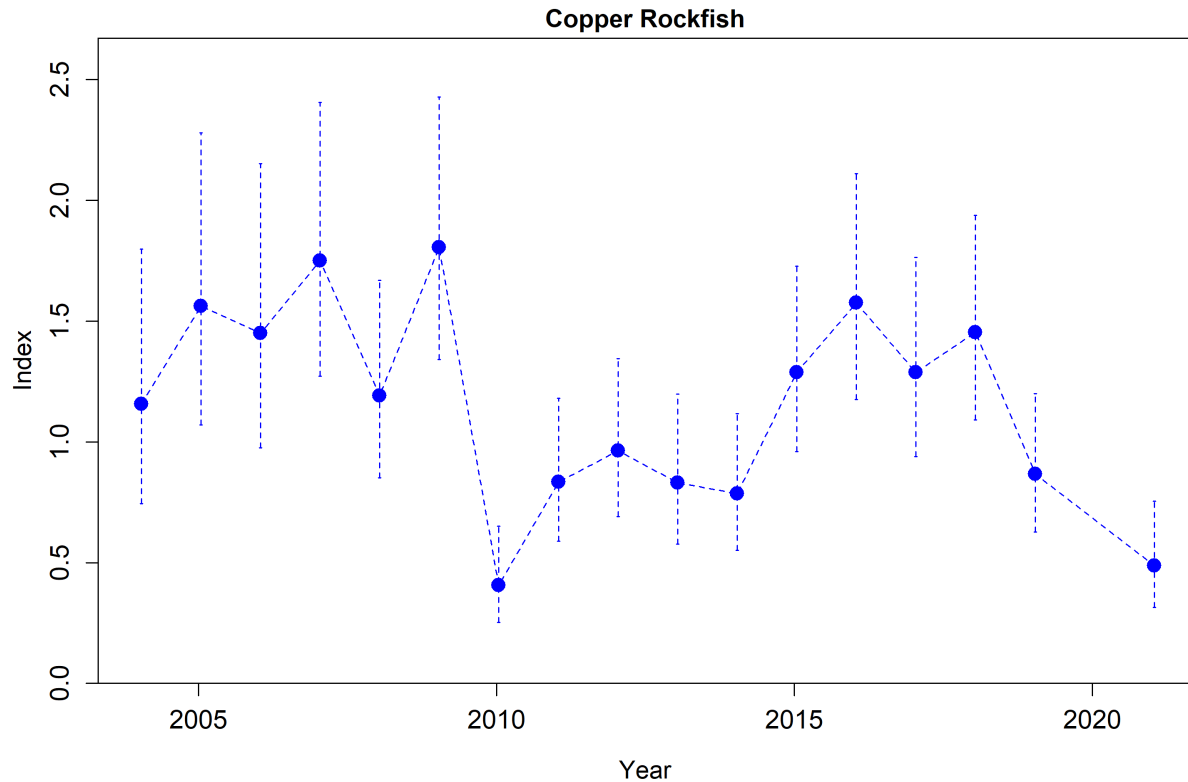


Figure 9: A preliminary relative index of abundance calculated using available data between 2004-2021 estimated using a generalized linear mixed model including fixed effects for year, site, hook, and drop and angler random effects. Once data from 2022 are available estimation of the index of abundance across additional model structures will be explored (source: NWFSC Hook and Line survey).

### NWFSC West Coast Groundfish Bottom Trawl Survey

The NWFSC West Coast Groundfish Bottom Trawl (WCGBT) survey has been conducted across the West Coast annually since 2003 (there was no sampling conducted in 2020 due to the COVID-19 pandemic). The number of observations of copper rockfish by the NWFSC WCGBT survey are limited due to the sample gear (bottom trawl) which is deployed on soft bottom substrate. A summary of the observations by this survey between 2003-2021 can be found online. The majority of observations of copper rockfish by the NWFSC WCGBT survey occur south of Point Conception. The limited number of tows by year will likely prevent the calculation of an index of abundance for this survey. Additionally, observations using bottom trawl gear may not be informative of population trends for rocky-habitat and or hard-bottom associated species such as copper rockfish. However, the collected otolith and length data from this survey will be used to help inform growth (north = 195 samples, south = 584 samples).

### Additional Data Sources Being Considered

Multiple inquiries regarding additional data that could be considered to generate indices of abundance and/or composition data have been made for the follow datasets:

- SMURF data

- PISCO
- ReefCheck
- CDFW ROV data

Finally, the southern California Publicly Owned Treatment Works (POTW) dataset has been evaluated for observations of copper rockfish. However, the number of copper rockfish observations were determined to be too limited for the creation of a potential index of abundance.

## Fishery-Dependent

Fishery-dependent indices will be explored for both the CPFV (PC) and Private/Rental (PR) fleets using onboard observer data and dockside sampling, i.e., angler interviews. The indices of abundance for each fleet will likely only be developed through 2019 due to the reduction in trips and sampling in 2020 due to the COVID-19 pandemic and regulation changes in 2021. Additionally, the recreational fleet actively avoided copper rockfish in 2023.

## Composition Data

### Commerical length compositions

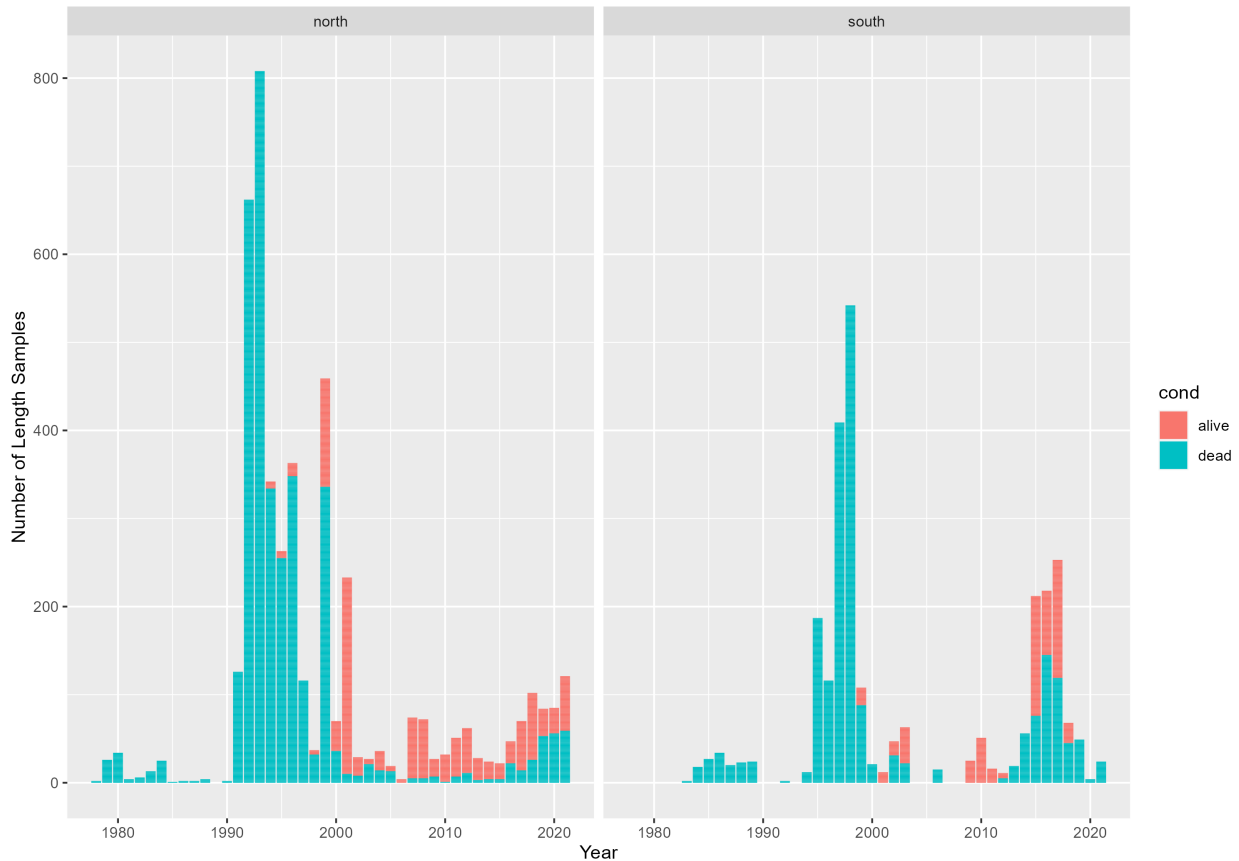


Figure 10: The number of length samples by year from live and dead copper rockfish from the area south and north of Point Conception. Since 1981, there are a total of 3,517 dead and 1,099 live length samples north of Point Conception and 553 live and 2,135 dead length samples south of Point Conception (source: PacFIN).

The majority of lengths are from hook and line gear for each area:

- North of Point Conception (total lengths = 4,616):
  - 4,268 from hook and line gear,
  - 32 from net gear,
  - 139 from pot gear,
  - 15 from troll gear, and
  - 162 from trawl gear.
- South of Point Conception (total lengths = 2,688):
  - 2,585 from hook and line gear,
  - 24 from net gear,
  - 39 from trawl gear, and
  - 36 from shrimp trawl gear.

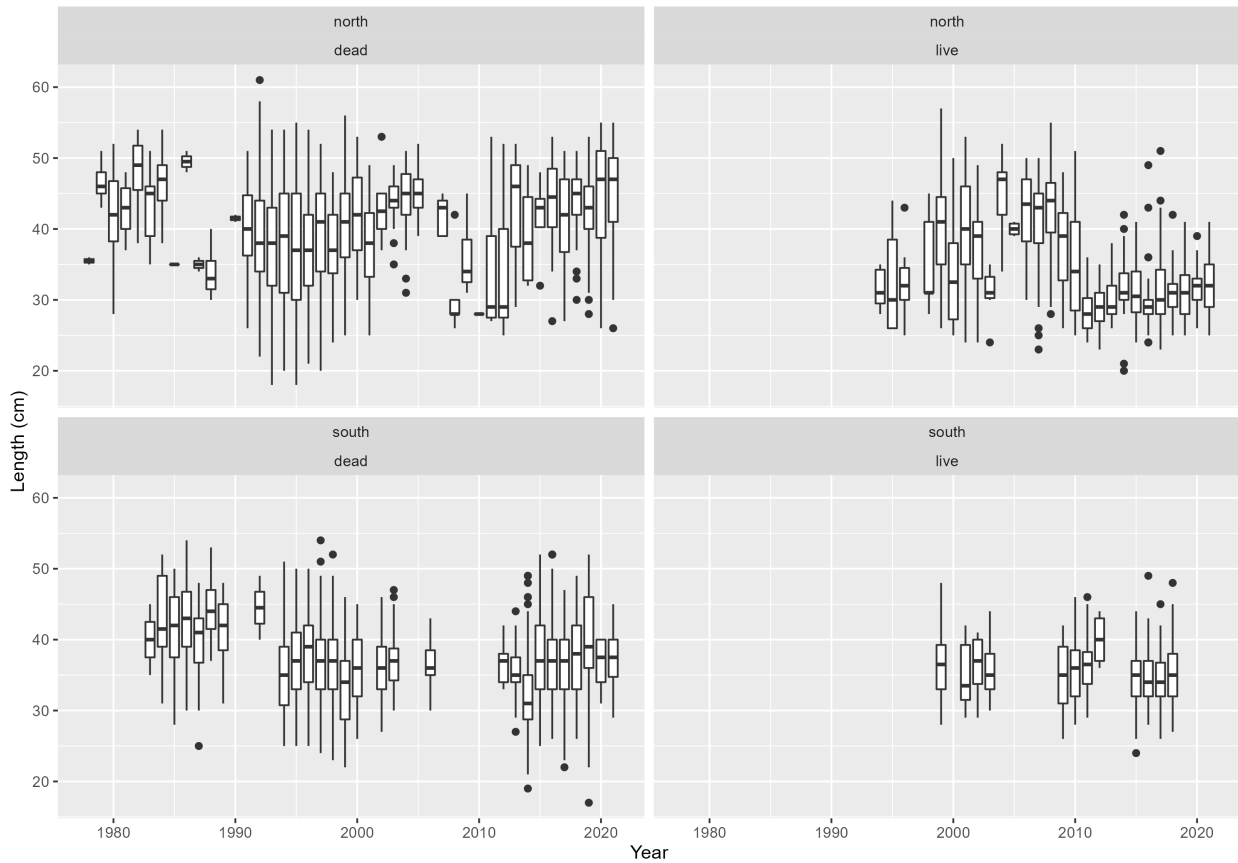


Figure 11: The distribution of length samples by year from live and dead copper rockfish from the area south and north of Point Conception. The black horizontal line within each box indicates the median length observed that year where the median is defined as an equal number of observations from that year that are greater than and lesser than that value. The lower range of each box indicates the 25th percentile where 25 percent of observations that year are less than that length. The upper range of each box indicates the 75th percentile where 75 percent of observations that year are less than that length (source: PacFIN).



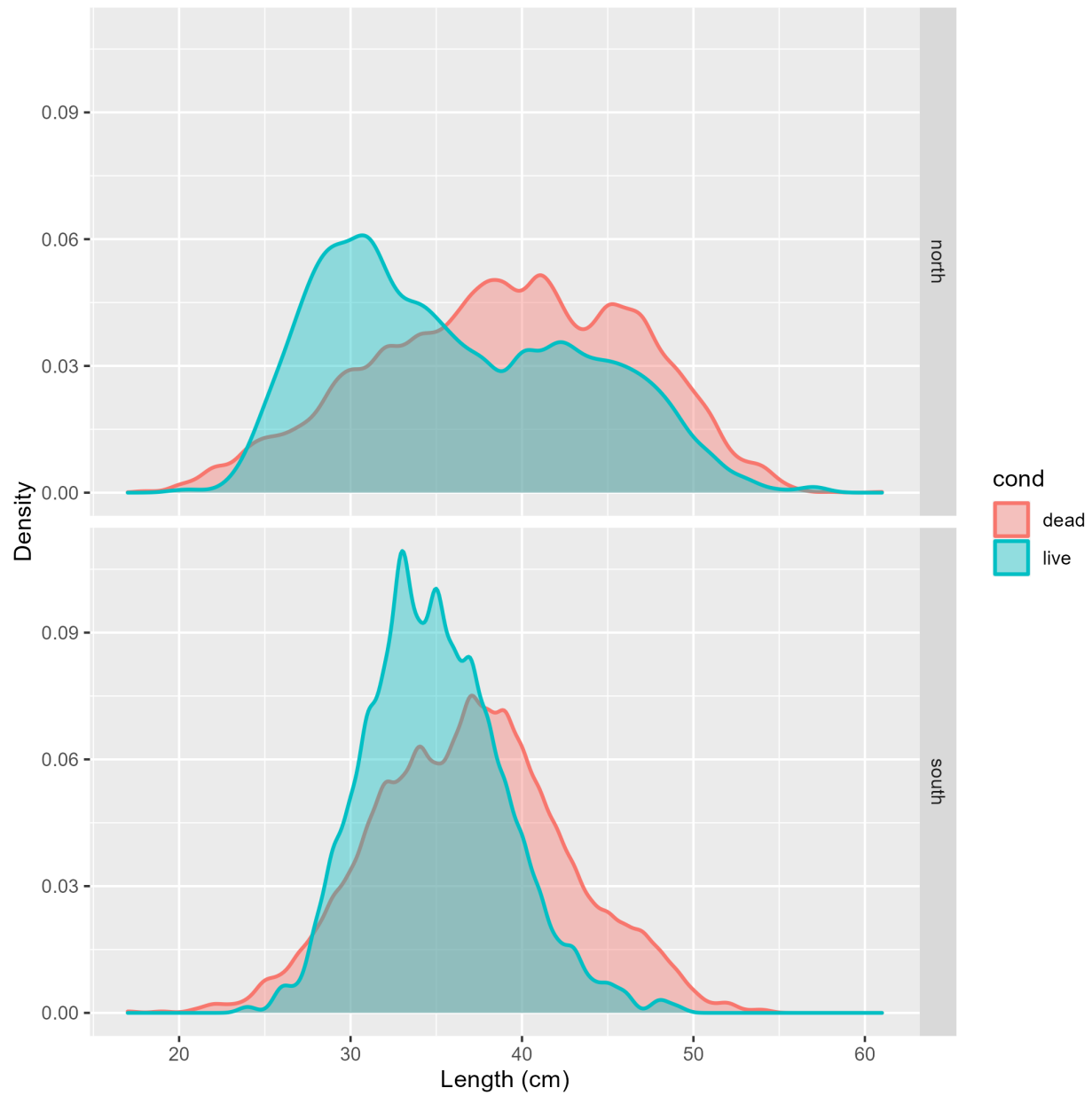


Figure 12: The density of size selected by landed condition, live or dead, for each area across all years (source: PacFIN).

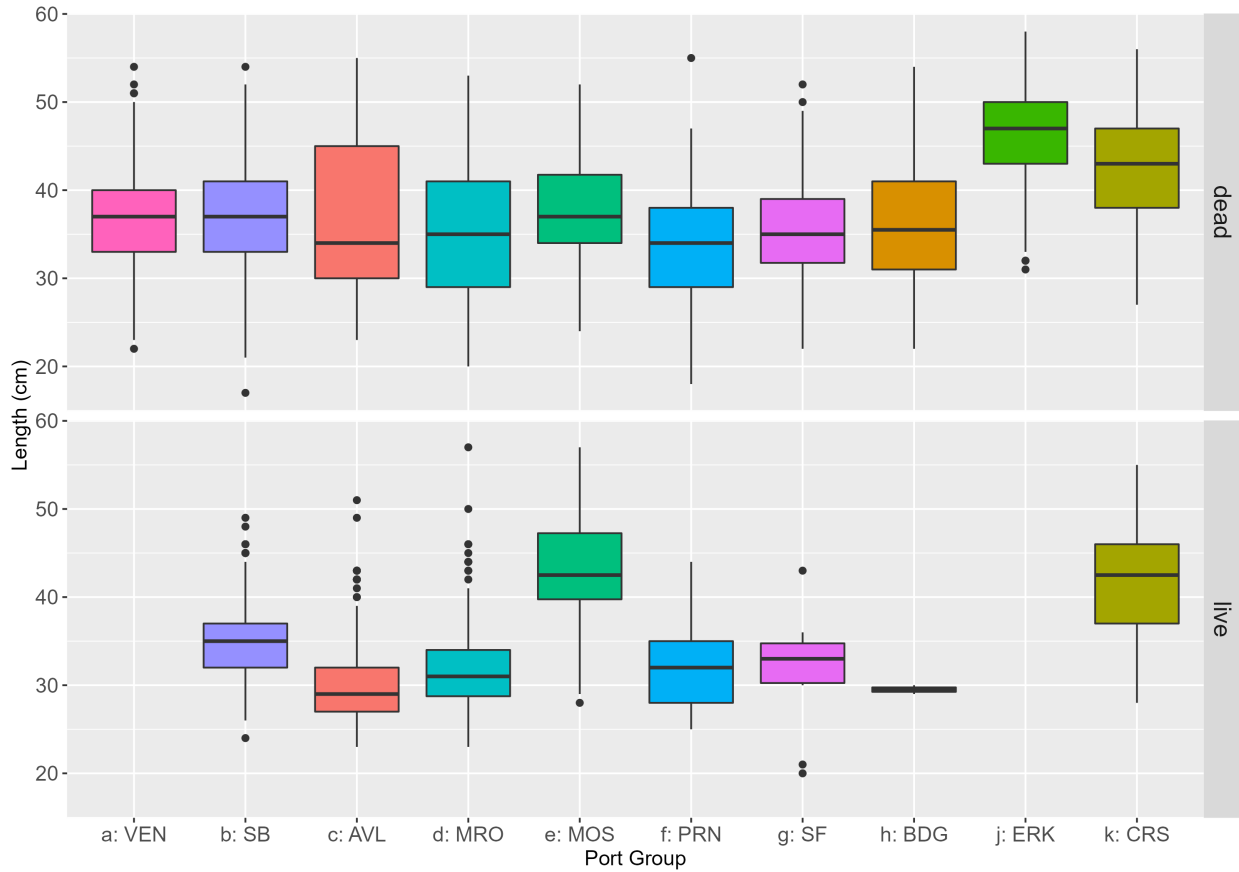


Figure 13: Boxplot of lengths by landed port, area, and fish condition (live or dead) across all years. Only ports with greater than 100 length samples (live + dead > 100 samples) across all years are shown. The Ventura (VEN) and Santa Barbara (SB) ports are south of Point Conception. The ports north of Point Conception are Avila (AVL), Morro Bay (MRO), Moss Landing (MOS), Half Moon Bay (PRN), San Francisco (SF), Bodega Bay (BDG), Eureka (ERK), Crescent City (CRS) (source: PacFIN).

## Recreational length compositions

The recreational length composition data summarized below represent data pulled from RecFIN collected by either the MRFSS (1980 - 2003) or CRFS (2004 - 2022) sampling programs. There are additional data sources that contain historical length samples from the CPFV fleets (1975-1979 from Collins and Crooke, 1987-1998 from Deb Wilson-Vandenberg, and 1986-1989 from Alley and Ono) that will be evaluated and used within each assessment model as appropriate but are not included here.

The total number of length samples within RecFIN across MRFSS and CRFS are:

- North of Point Conception (total lengths = 38,994):
  - 11,969 from CPFV, and
  - 27,025 from Private/Rental vessels.
- South of Point Conception (total lengths = 31,036):
  - 23,535 from CPFV, and
  - 7,501 from Private/Rental vessels.

In RecFIN there are lengths from shoreside modes that were not included in the analysis presented below (north of Point Conception = 148 and south = 20). All lengths below represent retained fish. There were limited length observations of released fish (north = 52 and south = 187).

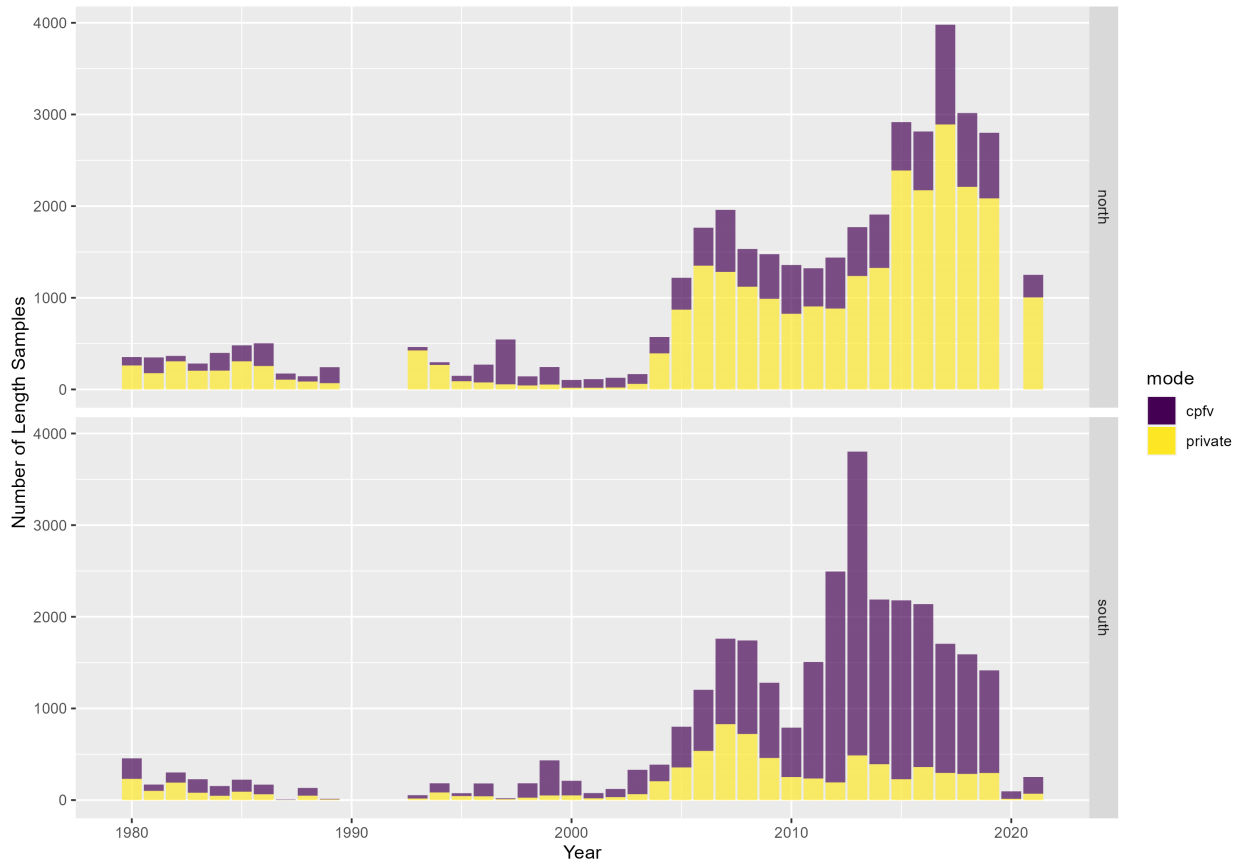


Figure 14: The number of length samples by year and mode for copper rockfish for areas south and north of Point Conception. Since 1980, there are a total of 11,969 CPFV and 27,025 Private/Rental length samples north of Point Conception and 23,535 CPFV and 7,501 Private/Rental length samples south of Point Conception (source: RecFIN).

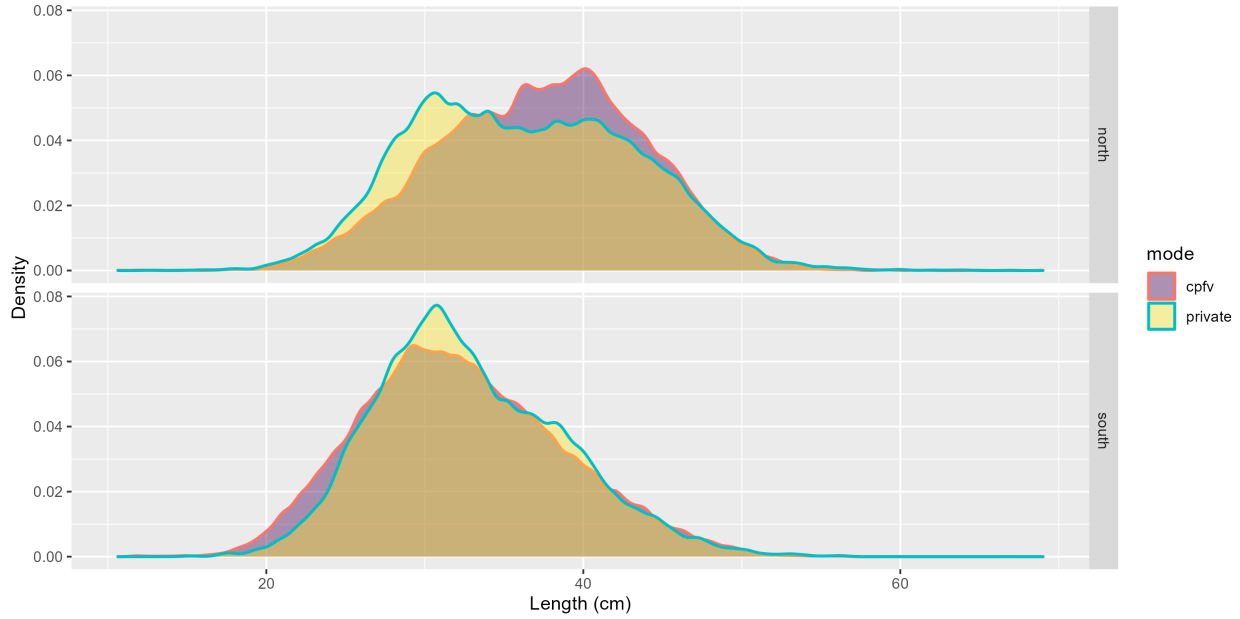


Figure 15: The density of size selected by mode, CPFV or Private/Rental, for each area across all years (source: RecFIN).

### Potential bias in length sampling with CPFV trip duration

The CDFW California Recreational Fisheries Survey (CRFS) collects length samples from fish caught on CPFVs. These samples are collected by both staff on board CPFV trips and at the docks when vessels return. On board CRFS staff are unable to sample overnight trips with as high a frequency as day trips. In many cases, these overnight trips may reach destinations that are farther from port and therefore experience lower fishing rates and contain larger fish. This could result in a bias in length distributions aggregated across trip duration if sites with larger fish are under-sampled.

The STAT examined the length distributions of fish sampled on trips of varying duration by district. Overnight trips only occur in the southern California sampling districts 1 (San Diego, Orange, and Los Angeles counties) and 2 (Ventura and Santa Barbara counties). Some separation in copper rockfish length frequencies is observed in district 1.

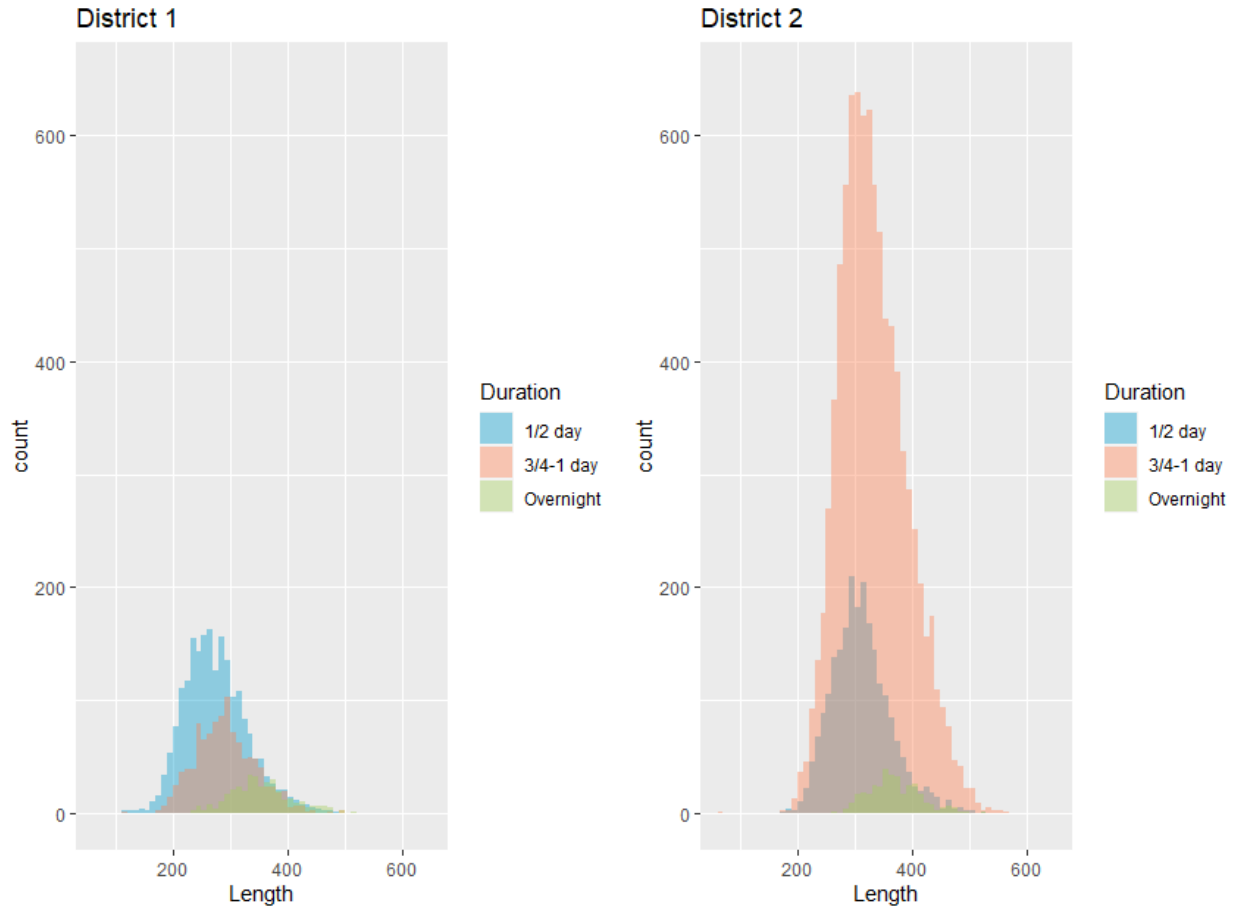


Figure 16: Copper rockfish length frequency by CPFV trip duration for CRFS districts 1 & 2 for 1/2 day, 3/4 day, and overnight fishing trips (source: CRFS PC Onboard + Dockside Surveys).

To determine if overnight trips are under-sampled, relative to their frequency, we need to compare catch rates relative to sampling rates. A sharp increase in the number of rockfish caught on overnight CPFV trips, as well as other fish species, was observed in 2014 with catches remaining relatively high through 2020. No increase was observed in the single day trips. This was coincident with an increase in the number of overnight trips being made in 2014. The increase in catch was likely driven by the arrival of warm water which drove increases in pelagic species. A large proportion of the trips made in 2014 listed tuna as the target species. Many trips targeting pelagic species will also visit sites to target groundfish, and this is the likely cause for the coincident increase in groundfish catch.

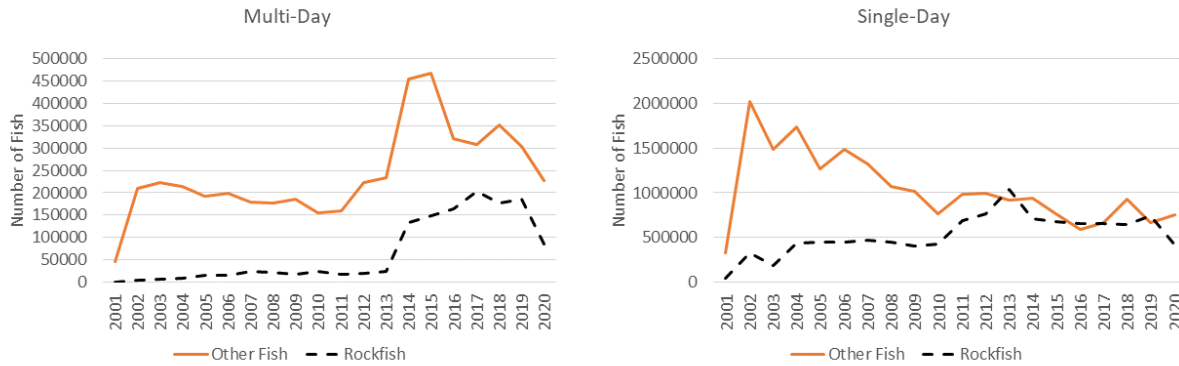


Figure 17: CPFV catch of rockfish and non-rockfish on multi- and single-day trips (source: CPFV Logbooks).

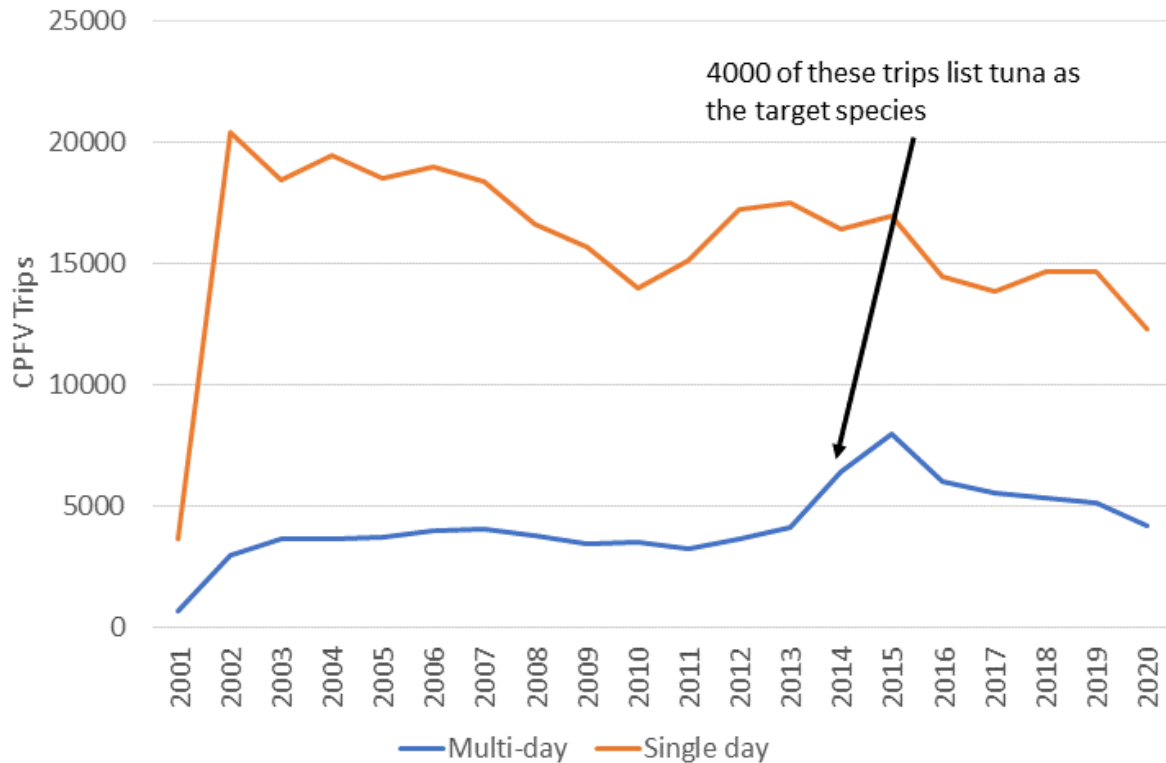


Figure 18: The number of of multi- and single-day CPFV trips (source: CPFV Logbooks).

We calculated the percent of copper rockfish in southern California caught on overnight trips relative to the total number of CPFV trips. We compared this to the percent of copper rockfish length samples collected from CPFVs that were taken from overnight trips. The lower proportion of sampling relative to catch shows that there is under-sampling of these trips. Given this, we will consider weighting length samples from CPFVs according to trip duration to correct for this bias, particularly since 2014.

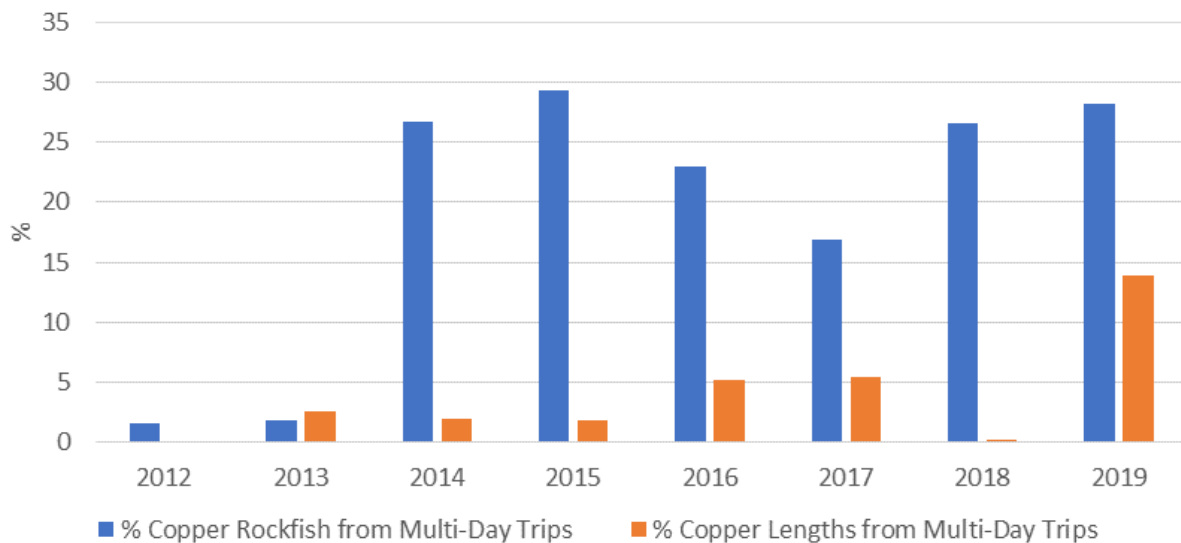


Figure 19: Percentage of copper rockfish caught on multi-day the percentage of length samples from multi-day trips (source: CPFV Logbooks and CRFS PC Onboard and Dockside Surveys).

Additionally, in order to understand the potential impact of biased and unbiased sampling of trips by duration a simulation analysis was conducted. The simulation analysis examined the average size of fish and the variability around that average (standard deviation) by trip type:

- Single-day trip: average fish length of 31.9 cm with standard deviation of 6.1 cm, and
- Multi-day trip: average fish length of 35.2 cm with standard deviation of 5.6 cm.

A bias (over-sampling of single-day trips) and an unbiased (sampling aligns with the proportion of trip type) of a 1,000 total length sample were randomly generated based on the average length and standard deviation of observations from each trip type. The bias sampling approach was based on the observed proportion of samples coming from single-day trips. The most extreme difference in sampling proportion observed in the data was used to generate the biased sample where 980 lengths were collected from single-day trips and 20 lengths were collected from multi-day trips. The unbiased sample was based on the proportion of single-day and multi-day trips observed between 2014 - 2018 where 81% of the trips were single-day were 810 samples were from single-day trips and 190 samples from multi-day trips were randomly generated.

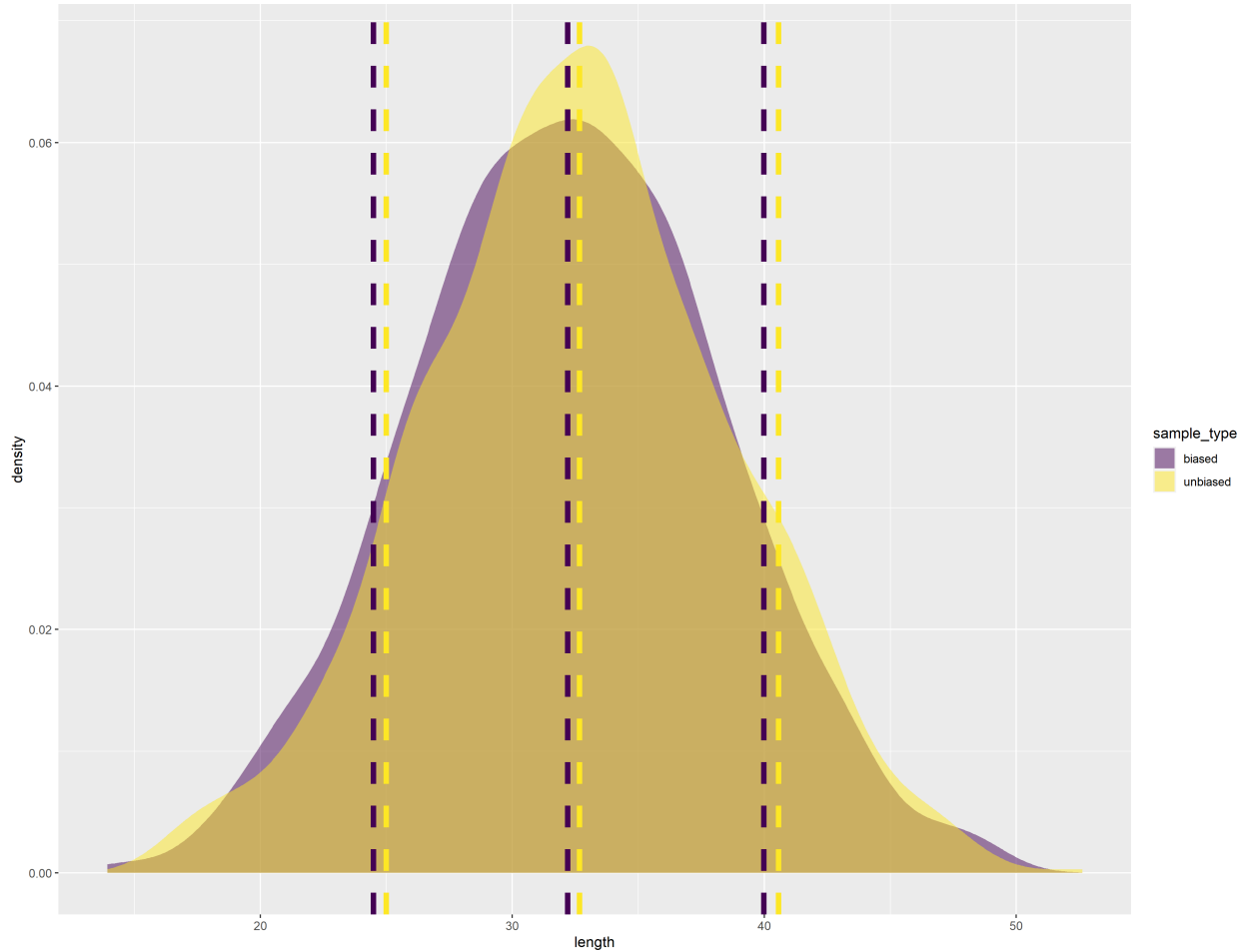


Figure 20: Simulated length distribution based on biased and unbiased sampling of trip by duration (single-day or multi-day). The 10%, 50%, and 90% quartile from each sample type is show by the dashed verticle lines. The median length (50% quartile) of the unbiased sample was approximately 0.5 cm greater than the median length from the biased sample. While there are small differences in the length distribution between the biased and unbiased samples, the difference is not great enough to have a measurable impact the length composition data when binned using 2 cm bins for use in an assessment model (source: simulated samples based on CPFV Logbooks and CRFS PC Onboard and Dockside Surveys).

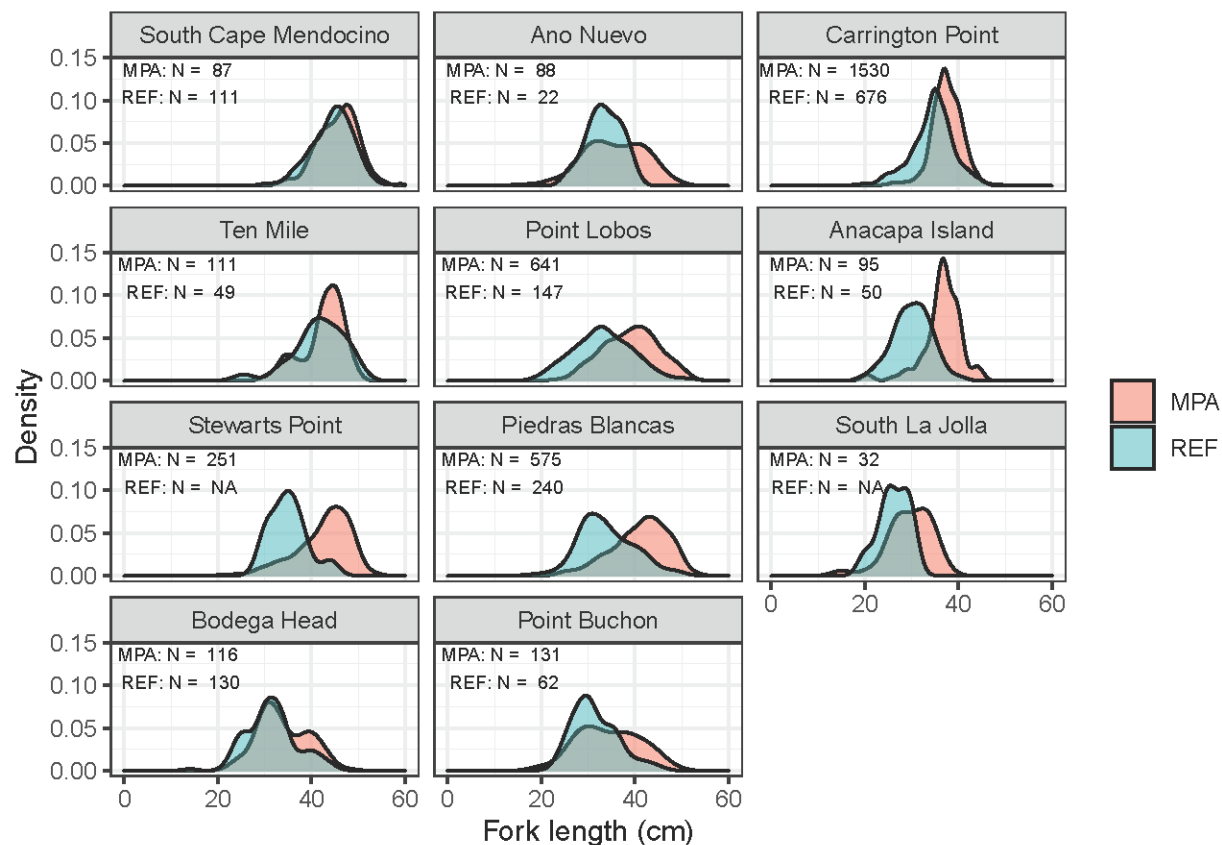
While the differences in the simulated length distribution for copper rockfish, there may be greater impacts for other species and or if the sampling bias continues (or increases) across years in the future. Additional efforts should be made to align sampling with the proportion of trip type.

## Survey length compositions

### CCFRP Survey

An initial look at the length distributions also suggests the survey observes larger fish in the MPAs from San Francisco and south. The CCFRP data for 2022 are not yet available.





### NWFSC Hook and Line survey

Between 2004-2021 the NWFSC Hook and Line survey has caught a total of 1,151 copper rockfish with otoliths for ageing being collected from each fish. The majority of these observations have occurred outside the CCA (outside CCA = 1,057 and inside CCA = 94). Observations of copper rockfish have occurred across a range of depths between 22 - 66 fathoms with the median of observations occurring around 44 fathoms. The NWFSC Hook and Line data from 2022 is not yet available and not included in these data summaries.

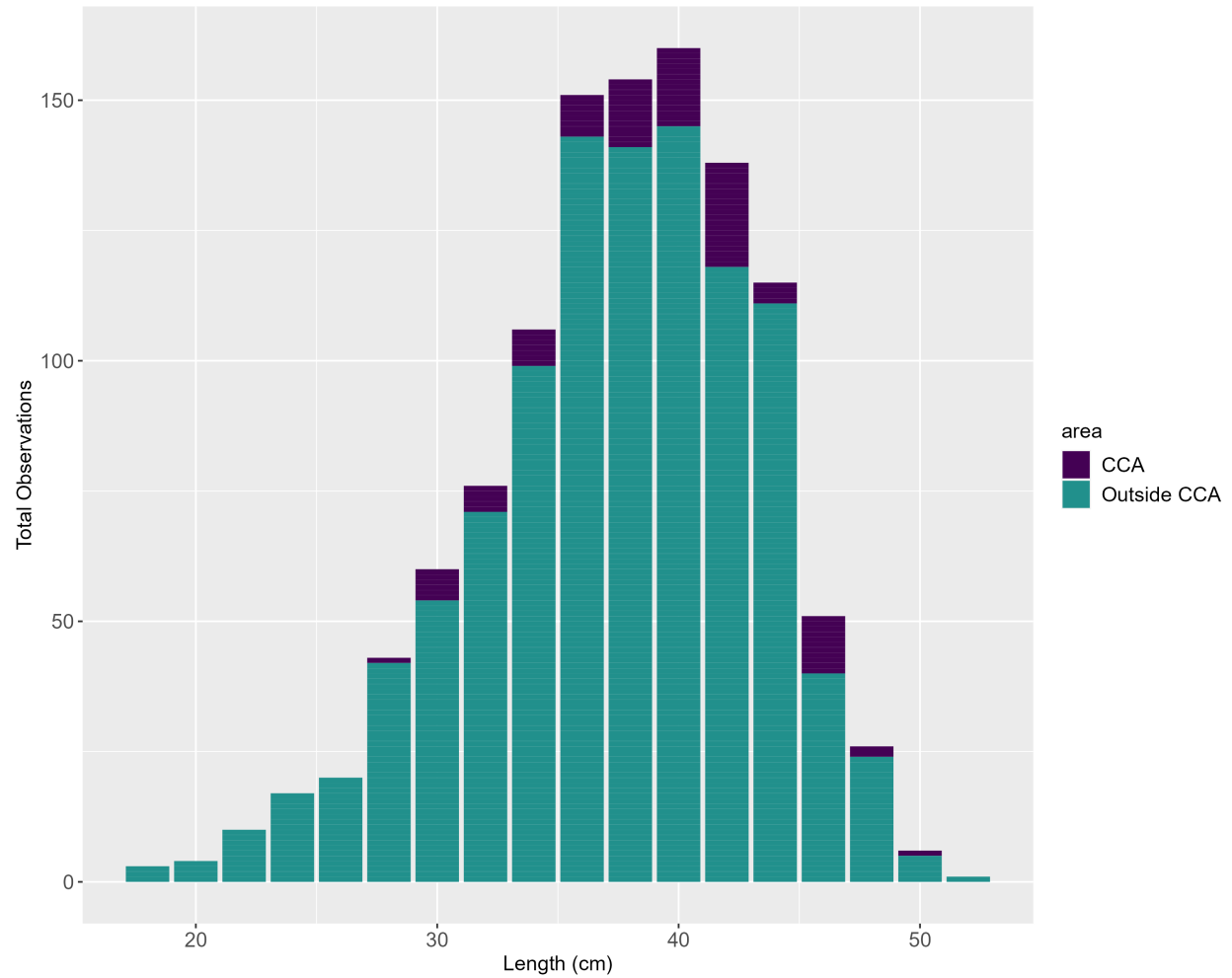


Figure 21: Total observations by length (cm) of copper rockfish between 2004-2021 inside and outside of Cowcod Conservation Areas from the NWFSC Hook and Line survey (source: NWFSC Hook and Line survey).

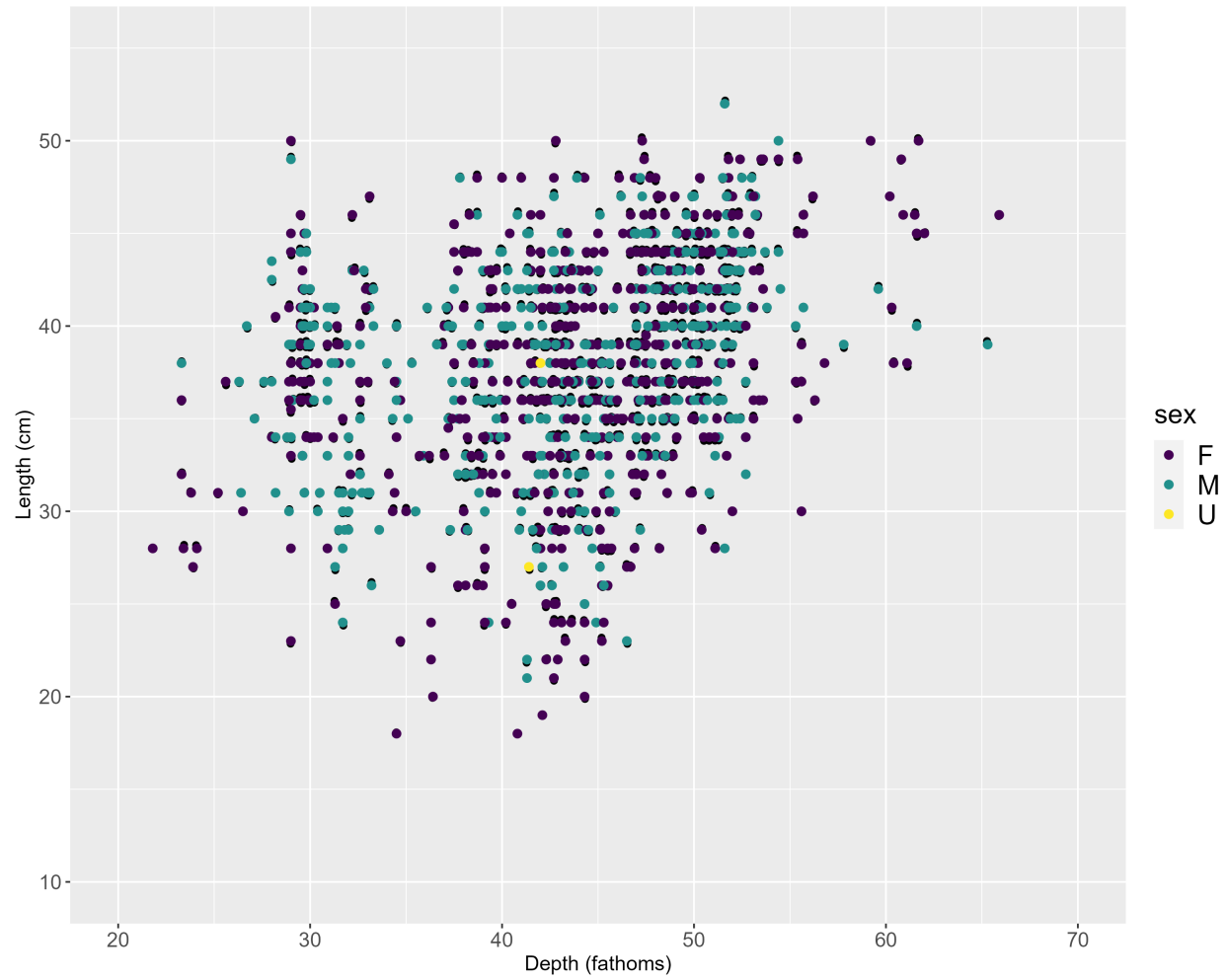


Figure 22: Measured lengths (cm) by depth in fathoms of copper rockfish between 2004-2021 from the NWFSC Hook and Line survey (source: NWFSC Hook and Line survey).

## NWFSC WCGBT survey

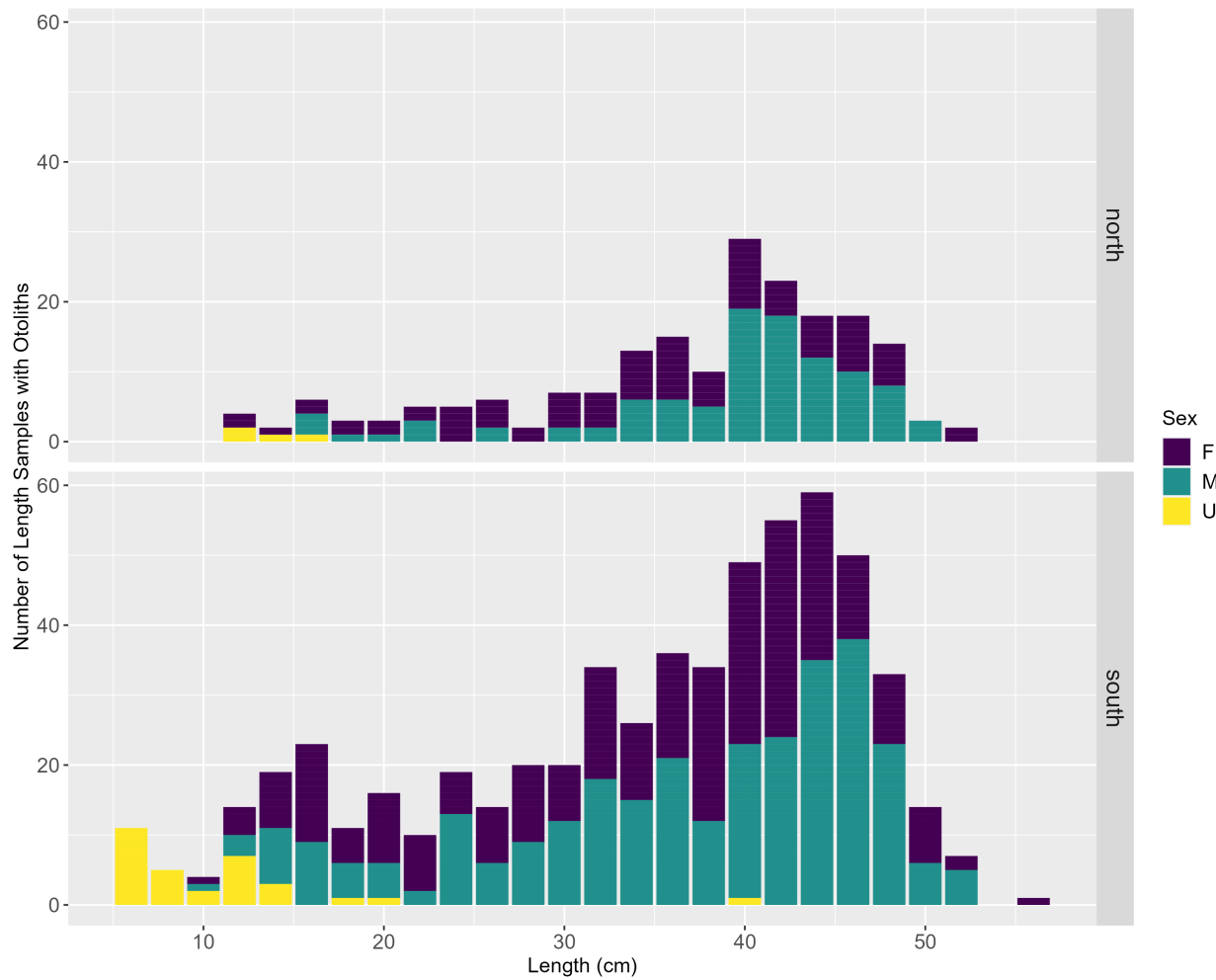


Figure 23: Number of lengths with otoliths by length and area collected by the NWFSC WCGBT survey between 2003 - 2021. A total of 195 and 584 otoliths were collected from the areas north and south of Point Conception, respectively (source: NWFSC WCGBT survey).

## Biology

### Maturity and Fecundity

Currently, there is an extensive collaborative effort to collect biological samples for copper rockfish in California. These samples will support new estimates of maturity- and fecundity-at-length. These data are not yet available but are expected to be completed in time for use in the 2023 assessment of copper rockfish.

For informational purposes, maturity and fecundity curves that were used in the 2021 assessment are shown below.

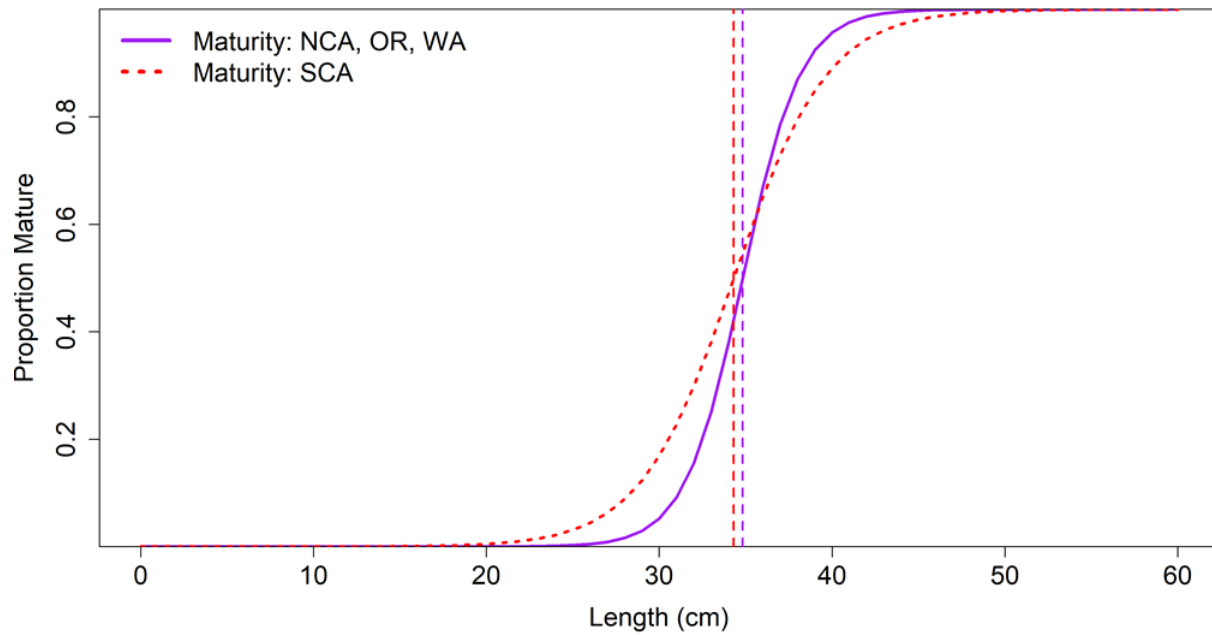


Figure 24: Estimates of maturity-at-length used in the 2021 assessments of copper rockfish. The same maturity curve was used in California north of Point Conception, Oregon, and Washington. A unique maturity curve was estimated based on 111 samples from the NWFSC WCGBT and Hook and Line surveys south of Point Conception (source: Hannah, 2004; Melissa Head (NWFSC)).

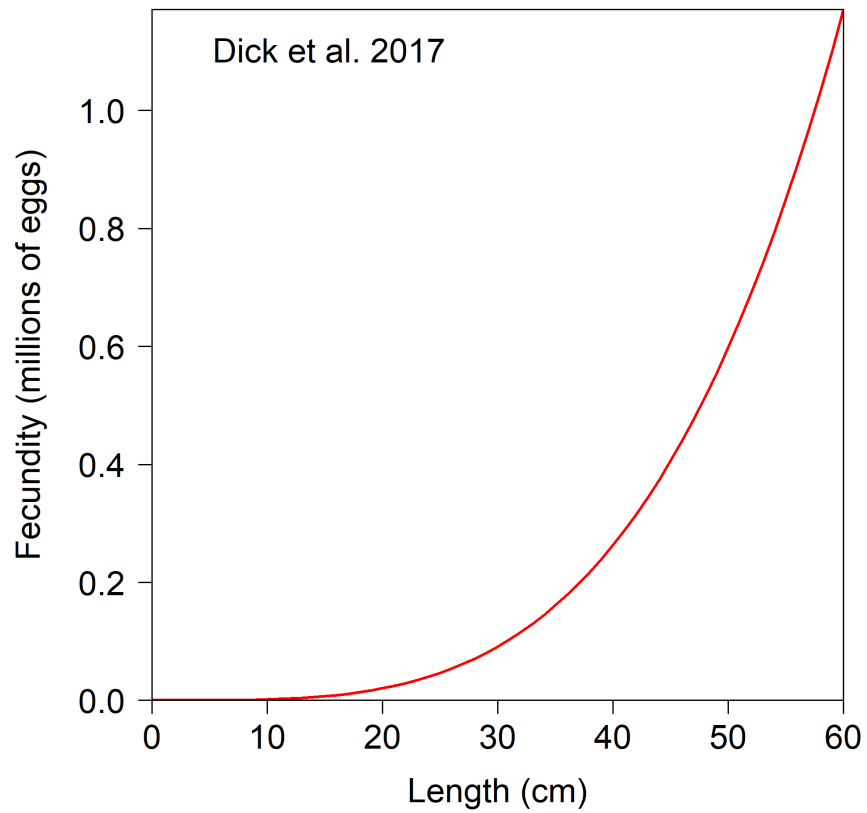


Figure 25: Estimates of fecundity-at-length used in the 2021 assessments of copper rockfish. (source: Dick et al., 2017).

## Length-Weight

The length-weight relationship was estimated using all biological data available from the NWFSC West Coast Groundfish Bottom Trawl (WCGBT) and the NWFSC Hook and Line surveys.

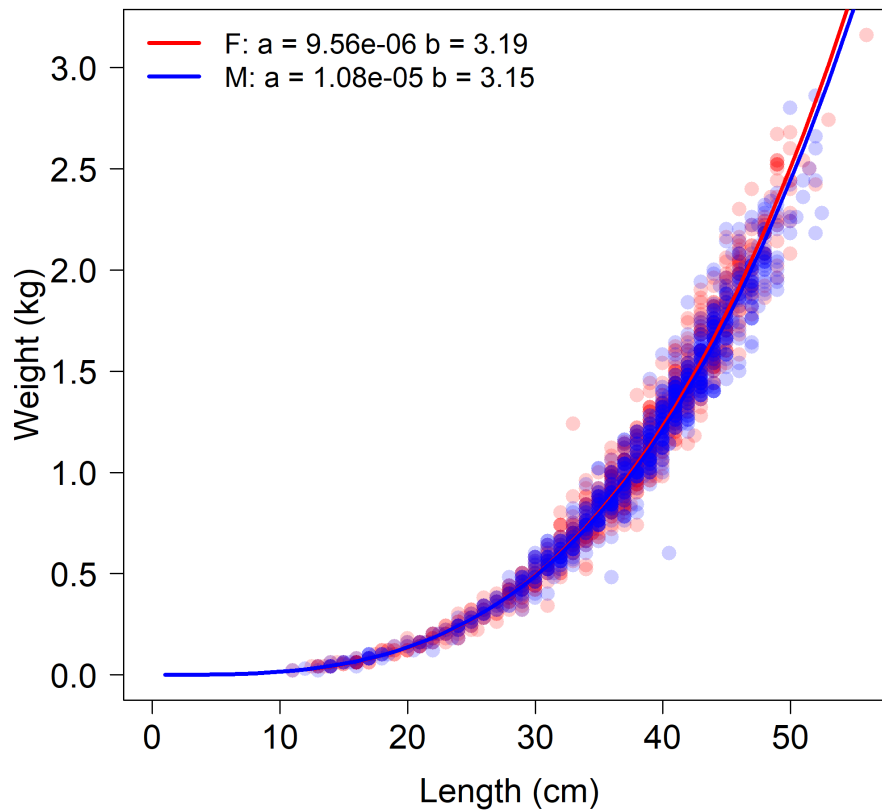


Figure 26: Estimated length-weight relationship by sex for copper rockfish (source: NWFSC WCGBT and Hook and Line Surveys).

### Length-at-Age

The NWFSC ageing lab is currently reading copper rockfish otoliths that were not aged as part of the effort for the 2021 stock assessment. There are a number of new sources of copper rockfish otoliths. The below represent estimates of the number of copper rockfish ages expected to be available for the 2023 assessment.

- North of Point Conception (N ~ 1,284):
  - 211 from CPFV cooperative collections,
  - 99 from Private/Rental vessels collected by CDFW,
  - 79 from commercial fisheries,
  - 87 from CCFRP,
  - 423 from a research survey conducted by Don Pearson,
  - 195 from NWFSC WCGBT survey, and
  - 190 from historic data collections in the late-1970s and early 1980s (refugia) otoliths found by CDFW.
- South of Point Conception (N ~ 2,237):
  - 484 from CPFV cooperative collections,
  - 9 from commercial fisheries,

- 1,073+ from NWFSC hook and line survey,
  - 584 from NWFSC WCGBT survey,
  - 52 from CCFRP, and
  - 34 from a research survey conducted by Don Pearson.
- Otoliths that need to be linked to data north and south of Conception
    - 304 from early recreational fisheries data collections from 1978, 1981, and 1984

## Natural Mortality

Natural mortality was fixed in the 2021 assessments at a value of  $0.108 \text{ yr}^{-1}$  based on an assumed maximum age of 50 years. The maximum age was selected based on available age data collected within Oregon and Washington and literature values. The oldest aged observed was 51 years with two observations off of the coast of Washington and Oregon in 2019. This selection was consistent with the literature examining the longevity of copper rockfish and was supported by the observed ages that had multiple observations of fish between 44 and 51 years of age.

The input parameter value for natural mortality will be reconsidered within the 2023 assessments based on any new available age data. Additionally, the 2023 assessments will explore the ability to estimate natural mortality within the model and will conduct sensitivities and profiles to understand the information in the data on natural mortality and the impact of select values on the model estimates.