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The 2021 U.S. West Coast Bottom Trawl Survey of Groundfish Resources off Washington, Oregon, and California: Estimates of Distribution, Abundance, and Length Composition

June 2023

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

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Cover image: FV *Last Straw* setting sail at dawn from Eureka, CA, July 2022. Photograph by J. LaFargue, NMFS/NWFSC.

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NOAA FISHERIES

The 2021 U.S. West Coast Bottom Trawl Survey of Groundfish Resources off Washington, Oregon, and California: Estimates of Distribution, Abundance, and Length Composition

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U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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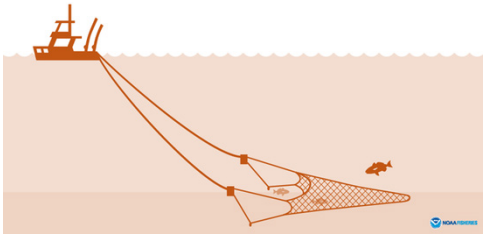
Background

Groundfish is a term that includes dozens of ocean-dwelling fish, including species of sharks, skates, flatfish, and rockfish. Groundfish live off the entire U.S. West Coast, from Canada to Mexico, in environments from the nearshore to over 1,000 fathoms deep. Unfortunately, many groundfish species were overfished in the 1980s and 90s, leading to a fishery management plan that first went into effect in 1982. The U.S. West Coast groundfish fishery is supported by more than 90 commercially valuable species.

The West Coast Groundfish Bottom Trawl Survey, conducted annually by NWFSC, provides essential data necessary to support assessments of the status and trends of bottom-dwelling fish and invertebrates within the fishery. The survey is conducted from chartered west coast bottom trawl fishing vessels, and provides measures of change in species abundance, distribution, and condition. This information is used by fishery managers, fishers, and interested citizens.



In this report, we document the operations, design, and initial results of the survey conducted from May to October, 2021. The results are summarized in 18 tables and 53 figures by both geographic area and depth zone, and include data on over 420 unique taxa of fish and invertebrates.

Links used in this section:

- Groundfish: https://www.fisheries.noaa.gov/species/west-coast-groundfish
- Fishery management plan: https://www.fisheries.noaa.gov/management-plan/pacific-coast-groundfish-fishery-management-plan
- U.S. West Coast groundfish fishery: https://www.pcouncil.org/managed_fishery/groundfish/
- West Coast Groundfish Bottom Trawl Survey: https://www.fisheries.noaa.gov/west-coast/science-data/us-west-coast-groundfish-bottom-trawl-survey
- Bottom trawl: https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-bottom-trawls
- Fishery managers, fishers, and interested citizens: https://www.fisheries.noaa.gov/podcast/citizens-guide-fishery-management

Executive Summary

The Northwest Fisheries Science Center's Fishery Resource Analysis and Monitoring Division (FRAM) completed the twenty-third in an annual series of groundfish bottom trawl surveys in 2021. The survey occurred from 20 May to 29 October 2021 and targeted the commercial groundfish resources inhabiting depths of 55 to 1,280 m (30–700 fathoms) from the area off Cape Flattery, Washington (lat 48°10′N) to the U.S.–Mexico border (lat 32°30′N) using chartered commercial trawl vessels. This ongoing series of annual surveys, conducted by FRAM since 1998, focuses on monitoring long-term trends in the distribution and abundance of U.S. West Coast groundfish, especially those species of management concern. Due to the global COVID-19 pandemic, no survey occurred in 2020, representing the first break in the time series since it started. The 2021 survey sampled within a depth range that included both the continental shelf (55–183 m) and continental slope (183–1,280 m) using a stratified random sampling design. Because of COVID-19, we modified the sampling schedule for the first half of the 2021 survey to include longer legs (11–18 days versus the typical 8–10 days) and fewer port calls (two versus the typical four).

In 2021, we selected 752 primary sampling sites (and associated secondary and tertiary sites) prior to the start of the survey. We allocated trawling locations according to a stratified random sampling design that divided the region into two geographic areas (north and south of Point Conception, California) and three depth zones (55–183 m, 184–549 m, 550–1,280 m). The objective was to provide a representative sample and relative numbers of the various groundfish species inhabiting each depth stratum. By selecting random stations within certain depth zones, we give all towable ground an equal probability of being sampled during the survey. Thus, the method produces unbiased estimates of the relative stock size. In 2021, we completed 681 successful tows of 715 attempts. We used SIMRAD Integrated Trawl Instrumentation net mensuration data, as well as global positioning system (GPS) navigation data and bottom contact sensor data, to document performance (e.g., bottom tending) for most tows.

The survey utilized an Aberdeen-style net with a small mesh (1½″ stretched measure) liner in the codend (to retain smaller specimens) to sample fish biomass. Target duration of each tow was 15 minutes. We determined tow duration as the difference in time between touchdown and lift-off of the trawl net from the seafloor based on bottom contact sensor readings.

Unless there was an extreme catch event, we sorted the entire catch to species, aggregate, or other appropriate taxonomic level then weighed each species using an electronic, motion-compensated scale. We identified a total of 567 species or families within the survey area in 2021. Although the biological sampling efforts continue to include the major slope species—Dover sole (*Microstomus pacificus*), shortspine thornyhead (*Sebastolobus alascanus*), longspine thornyhead (*S. altivelis*), and sablefish (*Anoplopoma fimbria*), the focus now encompasses all groundfish species of management concern (94+ species). We collected up to 100 length measurements, sex determinations, and individual weights, and up to 50 age structures per haul, for each species of management concern.

Acknowledgments

We thank the captains and crew of the fishing vessels *Ms. Julie*, *Excalibur*, *Noah's Ark*, and *Last Straw* for their efforts during the 2021 Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey. We also thank the biologists who participated in the 2021 survey, including: Kelly Andrews, Laurie Beale, Phillip Bizzell, Gabriel Brooks, Keith Bosley, John Buchanan, Aaron Chappell, Cassandra Donovan, Doug Draper, Jahnava Duryea, Meredith Everett, Peter Frey, Sean Gross, John Harms, Chris Harvey, Melissa Head, Laurel Lam, Matt Nesbit, Kolton Ollom, Jacob Rennert, Katie Schmidt, Adam Smith, Bradley Speidel, Josie Thompson, Vanessa Tuttle, and Erin Tyler. Scott McEntire at the Resource Assessment and Conservation Engineering Division of the Alaska Fisheries Science Center designed the bottom contact sensors. We also express our appreciation to Rick Brown, Veralyn Evans, Jim Fellows, John Wallace, and Curt Whitmire for their shoreside support.

Introduction

The U.S. West Coast groundfish fishery, supported by 94+ commercially valuable species, spans the area from the U.S.–Canada to the U.S.–Mexico borders in nearshore to offshore waters. Multiple vessel types, ranging in size from kayaks to trawlers, participate in the fishery. The fishery sectors deploy mobile and fixed gear including bottom trawls, midwater trawls, pots, longlines, and other hook-and-line gear; however, trawlers account for the majority of landed groundfish. Active management of the fishery began in the early 1980s with the establishment of optimum yields and trip limits for several managed species. Management measures currently include landing limits, size limits, gear restrictions, and time and area closures, designed to avoid overfishing and to rebuild overfished stocks.

The Fishery Resource Analysis and Monitoring Division (FRAM) of the Northwest Fisheries Science Center (NWFSC) completed the 23rd in a series of annual bottom trawl surveys of groundfish resources off the U.S. West Coast, conducting survey operations from 20 May to 29 October 2021. The major objective of the NWFSC West Coast Groundfish Bottom Trawl Survey (WCGBTS) is to provide the fishery-independent data necessary to support the assessment of the status and trends of fish species inhabiting trawlable habitat along the upper continental slope and shelf of the U.S. West Coast. The survey area extended from northern Washington (U.S.–Canada border) to southern California (U.S.–Mexico border), in waters ranging from 55 to 1,280 m (30–700 fathoms [fth]). Annual, coastwide sampling cruises have been undertaken by NWFSC since 1998 as part of an ongoing time series of groundfish catch, fishing effort, and individual fish measurement data (Turk et al. 2001, Builder-Ramsey et al. 2002, Bradburn et al. 2011, Keller et al. 2005, 2006a, 2006b, 2007a, 2007b, 2008, 2017).

Although NWFSC assumed responsibility for the slope portion of the groundfish survey in 1998, the time series began as an annual U.S. West Coast continental slope survey conducted by the Alaska Fisheries Science Center (AFSC) in 1988. In 2003, NWFSC expanded the depth coverage to include the continental shelf (55–183 m) as well as the continental slope (184–1,280 m). Consequently, in the current sampling configuration, the WCGBTS now also encompasses the area historically monitored by the continental shelf survey conducted triennially by AFSC (1977–2001). NWFSC's groundfish survey currently provides not only an annual (sans 2020) snapshot of groundfish stock status, but also an extension of two established, long-term time series for use in making informed management decisions.

Prior to 1998, surveys conducted by AFSC were the principal source for fishery-independent data of groundfish resources along the upper continental slope and shelf of the U.S. West Coast (Methot et al. 2000, Keller et al. 2017). AFSC conducted slope surveys periodically from 1984–87 and annually beginning in 1988. Triennial shelf surveys occurred from 1977 through 2001. AFSC conducted slope surveys using the NOAA RV *Miller Freeman*, while the triennial survey used chartered Alaska fishing vessels. Spatial coverage of the U.S. West Coast surveys varied between years due to constraints imposed by annual budget levels and availability of NOAA ship time (Lauth 2001).

The NWFSC groundfish survey was initially designed to cover the same depths and latitudes established by the AFSC slope survey. Beginning in 2003, the WCGBTS expanded to include the continental shelf and slope (range of depths from 55 to 1,280 m) along the entire U.S. West Coast (U.S.–Canada border to U.S.–Mexico border). Since its inception in 1998, the NWFSC groundfish survey has utilized chartered fishing vessels from the west coast commercial fishing industry. This capitalizes on the skills of fishing captains familiar with the challenges of fishing off the U.S. West Coast and fulfills the cooperative research provisions of the Magnuson–Stevens Fishery Conservation and Management Act (MSA).[1] The results of the surveys provide measures of change in relative abundance, distribution, and condition of groundfish stocks over time, information of interest to fisheries managers, fishers, and concerned citizens.

The WCGBTS spans from lat 48°10′N to lat 32°30′N and is geographically subdivided into two geographic strata with a simple north–south division at lat 34°30′N (Point Conception, California; Figure 1). The current strata and station allocation scheme maintains the number of sites sampled north of Point Conception at levels similar to those sampled prior to 2003 using the transect-based design, while reducing the variance of survey catch rates within a stratum (Keller et al. 2017). Sampling allocation among strata was constrained by the cost of the survey, the desire to maintain sampling north of Point Conception at historical levels while adding sufficient sampling south of Point Conception to inform stock assessments, and the timing of the survey (i.e., staying within the dates previously established as the survey period). The number of stations south of Point Conception resulted in a lower sampling density for the deepest stratum (549–1,280 m) than in the stations north of Point Conception, because of the large size of the Southern California Bight and the constraints noted above.

The objective of this report is to document the operations, survey design, and initial results of the 2021 survey. We provide data summaries for species composition, catch, distribution, relative density, biomass estimates, and size composition of selected species. The results are summarized by geographic strata (north–south of Pt. Conception, lat 34°30′N) and depth strata (55–183 m, 184–549 m, and 550–1,280 m, or 30–100 fth, 101–300 fth, and 301–700 fth). We describe weight–length and length-at-age relationships, with age determined from otoliths or other fish structures, for select groundfish species. This report documents operations and results of the 2021 groundfish survey with intent to summarize the data used in the creation of indices of abundance for stock assessment purposes.

[1] Mandated authority over fisheries along the west coast of the United States, including specifically the states of Washington, Oregon, and California, resides principally with the Pacific Fishery Management Council, created in 1976 as part of the MSA. This legislation also established a 200-mile exclusive economic zone surrounding the nation's coastline.

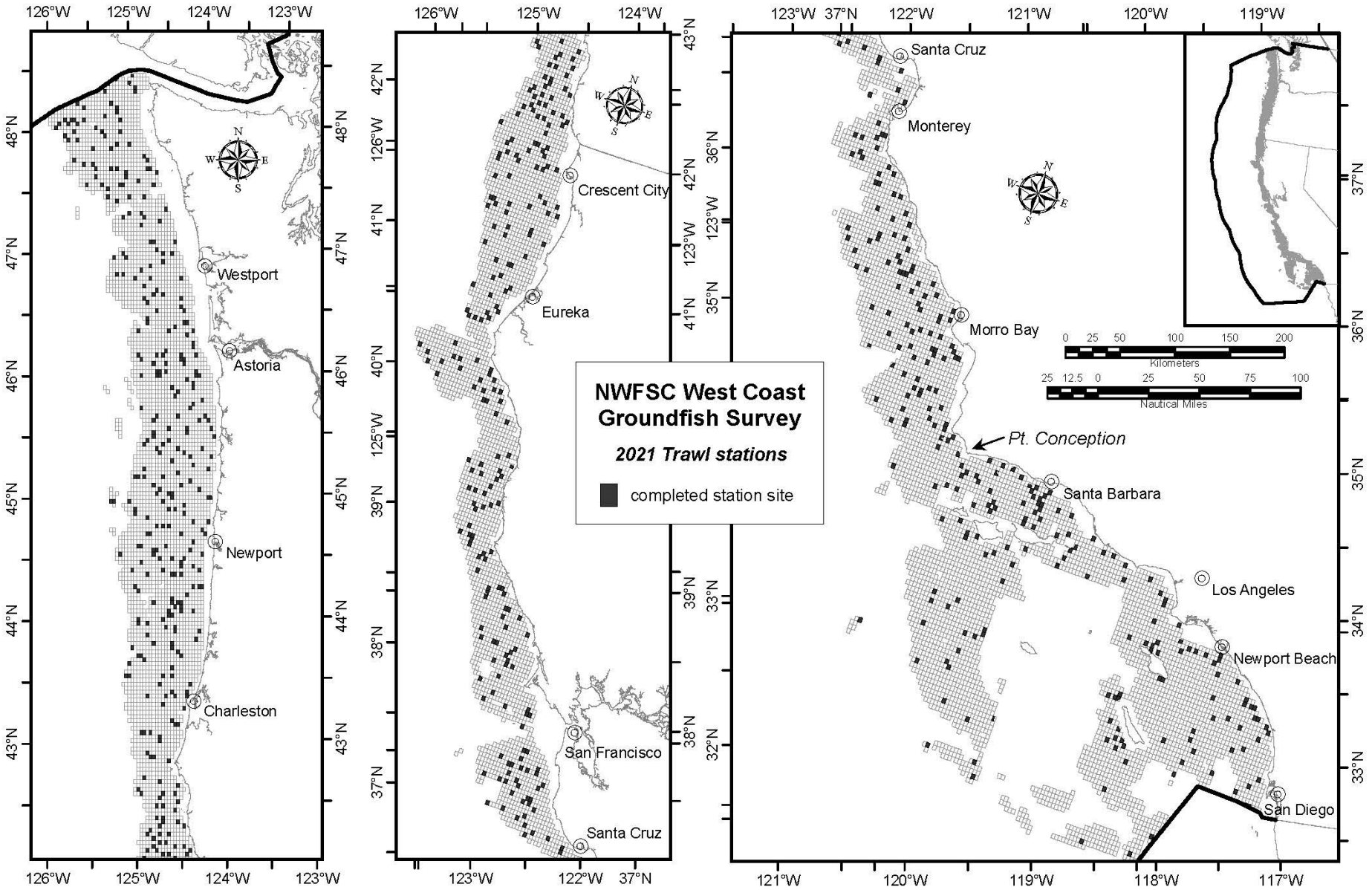


Figure 1. Chart showing extent of the 2021 U.S. West Coast Groundfish Bottom Trawl Survey and the locations of completed stations.

Survey Methods

Survey Period and Area

The 2021 WCGBTS occurred during two cycles of operations, or passes, between 14 May and 26 October 2021 from the areas off Cape Flattery, Washington (lat 48°10′N) to the U.S.–Mexico border (lat 32°30′N). As a cooperative research effort, the 2021 WCGBTS chartered four west coast bottom trawl vessels through a standard competitive bid process. We utilized the fishing vessels (FVs) *Ms. Julie* and *Last Straw* during the first survey period from 14 May to 23 July 2021, and two additional vessels, the FV *Excalibur* and FV *Noah's Ark*, during the second survey period from 16 August to 26 October 2021. All vessels started operations off Newport, Oregon, sampling north to Cape Flattery, then progressed south along the coast, finishing the completed cycle south of San Diego, California.

Vessels and Sampling Gear

The chartered vessels ranged in size from 65 to 75 ft (19.8 to 22.9 m) and in power from 450 to 600 horsepower. Each vessel was rigged as a stern trawler, with a rear gantry housing one or two net reels to set and retrieve trawl gear. Vessels were outfitted with split trawl winches and equipped with modern electronics including global positioning systems (GPS), multiple depth sounders, radars, and other navigational aids. Prior to the start of the survey, NWFSC provided each vessel with two ⅝″ steel-core trawl cables, each 2,288 m (1,250 fth) in length. We measured and marked side-by-side cables, at 25-fathom increments, while spooling them onto the vessel's winches. The markings provided real-time verification of the release of equal warp length from both winches while setting a tow.

We equipped each vessel with two standard four-panel, single-bridle, Aberdeen-style nets (Figure 2) spread by 5 × 7-ft (1.5 × 2.1-m) steel V doors weighing 590 kg. The headrope and footrope measured 25.9 and 31.7 m, respectively (Figure 3). Each net had a small mesh liner (1½″ stretched measure, #24 twisted polypropylene) in the codend to retain smaller fish and invertebrates. Nor'Eastern Trawl Systems (Bainbridge Island, Washington) manufactured the Aberdeen trawl nets and NWFSC personnel annually certified each net. NWFSC outfitted each vessel with primary and secondary nets and provided additional nets if severe damage occurred during trawl operations. To ensure continuity, we conducted fishing operations in compliance with national and regional protocols (Stauffer 2004). We recorded various aspects of the mechanical performance of the nets (e.g., wing spread, vertical distance from the center of the headrope to the bottom, distance from the headrope to the footrope, and clearance between the footrope and bottom) using acoustic and bottom contact instruments hung from the net during each deployment. We also recorded additional information on operational conditions such as depth, amount of towing cable deployed, towing speed, tow duration, and weather conditions.

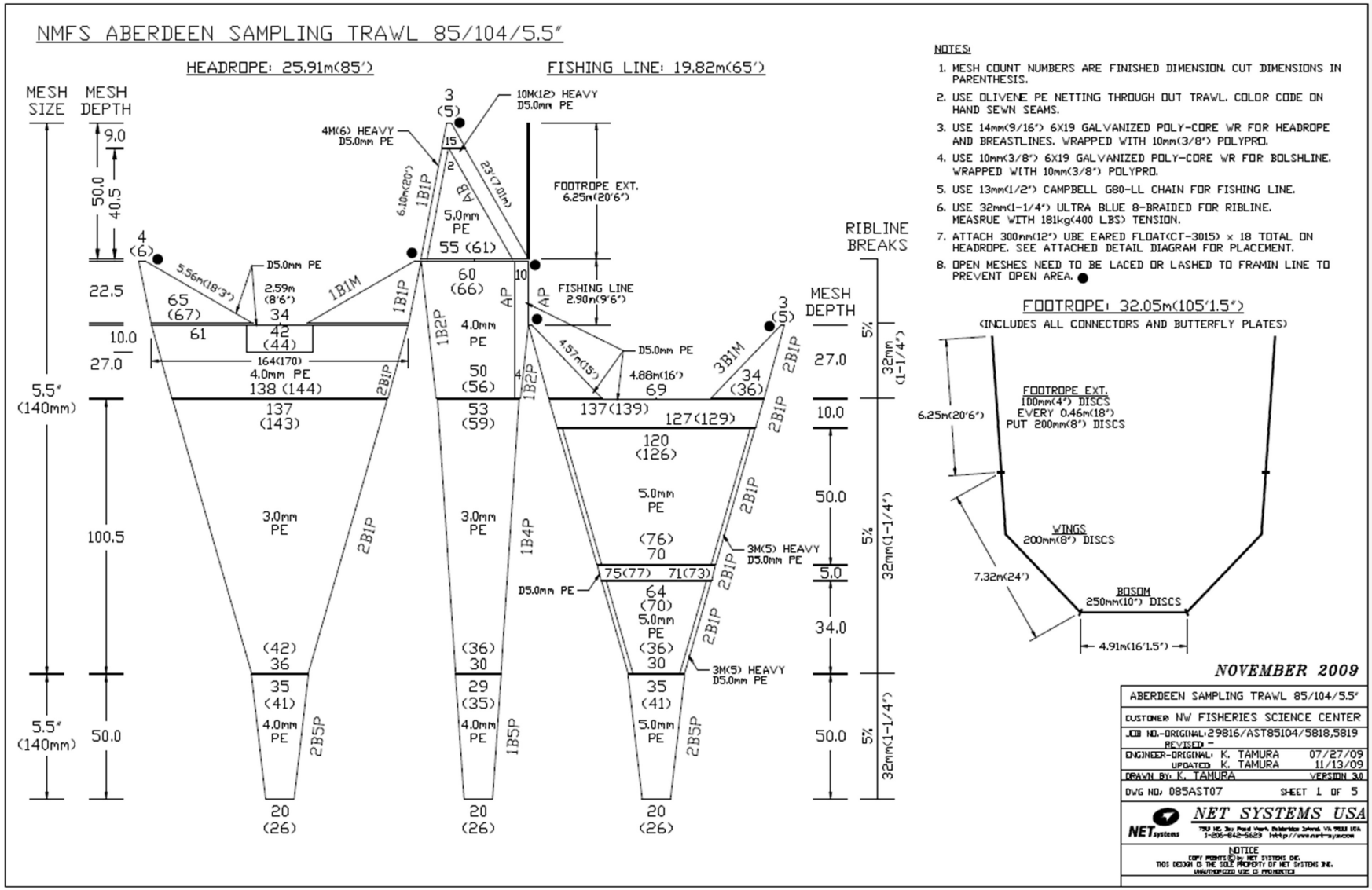


Figure 2. Detailed diagram of the NWFSC Aberdeen-style sampling trawl, including descriptions of dimensions, materials, mesh sizes, and mesh counts. See Figure 3 for a detail of the footrope.

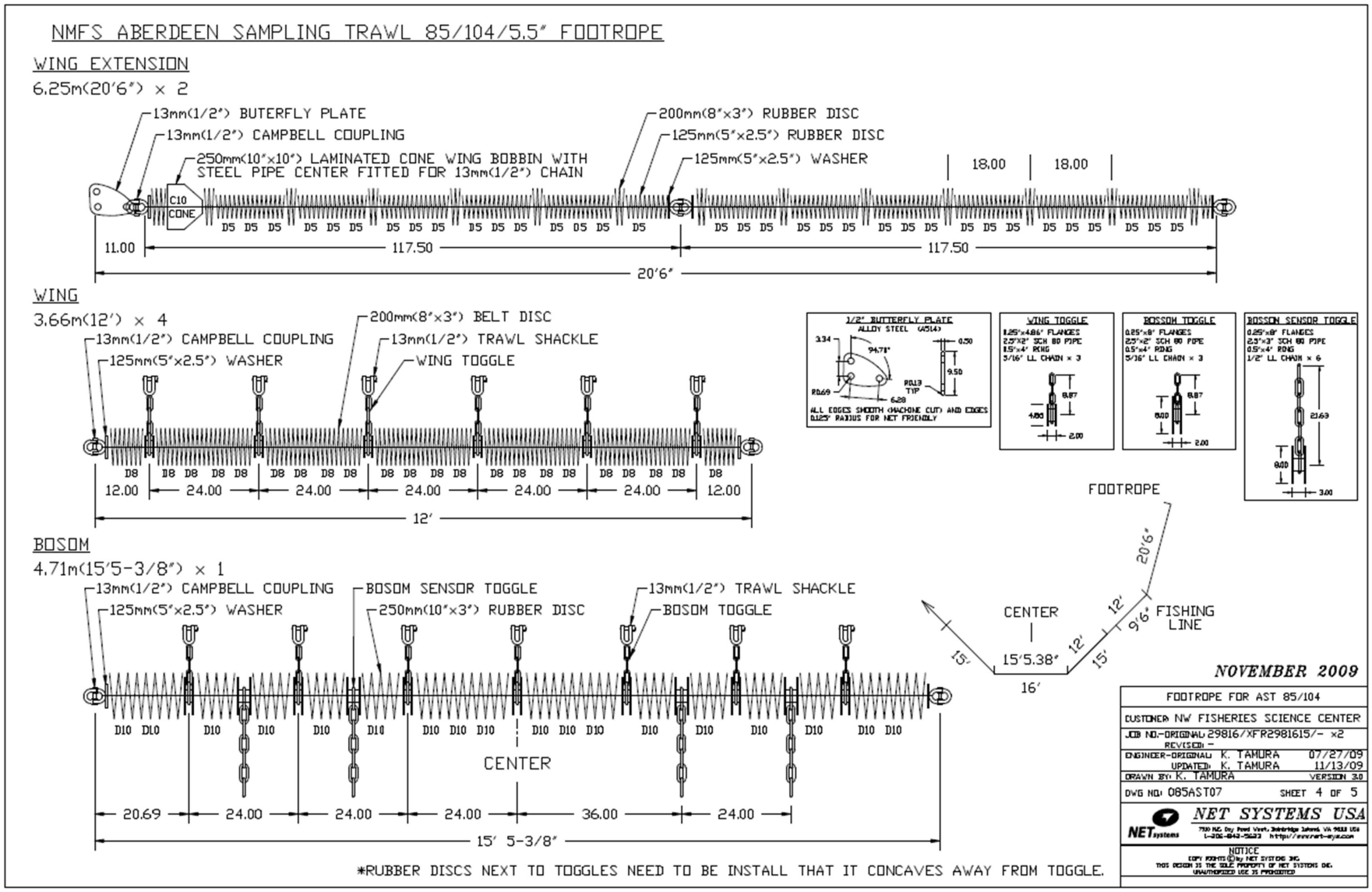


Figure 3. Footrope for the NWFSC Aberdeen-style sampling trawl composed of seven sections with an overall length of 104 ft. A single section of each component of the footrope is shown in the figure. Notes: Footrope composed of ½″-long link steel alloy (grade 7) chain, with rubber discs (8–10″) and dropper chains (10″) strung along the length, and section lengths (measured from bearing point to bearing point, B–B) connected by ½″ Campbell hammerlocks and stainless pins and spacers.

Trawl Station Allocation

From 1998 through 2002, we based selection of sample sites for the WCGBTS on a fixed transect design. Following an evaluation of the transect-based survey design by assessment and survey scientists, we subsequently adopted a stratified random sampling design in 2003. The survey area was partitioned into approximately 12,000 adjacent cells of equal area (1.5 nautical miles [nmi] longitude by 2.0 nmi latitude based on Albers Equal Area projection), with each vessel assigned a primary subset of 180 randomly selected cell sites. In 2003, we assigned sampling density to areas based on International North Pacific Fisheries Commission (INPFC) areas and specified depth categories. After the 2003 survey season, further review by assessment scientists indicated that a greater flexibility in the development of post-stratification strategies would be gained if the geographic allocation of randomly selected sites were reduced to a simple north–south geographic division at lat 34°30′N (Point Conception, California).

Consequently, starting in 2004, we allocated sampling locations accordingly, with 80% of the effort allocated to the northern portion of the survey and 20% allocated to the southern area. This allocation scheme maintained a comparable level of sampling effort in the area north of Point Conception (34°30′N) as sampled in prior years. The survey area was further stratified into three depth zones (55–183 m, 184–549 m, and 550–1,280 m), with the percentage of sampling stations allocated to each of the three depth ranges in the northern and southern geographic areas based roughly on the proportion of the area within each depth stratum. North of Point Conception, 40% of the area is located within the shallow depth stratum (55–183 m) and 30% within each of the two remaining strata (mid-depth and deep zones). South of Point Conception, 25% of the area was allocated within the shallow depth zone, 45% within the mid-depth zone, and the remaining 30% within the deep depth range.

The total number of sites targeted for the survey year was apportioned across geographic area and depth categories based on the above scheme, and then primary stations were drawn from the survey cell pool, by stratum, using a pseudorandom number generator. Each cell was sequentially assigned to an individual vessel. The process was repeated to identify two alternate sampling sites per location. Additional constraints were imposed to ensure alternate sites were neither so close to an untrawlable primary site that they exhibit the same untrawlable features, nor at an impractical transit distance. In 2021, we selected 752 primary sites, with each vessel assigned 188 tows (one tow per cell). A total of 681 successful tows were completed out of 715 attempted tows.

Trawl Operation Protocol

We followed standardized trawl operations to minimize differences in sampling (fishing) efficiency across the range of conditions encountered during the survey and over time (Stauffer 2004). Trawling operations occurred only during the daylight period (dawn to dusk). The initial tow each day began (net on seafloor) following official sunrise, and the last tow of the day ended (net off seafloor) before official sunset. Once a vessel entered a preselected sampling area (1.5 × 2.0-nmi cell), the captain observed a series of search rules to identify a specific tow site: 1) search within the specified depth range, 2) remain fully

within the specified area, and 3) complete the search for trawlable ground within 1 hour. If no trawlable site was found within the 1-hour limit, we designated the cell in the log as untrawlable and the vessel proceeded to the secondary cell. If the secondary cell also proved untrawlable, the tertiary cell was attempted. If a tow was attempted but judged unsatisfactory, or if the tow was aborted, a reasonable attempt was made to redo the tow within the primary site before proceeding to alternate sites. Rarely do the primary, secondary, and tertiary cells fail to produce an acceptable tow.

We monitored all fishing operations, including vessel operations and gear performance, using a suite of trawl instrumentation systems. A GPS navigation unit (Garmin unit 152, Garmin International Inc., Olathe, Kansas) supplied by the National Marine Fisheries Service (NMFS), or the vessel's speed indicators, were used to monitor towing speed for each survey haul (target 2.2 knots over ground). We equipped the trawl with several sensors to track net position and collect oceanographic data and additional information on operational conditions (e.g., depth, scope, towing speed, tow duration, and weather conditions) using custom programs to manually record the data.

We monitored net position, performance, and geometry using SIMRAD Integrated Trawl Instrumentation Systems (ITI), SIMRAD PX TrawlEye catch monitoring sensors, SIMRAD PI44 Catch Monitoring System (SIMRAD Fisheries, Lynnwood, Washington) and bottom contact sensors (BCSes; AFSC). Net mensuration instruments provided georeferenced trawl positions relative to ship position to track trawl location along the seafloor during each survey tow. The ITI and PI44 systems delivered data acoustically to the vessels and are redundant, with either adequate to monitor net performance. Following the completion of the survey, we reviewed the trawl data supplied by sensors to determine trawl performance.

Sensors mounted on the net provided information on the vertical opening of the trawl, distance to the seafloor, footrope clearance above the bottom, ambient temperature, and depth. Paired sensors attached on the port and starboard wings measured mean net width, and sensors on the trawl doors measure doorspread (distance between the doors). Trawl instruments displayed gear performance and the SIMRAD ITI provided georeferenced trawl positions relative to ship position, supplying a means to track the trawl location along the seafloor throughout each tow. We logged all features of the trawl event (i.e., commencement of net deployment through completion of net retrieval), and trawl mensuration data using customized software programs (NWFSC).

We deployed a pair of BCSes on each haul. A BCS is a tilt-meter housed in a heavy steel case which is vertical when the net is off the bottom, and more horizontal when the net contacts the bottom. We attached the BCS units on either side of the center-point of the footrope. Since the BSCes recorded the angle of incline of the net, indicating when the net landed on and lifted off the seafloor, they provided redundancy in the event that the other instrumentation failed to adequately identify the position of the net relative to the seafloor.

We additionally deployed both a Sea-Bird SBE 39 and a Sea-Bird SBE 19+ conductivity, temperature, and depth profiler (Sea-Bird Electronics Inc., Bellevue, Washington) equipped with a calibrated SBE 43 polarographic membrane-type oxygen sensor at each site to

provide near-bottom depth (m), temperature (°C), salinity, oxygen (mL/L), and depth (m) during each trawl. In addition to monitoring trawl performance, we used the data from the sensor systems (SIMRAD ITI, BCS, and Sea-Bird) to calculate net dimensions (net height and net width), duration of tow, and distance fished.

Vessel speeds varied from 2.2 to 5.0 knots while setting the gear. After the net contacted the seafloor, we targeted vessel speed as 2.2 ±0.5 knots. The haul officially began when the net achieved proper fishing configuration and maintained steady contact with the bottom. The haul ended when the net lifted off the bottom after the start of haul back. We targeted tow duration as 15 minutes. The SIMRAD trawl system monitored real-time, ground gear contact during a haul, but the actual bottom time was determined using BCS data in a post-hoc analysis.

We used position data, collected at 2-second intervals for each haul, using a GPS to monitor ground speed, track the vessel path, and estimate distance fished. We calculated average net speed over ground and distance fished using position data and the trawl's actual bottom time. We logged all features of the trawl event (i.e., from commencement of net deployment to completion of net retrieval), including net mensuration information, GPS data, trawl location, scope, vessel depth, trawl gear depth, and sea state conditions, using customized software programs. Following every haul, we reviewed data to determine a performance rating for each tow. We classified a tow as unsatisfactory when severe damage to gear occurred during a haul, which could affect catch size and composition. We deemed gear performance unacceptable for other reasons, such as a catch of large quantities of mud or jellyfish, ensnarement of lost or abandoned fishing gear, or presence of hazardous waste. If the net came off bottom for an extended period (2 minutes aggregated off-bottom time) during the tow, we categorized the tow as unsatisfactory.

Sampling Procedures and Biological Data Collection

We sorted catches to species or other appropriate taxonomic level and then weighed the catch in aggregate using an electronic, motion-compensated scale (Marel, Reykjavik, Iceland). We randomly selected subsamples of important management species for individual measurements (length and weight) and biological sampling (maturity, age structures, and sex determination). For each species, we collected up to 100 sex determinations and length measurements (to the nearest centimeter) per haul. Although we generally measured fork length (or total length) for most species, anal length was recorded for Pacific grenadier (*Coryphaenoides acrolepis*) and spotted ratfish (*Hydrolagus colliei*).

For groundfish present in the U.S. West Coast fisheries management plan (FMP species), we typically removed otoliths to determine age. However, exceptions to the use of otoliths included collection of fin rays from lingcod (*Ophiodon elongates*) and second dorsal spines from spiny dogfish (*Squalus acanthias*). We randomly selected fish for ageing from the subset chosen for length determination. We targeted up to 25 individuals per haul by species for otolith collection. We measured individual lengths and weights for all FMP fish selected for age-structure removal. For species not present in the U.S. West Coast FMP, we recorded

total counts and aggregate weights. We collected additional information for special projects (including stomach contents, tissue samples, special collections, fecundity, and toxicology). We logged all data wirelessly using ruggedized computers and customized data-capture programs.

We labeled, froze, or preserved (in formalin) and retained unidentified species for later identification. Although we typically sell marketable fish (in Washington and Oregon) to offset the cost of the groundfish survey, we did not do so in 2021 due to COVID-19 and a desire to avoid entering port except when essential to change crew. We returned species with catch prohibitions to the sea as soon as possible.

Survey Analysis

Sensor Data

Instrumentation played an important role in monitoring trawl performance, with mensuration data used to facilitate detection and correction of gear malfunction and to identify deviation from standardized fishing procedures. In addition to their role in evaluating trawl performance, sensors—BCS, SIMRAD, and GPS—provided data used to estimate effort following the completion of the survey. Because of the occasional erratic readings inherent to acoustic data, we reviewed sensor streams prior to use.

Since sensor readings should be present throughout a tow, we treated recorded values of zero as missing values and removed all missing values prior to estimation of depth, net geometry, and temperature. Exclusion of extreme points was more difficult. Large, isolated spikes in the depth, net dimension, and temperature readings were frequent and assumed to be the result of acoustic or electronic noise and were removed prior to processing. Trawl execution problems also produced datasets with large fluctuations in readings that we subsequently removed. However, when multiple extreme points occurred in sequence, they were more difficult to evaluate since large swings in sensor data can occur during tows over sloped and/or irregular substrates. Consequently, we did not exclude extreme values either recorded as part of a continuous variation in magnitude or during a particularly variable stretch of readings prior to analysis.

To ensure reliability of on-bottom readings, we restricted sensor data used to estimate depth and net width/height to a subset of values collected from the center 80% of the tow duration. In the vast majority of tows, this criterion did not appreciably reduce the number of observations, but did effectively exclude small offsets between the BCS and SIMRAD sensor systems and noise introduced by net touchdown and liftoff.

For some tows, we acquired few satisfactory sensor readings (depth, net dimension, and temperature). The extent to which these single or few point subsamples represented a tow was determined subjectively. If the points aligned with the trajectory of points outside the subset time interval, we used them as the basis for estimation. Notations hand-recorded during a tow provided an additional level of data checking. We subsequently considered these notes to determine whether to accept or reject a tow.

Net Mensuration

We determined tow duration as the difference between the times marking touchdown and liftoff of the trawl net. Whenever possible, we derived these times from BCS traces of tow progression from net deployment to retrieval. We used patterns in SIMRAD sensor reading, Seabird temperature and depth readings, or field party chief (FPC) observations of net touchdown and liftoff times in place of suspect BCS information.

In general, we calculated mean net widths and heights from trawl sensor readings of wingspread and headrope height off bottom, respectively. Although electronically recorded sensor readings provided the preferred basis for estimation, we substituted hand-recorded readings if necessary. When neither dataset provided sufficient information, we calculated estimates from linear regressions using relationships developed from other tows. In 2021, for tows lacking reliable wingspread data, we used mean doorspread by vessel to calculate average wingspread based on linear regression. For tows lacking both quality wingspread and doorspread data, we determined average wingspread by vessel using vessel-specific logarithmic regressions of wingspread versus depth. To predict net height (m), we initially regressed height versus tow depth (m), incorporating vessel identification as an indicator variable. In the absence of available data, we determined net height by averaging available data by vessel and applying the average to tows with missing values.

The period that we towed a net over the seafloor incorporated two distinct phases used to estimate distance fished. The first phase, defined as normal towing, started when the net began fishing as it settled on the seafloor and ended when haul back began. The FPC controlled the length of the first phase and, unless problems occurred, this phase took ~15 minutes. The second phase, referred to as liftoff lag, followed sequentially and represented the time required for the net to lift off the seafloor in response to the initiation of the haul-back operation. The length of this phase varied by vessel, depth, current, slope of the seafloor, and bottom type.

Smoothed track lines provided estimates for net location and distance towed for time on bottom. We visually examined each track line to determine the appropriate smoothness required for each haul. In most cases, we applied a default value for smoothing, including but not limited to tows done in a relatively straight line with good signals from the SIMRAD system (J. R. Wallace, NWFSC, unpublished reports). We used a trigonometric method, developed for the 1998 survey analysis (Turk et al. 2001, Wallace and West 2006), when the default smoothing parameter failed to produce reasonable estimates. Within the database, we labeled all net configuration estimates with qualifying information to indicate the estimation method employed.

Wherever possible, we estimated gear depth and bottom depth from electronically recorded trawl sensor readings for the headrope depth and distance from bottom. We calculated bottom depth as the sum of the headrope depth and distance from bottom. Hand-recorded data were utilized as needed. Since we estimated mean values using data limited to the center 80% of the tow duration (see Sensor Data), we ensured sole inclusion of on-bottom readings.

In a few cases, no acceptable data existed within the center 80% of the tow duration for either electronic or hand-recorded gear depth. For these tows, we estimated mean gear and bottom depths from observations made just outside the center 80% of tow duration. These estimates often fell within the limits of net touchdown and liftoff. For some tows, few to no coincident records of headrope depth and headrope distance from bottom existed. In these cases, if gear depth and net height were available for a tow, we estimated bottom depth as the sum of these two endpoints, regardless of how the separate estimates had been derived.

In cases with no reasonable observation of gear depth, bottom depth was estimated from the vessel's navigational equipment records, if available. We labeled estimates with qualifying information within the database.

Area Estimates

We determined area estimates for the regions surveyed north and south of Pt. Conception (and overall) using digital bathymetry points acquired from Naval Oceanographic Office DBDB-V (Digital Bathymetric Data Base–Variable resolution) version 2.0 (NOO 2000). The input data had variable resolutions of 5.0 minutes, 1.0 minute, and 0.5 minute. We used data points gridded at 1-minute pixel resolutions to create contour lines for the survey depth zones. The contour lines occurred at 55, 183, 549, and 1,280 m. We used contour lines, combined with geographic area boundaries (with the maximum latitudinal extent of the survey at lat 32°30′N (or the U.S.–Mexico border) in the south, and lat 48°10′N (or the U.S.–Canada border) in the north (exclusive economic zone), to create polygons of each depth zone. Bathymetry data were projected to the Albers Equal Area projection and the total seafloor area was calculated in the three depth zones (55–183 m, 184–549 m, and 550–1,280 m) and the two geographic areas (north and south of lat 34°30′N). Note that any areas westward of the primary 1,280-m contour (e.g., seamounts) or eastward of the primary 55-m contour were not included in the area calculations, even if they had a value between 55 and 1,280 m.

Temperature

We recorded near-bottom water temperature during each tow using a SIMRAD ITI temperature sensor (accuracy ±0.2°C) and Seabird temperature sensors (accuracy +0.002°C) using both a Sea-Bird SBE 39 and a Sea-Bird SBE 19+ conductivity, temperature, and depth profiler (Sea-Bird Electronics Inc., Bellevue, Washington). Sensors are factory calibrated before and after deployment on an annual basis and mounted on the trawl net. The output sensor pattern indicated that the SIMRAD sensor required the full duration of the tow to acclimate. Because the Sea-Bird sensors demonstrated higher accuracy and faster acclimation time than the SIMRAD sensor, we estimated bottom temperature as the mean of the Sea-Bird sensor readings taken while the net was on bottom during the middle 80% of the tow duration. If Sea-Bird data were missing, we estimated bottom temperature from the SIMRAD sensor, based on data collected during the final 10% of the tow duration. Haul-mounted surface temperature sensors (Sea-Bird SBE 38) recorded surface temperatures continuously during tows, with mean values per tow calculated from start of tow to end of tow.

Relative Density and Biomass Estimates

We calculated relative density as catch per unit effort (CPUE) for individual species in each area and depth stratum by dividing total catch weight (kg) per species by area swept (ha) per tow,

$$CPUE = C/A \tag{1}$$

with *CPUE* the mean CPUE in kg/hectare (ha), *C* as catch per tow in kg for a given species, and *A* as area swept (in ha).

Mean estimates were initially calculated for each depth stratum within each area by averaging all tows, including those with zero catch, by species. To estimate mean CPUE by species for the total area (north and south of Pt. Conception combined), depth strata (shallow, mid-depth, and deep for all areas combined), and the individual areas (depth strata combined within areas), the initial means were weighted using the appropriate areas within each stratum. Mean biomass estimates (metric tons) were similarly calculated by multiplying the weighted mean CPUE for total area, depth strata, or region (north and south of Pt. Conception) by the appropriate area of the stratum or region,

$$\hat{b} = \sum_{i=1}^{n} (\overline{CPUE_i} \times A_i)/1000 \quad (2)$$

with the mean biomass estimate in metric tons (mt), *CPUE* the mean CPUE in kg/ha, calculated as noted above by weighting the initial mean by area, *A* the area of the stratum or region in ha, and $n = 3$ when depth strata (shallow, mid-depth, and deep) were combined within an area or $n = 2$ if individual areas were combined. We calculated variance for mean biomass estimates (within and among areas and depth strata) as

$$\text{Var}\,(\hat{b}) = \sum_{i=1}^{n} (\text{Var}\,(\overline{CPUE_i}) \times A_i^{\,2})/1000 \quad (3)$$

after first adjusting for differences in units and with symbols as defined in Equation 2.

We determined coefficients of variation (CV) for biomass estimates using the standard error divided by the mean biomass estimate.

Results

Haul, Catch, and Biological Data

The 2021 WCGTS incorporated 752 primary sampling locations, with 715 tows subsequently attempted, including failed tows, aborted tows, or tows at secondary or tertiary sites. In total, we successfully sampled 684 tows (Table 1). We obtained Simard ITI, PI44, and PX net mensuration data, as well as GPS course and position data, and BCS data from most of the successful tows. Table 1 shows the latitudinal boundaries, depth-strata areas (km^2), and sampling densities (hauls per 1,000 km^2) by area based on successful tows.

Table 1. Latitudinal boundary, depth stratum area (km^2), and sampling density, by geographic and depth strata, based on successful tows during the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)			Mid-Depth (184–549 m)			Deep (550–1,280 m)			All strata (55–1,280 m)		
Latitude bounds	**Area (km^2)**	**No. hauls**	**Hauls/ 1K km^2**	**Area (km^2)**	**No. hauls**	**Hauls/ 1K km^2**	**Area (km^2)**	**No. hauls**	**Hauls/ 1K km^2**	**Area (km^2)**	**No. hauls**	**Hauls/ 1K km^2**
U.S.–Canada border to Pt. Conception (48°10′N–34°30′N)	33,810	245	7.25	19,099	165	8.64	34,216	147	4.30	87,124	557	6.39
Pt. Conception to Mexico Border (34°30′N–32°30′N)	7,292	45	6.17	10,111	51	5.04	29,091	31	1.07	46,494	127	2.73
Entire survey area (48°10′N–32°30′N)	41,102	290	7.06	29,210	216	7.39	63,307	178	2.81	133,618	684	5.12

We determined mean net widths (m) and distances fished (km) for each haul. Using net mensuration data, we calculated the mean net width for each tow based on 80% of the tow duration, excluding the initial and final 10% of the tow time. We determined distances fished by estimating the length that the net traveled on the seafloor from the point where it touched down to the point where it lifted off. We calculated an overall mean width of 13.09 m using data from 684 hauls that both exhibited good trawl performance and had available net mensuration estimates. The mean net widths ranged from 9.96 m to 15.48 m, with a standard deviation (SD) of ±0.77. We similarly calculated mean net height as 5.18 ±0.59 m, with a range of 2.28–7.93 m. We plotted mean net width and height per tow (including values calculated using regressions) versus depth for the individual chartered vessel (Figure 4).

We summarize the number of lengths and age structures collected from groundfish and widths collected from invertebrate species (Table 2). We collected 71,052 individual length measurements from 70 groundfish species and 883 width measurements from two invertebrate species. We additionally collected 22,906 age structures from 64 fish species. The number of lengths collected ranged from 1–6,340 measurements per species, while the number of age structures collected ranged from 1–2,195 structures per species. The species with the greatest number of measurements (>2,000/species) included: Dover sole (*Microstomus pacificus*), shortspine thornyhead (*Sebastolobus alascanus*), longspine thornyhead (*S. altivelis*), sablefish (*Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*),

petrale sole (*Eopsetta jordani*), longnose skate (*Raja rhina*), English sole (*Parophrys vetulus*), stripetail rockfish (*Sebastes saxicola*), greenstriped rockfish (*S. elongatus*), spotted ratfish, Pacific hake (*Merluccius productus*), and Pacific sanddab (*Citharichthys sordidus*). The species with the greatest number of age structures (>700/species) included: sablefish, petrale sole, Dover sole, rex sole, Pacific ocean perch (*Sebastes alutus*), aurora rockfish (*S. aurora*), chilipepper rockfish (*S. goodei*), lingcod, longnose skate, and stripetail rockfish. We determined gender for 67,027 fish and 880 invertebrates. The overall biomass of the total catch equaled 249.4 mt. We collected tissue samples from 918 fish for DNA analyses. We took stomachs from 1,075 fish, primarily sablefish, shortspine thornyhead, longspine thornyhead, petrale sole, and lingcod. We also collected maturity samples for 565 fish—primarily sablefish, Dover sole, petrale sole, and redbanded rockfish (*S. babcocki*). We conducted special research projects in collaboration with NOAA and academic colleagues during the survey.

We identified 567 taxa of fish (n = 257) and invertebrates (n = 310) within the survey area (Table 3). Of these, we described 220 unique taxa of fish and 204 invertebrates (typically to the species level). For the remaining taxa, we identified organisms to the lowest taxonomic category possible and designated them as unidentified ("unid.") at taxonomic categories ranging from genus to higher taxonomic groups (Table 3).

Tables 4–6 list the number of individual fish lengths collected by species and depth stratum for all areas combined and for the individual areas north and south of Pt. Conception. The tables list the 35 most frequently measured fish species and one invertebrate species (grooved tanner crab, *Chionocetes tanneri*).

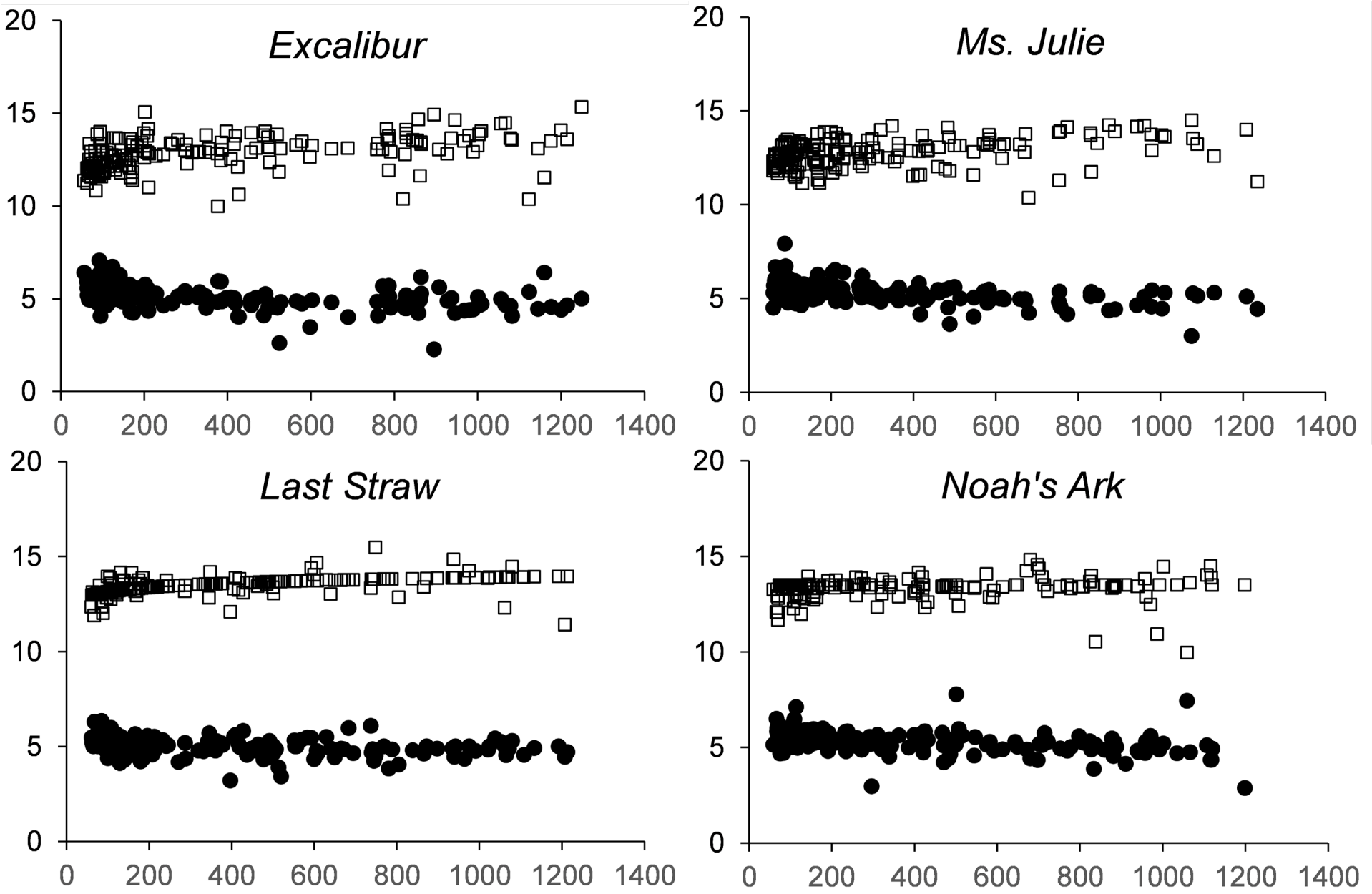


Figure 4. Mean net width and height for trawls conducted as part of the 2021 West Coast Groundfish Bottom Trawl Survey. Estimates are grouped by vessel, with net width (squares) and height (circles) in meters plotted relative to depth (meters).

Table 2. Number of individual length measurements and age structures collected by species during the 2021 West Coast Groundfish Bottom Trawl Survey. Age structures included dorsal spines (spiny dogfish), vertebrae (big skate, longnose skate), dorsal finrays (lingcod), and otoliths (all other species).

Species	Length	Age	Species	Length	Age	Species	Length	Age
arrowtooth flounder	1,409	633	giant grenadier	905	412	redstripe rockfish	310	207
aurora rockfish	1,558	784	greenblotched rockfish	32	32	rex sole	4,129	825
Baird's tanner crab	3	—	greenspotted rockfish	356	322	rosethorn rockfish	779	443
bank rockfish	24	24	greenstriped rockfish	2,036	629	rosy rockfish	2	2
big skate	334	139	grooved tanner crab	880	—	rougheye/blackspotted rockfish	149	149
black rockfish	6	6	halfbanded rockfish	978	530	sablefish	6,340	2,195
blackgill rockfish	606	423	honeycomb rockfish	7	7	sand sole	134	108
bocaccio	679	555	kelp greenling	32	32	sharpchin rockfish	908	572
brown rockfish	26	26	lingcod	1,475	763	shortbelly rockfish	778	452
butter sole	109	—	longnose skate	3,248	405	shortspine thornyhead	4,747	688
calico rockfish	49	49	longspine thornyhead	4,416	451	silvergray rockfish	5	5
California scorpionfish	335	211	Mexican rockfish	23	23	soupfin shark	1	—
California skate	484	—	Pacific cod	24	24	southern rock sole	305	224
canary rockfish	661	469	Pacific flatnose	189	155	splitnose rockfish	1,999	555
chilipepper	1,383	770	Pacific grenadier	1,006	—	spotted ratfish	2,495	—
copper rockfish	92	92	Pacific hake	2,483	601	squarespot rockfish	184	111
cowcod	33	33	Pacific ocean perch	821	819	starry flounder	16	16
curlfin sole	476	245	Pacific sanddab	2,343	460	starry skate	28	—
darkblotched rockfish	1,118	622	Pacific spiny dogfish	759	351	stripetail rockfish	2,514	718
deepsea sole	1,063	4	petrale sole	3,769	1,243	swordspine rockfish	4	4
Dover sole	5,665	1,126	pink rockfish	2	2	vermilion/sunset rockfish	283	204
English sole	2,662	578	pygmy rockfish	66	37	widow rockfish	66	66
flag rockfish	1	1	quillback rockfish	12	12	yelloweye rockfish	68	68
flathead sole	334	199	redbanded rockfish	226	226	yellowtail rockfish	493	383

Table 3. Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species, grouped by family (or higher taxonomic classification), caught during the 2021 West Coast Groundfish Bottom Trawl Survey.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Myxinidae							
Myxinidae	hagfish, unid.	94	140	1235	727	32.66	48.41
Eptatretus deani	black hagfish	43	213	1215	799	32.62	47.73
Eptatretus stoutii	Pacific hagfish	18	93	1080	617	32.63	44.39
Petromyzontidae							
Entosphenus tridentata	Pacific lamprey	2	436	680	558	42.69	42.92
Lampetra ayresii	west river lamprey	1	155	155	155	46.09	46.09
Triakidae							
Galeorhinus galeus	soupfin shark	1	104	104	104	37.41	37.41
Mustelus henlei	brown smoothhound	6	60	211	111	33.27	34.31
Scyliorhinidae							
Scyliorhinidae	cat shark, unid.	4	123	403	272	38.50	46.67
Apristurus brunneus	brown cat shark	255	144	1145	694	32.66	48.12
Apristurus kampae	longnose cat shark	12	579	1200	1037	32.62	36.93
Cephaloscyllium ventriosum	swell shark	4	77	101	90	34.03	34.43
Parmaturus xaniurus	filetail cat shark	85	268	942	509	32.70	40.09
Hexanchidae							
Hexanchus griseus	bluntnose sixgill shark	3	89	134	115	36.92	40.11
Somnosidae							
Somniosus pacificus	Pacific sleeper shark	3	910	1213	1111	39.95	45.00
Squalidae							
Squalus suckleyi	Pacific spiny dogfish	123	60	457	181	33.10	48.41
Squatinidae							
Squatinidae	angel shark, unid.	1	90	90	90	33.29	33.29
Squatina californica	Pacific angel shark	10	60	169	86	32.76	34.42
Etmopteridae							
Centroscyllium nigrum	combtooth dogfish	1	968	968	968	32.93	32.93
Selachii sharks	shark, unid.	4	70	399	158	37.43	45.00
Torpedinidae							
Torpedo californica	Pacific electric ray	35	60	408	155	33.19	46.67
Rajiformes (order)							
Rajiformes	unknown skate/ray, unid.	20	66	1207	379	34.51	48.07
Rajidae							
Raja sp.	Raja, unid.	3	80	583	368	39.02	43.55
Raja binoculata	big skate	126	56	1010	118	34.04	48.34
Raja inornata	California skate	96	60	254	96	32.76	45.64
Raja rhina	longnose skate	415	56	964	288	32.70	48.43
Raja stellulata	starry skate	24	62	232	103	33.80	44.53
Arhynchobatidae							
Bathyraja abyssicola	deepsea skate	4	589	1215	1016	34.21	45.00
Bathyraja aleutica	Aleutian skate	1	481	481	481	45.41	45.41
Bathyraja kincaidii	sandpaper skate	199	79	1035	302	32.80	48.43

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Bathyraja trachura	roughtail skate	100	339	1250	908	32.62	48.08
Myliobatidae							
Myliobatis californica	bat ray	6	72	238	106	33.29	34.51
Chimaeridae							
Hydrolagus colliei	spotted ratfish	345	60	554	190	32.58	48.43
Acipenseridae							
Acipenser medirostris	green sturgeon	1	68	68	68	44.41	44.41
Eurypharyngidae							
Eurypharyngidae	umbrellamouth gulper, unid.	1	1075	1075	1075	32.63	32.63
Nemichthyidae							
Nemichthyidae	snipe eel, unid.	2	361	937	649	33.54	41.84
Avocettina infans	blackline snipe eel	4	378	945	758	33.14	36.36
Nemichthys larseni	pale snipe eel	1	828	828	828	37.29	37.29
Nemichthys scolopaceus	slender snipe eel	4	202	935	518	32.72	34.26
Serrivomeridae							
Serrivomeridae	sawtooth eel, unid.	1	757	757	757	35.88	35.88
Serrivomer sp.	serrivomer, unid.	3	492	1067	834	33.05	41.41
Serrivomer sector	sawtooth eel	1	1250	1250	1250	43.79	43.79
Nettastomatidae							
Venefica sp.	whipsnout eel, unid.	1	1192	1192	1192	32.62	32.62
Venefica tentaculata	whipsnout eel	1	1192	1192	1192	32.62	32.62
Facciolella gilbertii	dogface witch eel	2	378	492	435	33.05	33.55
Saccopharyngidae							
Saccopharyngidae	whiptail gulpers, unid.	1	1035	1035	1035	35.91	35.91
Clupeidae							
Alosa sapidissima	American shad	36	60	299	111	34.24	48.41
Clupea pallasii	Pacific herring	45	59	184	99	34.57	48.39
Sardinops sagax	Pacific sardine	1	130	130	130	46.12	46.12
Engraulidae							
Engraulis mordax	northern anchovy	28	60	831	142	33.27	46.22
Argentinidae							
Argentina sialis	Pacific argentine	17	71	211	144	32.58	39.62
Bathylagidae							
Bathylagidae	deepsea smelt, unid.	82	610	1250	926	32.97	48.07
Bathylagus sp.	blacksmelt, unid.	28	568	1192	945	32.62	48.03
Bathylagus milleri	robust blacksmelt	8	644	1080	902	32.93	48.03
Bathylagus pacificus	Pacific blacksmelt	4	608	1133	946	34.21	35.71
Leuroglossus sp.	smoothtongue, unid.	1	516	516	516	32.73	32.73
Leuroglossus schmidti	northern smoothtongue	2	436	709	572	39.42	42.92
Leuroglossus stilbius	California smoothtongue	17	488	884	654	32.66	35.77
Opisthoproctidae							
Opisthoproctidae	spookfish, unid.	1	671	671	671	46.49	46.49
Macropinna microstoma	barreleye	3	937	1009	978	35.74	47.77

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Platytroctidae							
Sagamichthys abei	shining tubeshoulder	4	557	1079	825	34.86	46.49
Alepocephalidae							
Alepocephalidae	slickhead, unid.	1	809	809	809	44.92	44.92
Alepocephalus tenebrosus	California slickhead	150	579	1250	897	32.62	48.03
Bajacalifornia burragei	sharpchin slickhead	4	787	1066	878	32.66	40.12
Talismania bifurcata	threadfin slickhead	61	210	1192	843	32.62	48.11
Osmeridae							
Osmeridae	smelt, unid.	1	82	82	82	41.43	41.43
Allosmerus elongatus	whitebait smelt	10	61	260	118	40.61	48.34
Spirinchus starksi	night smelt	1	63	63	63	46.37	46.37
Spirinchus thaleichthys	longfin smelt	2	63	85	74	46.17	46.37
Thaleichthys pacificus	eulachon	76	72	329	153	41.53	48.43
Salmonidae							
Oncorhynchus tshawytscha	Chinook salmon	4	66	99	81	38.12	46.54
Gonostomatidae							
Gonostomatidae	bristlemouth, unid.	2	491	546	519	34.99	45.45
Sternoptychidae							
Sternoptychidae	hatchetfish, unid.	6	772	1123	964	32.63	47.63
Argyropelecus sp.	hatchetfish, unid.	1	516	516	516	32.73	32.73
Argyropelecus affinis	slender hatchetfish	5	323	1107	687	32.72	41.83
Sternoptyx diaphana	longspine hatchetfish	4	665	881	818	32.88	45.46
Stomiidae							
Malacosteinae (subfamily)	loosejaw, unid.	3	468	989	784	43.69	47.77
Melanostomiinae (subfamily)	scaleless dragonfish, unid.	1	989	989	989	47.77	47.77
Aristostomias scintillans	shining loosejaw	2	516	659	587	32.73	42.13
Chauliodus macouni	Pacific viperfish	57	411	1235	825	32.63	48.07
Idiacanthus antrostomus	Pacific blackdragon	14	387	1002	696	35.68	46.37
Stomias atriventer	blackbelly dragonfish	13	445	1192	746	32.62	47.77
Tactostoma macropus	longfin dragonfish	24	339	1215	745	39.48	48.08
Scopelarchidae							
Scopelarchidae	pearleye, unid.	3	565	1066	878	33.44	42.20
Benthalbella dentata	northern pearleye	1	1000	1000	1000	47.73	47.73
Paralepididae							
Lestidiops ringens	slender barracudina	1	420	420	420	38.94	38.94
Synodontidae							
Synodus lucioceps	California lizardfish	13	65	101	88	32.76	37.29
Alepisauridae							
Alepisaurus ferox	longnose lancetfish	1	1215	1215	1215	39.48	39.48
Neoscopelidae							
Scopelengys tristis	Pacific blackchin	3	789	864	828	32.87	47.87
Myctophidae							
Myctophidae	lanternfish, unid.	109	134	1250	726	32.62	48.12

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Lampanyctus sp.	lampfish, unid.	68	376	1250	869	32.73	48.08
Lampanyctus jordani	brokenline lampfish	3	554	865	704	34.72	46.97
Lampanyctus ritteri	broadfin lanternfish	2	448	749	598	34.62	34.88
Stenobrachius leucopsarus	northern lampfish	5	336	780	614	35.03	36.21
Tarletonbeania crenularis	blue lanternfish	1	695	695	695	35.77	35.77
Trachipteridae							
Trachipterus altivelis	king-of-the-salmon	5	227	975	668	33.38	41.86
Ophidiidae							
Chilara taylori	spotted cusk-eel	18	111	289	174	33.50	48.19
Bythitidae							
Brosmophycis marginata	red brotula	1	101	101	101	34.10	34.10
Cataetyx rubrirostris	rubynose brotula	15	284	787	516	32.86	42.24
Macrouridae							
Albatrossia pectoralis	giant grenadier	112	501	1250	910	32.97	48.08
Coryphaenoides acrolepis	Pacific grenadier	114	399	1250	923	32.73	48.08
Coryphaenoides cinereus	popeye grenadier	6	805	1213	1040	45.44	48.03
Nezumia liolepis	smooth grenadier	24	665	1192	864	32.62	35.74
Nezumia stelgidolepis	California grenadier	62	222	1123	544	32.66	45.64
Melanonidae							
Melanonus zugmayeri	arrowtail	1	979	979	979	46.37	46.37
Moridae							
Antimora microlepis	Pacific flatnose	41	456	1250	993	32.62	48.08
Physiculus rastrelliger	hundred fathom codling	12	268	502	352	32.70	35.08
Merlucciidae							
Merluccius productus	Pacific hake	326	72	1067	311	32.58	48.41
Gadidae							
Gadus macrocephalus	Pacific cod	8	75	204	139	47.63	48.25
Microgadus proximus	Pacific tomcod	31	59	124	80	38.38	47.80
Gadus chalcogrammus	walleye pollock	5	106	299	192	43.95	48.43
Batrachoididae							
Porichthys myriaster	speckledfin midshipmen	1	74	74	74	35.06	35.06
Porichthys notatus	plainfin midshipman	115	60	291	110	33.10	47.56
Ceratiidae							
Ceratiidae	seadevil, unid.	1	1250	1250	1250	43.79	43.79
Melanocetidae							
Melanocetus johnsonii	common blackdevil	1	888	888	888	36.36	36.36
Oneirodidae							
Oneirodidae	dreamer, unid.	4	680	1123	946	33.04	41.37
Melamphaidae							
Melamphaidae	bigscale, unid.	8	608	1235	918	33.04	48.03
Melamphaes lugubris	highsnout bigscale	2	759	935	847	32.75	32.94
Poromitra crassiceps	crested bigscale	13	516	1176	790	32.73	46.83

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Anoplogastridae							
Anoplogaster cornuta	fangtooth	10	754	1123	924	32.75	41.71
Scorpaenidae							
Scorpaena guttata	California scorpionfish	24	65	296	109	32.58	34.44
Sebastolobus alascanus	shortspine thornyhead	358	154	1250	609	32.62	48.35
Sebastolobus altivelis	longspine thornyhead	238	339	1250	773	32.62	48.08
Sebastes spp.	rockfish, unid.	9	60	301	183	33.92	48.25
Sebastes aleutianus	rougheye rockfish	30	112	432	284	43.08	48.43
Sebastes alutus	Pacific ocean perch	60	106	432	241	41.27	48.41
Sebastes auriculatus	brown rockfish	9	63	102	80	36.87	38.48
Sebastes aurora	aurora rockfish	91	192	798	454	32.70	48.06
Sebastes babcocki	redbanded rockfish	71	115	419	286	35.08	48.35
Sebastes brevispinis	silvergray rockfish	7	154	264	185	38.72	48.24
Sebastes caurinus	copper rockfish	17	67	122	95	33.81	37.40
Sebastes chlorostictus	greenspotted rockfish	47	72	291	149	32.58	48.39
Sebastes crameri	darkblotched rockfish	122	99	432	220	34.59	48.43
Sebastes dalli	calico rockfish	12	60	84	73	33.26	37.52
Sebastes diploproa	splitnose rockfish	131	117	502	285	32.70	48.34
Sebastes elongatus	greenstriped rockfish	169	64	420	162	32.58	48.39
Sebastes ensifer	swordspine rockfish	1	213	213	213	33.99	33.99
Sebastes entomelas	widow rockfish	20	60	293	180	36.87	48.39
Sebastes eos	pink rockfish	1	273	273	273	34.37	34.37
Sebastes flavidus	yellowtail rockfish	37	60	364	148	37.40	48.25
Sebastes goodei	chilipepper	127	63	445	153	32.72	46.03
Sebastes helvomaculatus	rosethorn rockfish	58	86	432	206	32.58	48.39
Sebastes hopkinsi	squarespot rockfish	10	74	114	96	33.26	37.13
Sebastes jordani	shortbelly rockfish	81	67	364	153	32.58	48.39
Sebastes levis	cowcod	20	78	301	157	32.59	43.42
Sebastes macdonaldi	Mexican rockfish	7	83	213	180	32.59	34.41
Sebastes maliger	quillback rockfish	8	60	123	91	43.09	48.41
Sebastes melanops	black rockfish	1	65	65	65	42.86	42.86
Sebastes melanostictus	blackspotted rockfish	3	164	413	325	44.83	48.43
Sebastes melanostomus	blackgill rockfish	39	210	829	425	32.70	45.11
Sebastes paucispinis	bocaccio	94	67	457	164	33.27	48.39
Sebastes pinniger	canary rockfish	54	65	347	141	35.06	48.41
Sebastes proriger	redstripe rockfish	8	114	376	184	36.89	48.39
Sebastes rosaceus	rosy rockfish	1	97	97	97	33.98	33.98
Sebastes rosenblatti	greenblotched rockfish	7	168	296	237	32.59	37.21
Sebastes ruberrimus	yelloweye rockfish	22	93	203	147	38.83	48.39
Sebastes rubrivinctus	flag rockfish	1	76	76	76	33.27	33.27
Sebastes rufus	bank rockfish	7	232	420	329	33.92	38.94
Sebastes saxicola	stripetail rockfish	166	65	346	170	32.58	48.24
Sebastes mystinus/diaconus	blue / deacon rockfish	1	60	60	60	43.13	43.13

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Sebastes semicinctus	halfbanded rockfish	73	60	233	107	32.58	44.38
Sebastes miniatus/crocotulus	vermilion and sunset rockfish	20	60	169	87	33.26	38.48
Sebastes miniatus/pinniger	vermilion and canary rockfish	1	86	86	86	37.54	37.54
Sebastes umbrosus	honeycomb rockfish	3	74	173	107	32.58	33.27
Sebastes wilsoni	pygmy rockfish	5	114	144	129	34.18	48.39
Sebastes zacentrus	sharpchin rockfish	58	112	432	228	33.92	48.39
Triglidae							
Prionotus stephanophrys	lumptail searobin	2	65	71	68	33.15	33.20
Anoplopomatidae							
Anoplopoma fimbria	sablefish	537	56	1235	429	32.62	48.43
Hexagrammidae							
Hexagrammos decagrammus	kelp greenling	12	60	144	97	36.89	48.18
Ophiodon elongatus	lingcod	230	56	384	128	33.92	48.41
Zaniolepis frenata	shortspine combfish	33	77	289	157	32.58	36.92
Zaniolepis latipinnis	longspine combfish	76	60	129	90	32.76	45.56
Cottidae							
Cottidae	sculpin, unid.	1	86	86	86	33.29	33.29
Chitonotus pugetensis	roughback sculpin	5	59	119	86	36.87	42.49
Enophrys bison	buffalo sculpin	1	78	78	78	34.33	34.33
Enophrys taurina	bull sculpin	5	77	92	86	34.03	34.43
Hemilepidotus hemilepidotus	red Irish lord	7	65	144	91	42.86	47.00
Icelinus burchami	dusky sculpin	2	90	272	181	33.29	44.77
Icelinus filamentosus	threadfin sculpin	60	86	501	173	33.88	48.41
Icelinus fimbriatus	fringed sculpin	2	93	264	178	38.72	44.39
Jordania zonope	longfin sculpin	6	127	203	180	44.61	47.90
Leptocottus armatus	Pacific staghorn sculpin	16	59	122	71	34.18	47.70
Malacocottus kincaidi	blackfin sculpin	1	362	362	362	48.11	48.11
Radulinus asprellus	slim sculpin	4	80	131	103	42.12	46.16
Triglops macellus	roughspine sculpin	1	69	69	69	33.69	33.69
Psychrolutidae							
Psychrolutes phrictus	blob sculpin	2	1145	1213	1179	41.35	44.97
Agonidae							
Agonidae	poacher, unid.	2	362	477	420	45.36	48.11
Agonopsis vulsa	northern spearnose poacher	3	75	173	116	44.14	46.86
Bathyagonus nigripinnis	blackfin poacher	25	235	873	529	38.96	48.12
Bathyagonus pentacanthus	bigeye starsnout poacher	4	136	320	242	33.53	44.02
Chesnonia verrucosa	warty poacher	3	61	72	66	41.43	43.38
Podothecus accipenserinus	sturgeon poacher	1	72	72	72	47.76	47.76
Xeneretmus latifrons	blacktip poacher	12	131	409	203	38.11	48.34
Liparidae							
Liparidae	snailfish, unid.	5	528	1250	1009	33.87	43.79
Careproctus sp.	snailfish, unid.	1	942	942	942	33.23	33.23
Careproctus sp.	blacktail snailfish group	1	289	289	289	33.50	33.50

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Careproctus colletti	Alaska snailfish	1	1066	1066	1066	48.03	48.03
Careproctus cypselurus	blackfin snailfish	21	678	1200	1017	33.43	47.63
Careproctus gilberti	smalldisk snailfish	1	387	387	387	43.08	43.08
Careproctus melanurus	blacktail snailfish	137	192	1200	603	32.72	48.11
Liparis pulchellus	showy snailfish	2	63	86	75	45.32	47.36
Nectoliparis pelagicus	tadpole snailfish	1	610	610	610	35.20	35.20
Paraliparis cephalus	swellhead snailfish	5	866	1176	968	32.94	47.48
Paraliparis dactylosus	red snailfish	4	749	935	808	32.81	36.21
Paraliparis pectoralis	broadfin snailfish	1	1052	1052	1052	34.21	34.21
Paraliparis rosaceus	rosy snailfish	1	114	114	114	36.41	36.41
Rhinoliparis barbulifer	longnose snailfish	1	780	780	780	36.21	36.21
Serranidae							
Paralabrax nebulifer	barred sand bass	2	65	69	67	33.15	33.69
Carangidae							
Trachurus symmetricus	jack mackerel	13	67	229	108	33.29	46.80
Sciaenidae							
Genyonemus lineatus	white croaker	43	60	176	85	32.76	41.43
Embiotocidae							
Cymatogaster aggregata	shiner perch	15	59	115	78	33.69	45.50
Hyperprosopon anale	spotfin surfperch	1	63	63	63	37.79	37.79
Phanerodon atripes	sharpnose seaperch	1	86	86	86	32.76	32.76
Rhacochilus vacca	pile perch	1	89	89	89	35.14	35.14
Zalembius rosaceus	pink seaperch	95	60	211	98	32.76	38.65
Zoarcidae							
Zoarcidae	eelpout, unid.	2	528	753	640	35.43	43.75
Lycodapus sp.	eelpout, unid.	1	640	640	640	35.60	35.60
Bothrocara brunneum	twoline eelpout	135	459	1235	853	32.62	48.08
Lycenchelys camchatica	Kamchatka eelpout	4	695	1066	880	32.94	48.03
Lycenchelys crotalinus	snakehead eelpout	110	364	1250	912	32.87	48.08
Lycodapus dermatinus	looseskin eelpout	1	1090	1090	1090	44.97	44.97
Lycodapus endemoscotus	deepwater eelpout	2	458	520	489	34.44	36.02
Lycodapus fierasfer	blackmouth eelpout	11	709	1192	951	32.62	45.46
Lycodapus mandibularis	pallid eelpout	1	582	582	582	48.00	48.00
Lycodes brevipes	shortfin eelpout	1	420	420	420	45.01	45.01
Lycodes cortezianus	bigfin eelpout	172	72	620	339	32.70	48.23
Lycodes diapterus	black eelpout	94	202	774	462	33.05	48.12
Lycodes pacificus	blackbelly eelpout	123	63	484	152	32.76	48.43
Maynea californica	persimmon eelpout	1	457	457	457	35.77	35.77
Melanostigma pammelas	midwater eelpout	1	942	942	942	39.42	39.42
Cryptacanthodidae							
Cryptacanthodes giganteus	giant wrymouth	6	185	364	264	47.88	48.34
Anarhichadidae							
Anarrhichthys ocellatus	wolf-eel	4	68	212	110	33.59	44.53

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Chiasmodontidae							
Chiasmodon niger	black swallower	1	945	945	945	33.21	33.21
Uranoscopidae							
Kathetostoma averruncus	smooth stargazer	8	60	212	127	32.58	34.24
Malacanthidae							
Caulolatilus princeps	ocean whitefish	2	77	93	85	34.35	34.43
Scombridae							
Scomber japonicus	Pacific chub mackerel	1	147	147	147	43.91	43.91
Tetragonuridae							
Tetragonurus cuvieri	smalleye squaretail	1	516	516	516	32.73	32.73
Stromateidae							
Peprilus simillimus	Pacific pompano butterfish	36	60	211	90	32.76	37.83
Centrolophidae							
Icichthys lockingtoni	medusafish	10	79	829	476	37.13	45.53
Paralichthyidae							
Citharichthys sp.	sanddab, unid.	1	98	98	98	34.25	34.25
Citharichthys sordidus	Pacific sanddab	239	56	242	104	32.58	48.41
Citharichthys xanthostigma	longfin sanddab	11	65	98	78	32.76	34.44
Pleuronectidae							
Atheresthes stomias	arrowtooth flounder	208	59	600	216	37.00	48.43
Embassichthys bathybius	deepsea sole	148	398	1250	863	32.63	48.07
Eopsetta jordani	petrale sole	297	56	420	140	33.81	48.43
Glyptocephalus zachirus	rex sole	431	56	698	233	32.58	48.43
Hippoglossina stomata	bigmouth sole	41	60	256	123	32.58	34.43
Hippoglossoides elassodon	flathead sole	50	85	462	169	34.85	48.43
Hippoglossus stenolepis	Pacific halibut	43	68	467	177	33.19	48.41
Isopsetta isolepis	butter sole	20	56	86	68	41.43	47.77
Lepidopsetta bilineata	southern rock sole	48	60	183	88	33.65	48.19
Lyopsetta exilis	slender sole	330	61	519	203	32.58	48.43
Microstomus pacificus	Dover sole	587	61	1200	376	32.63	48.43
Paralichthys californicus	California halibut	10	65	268	97	33.15	44.14
Parophrys vetulus	English sole	298	56	386	129	32.58	48.43
Platichthys stellatus	starry flounder	11	59	91	68	37.81	47.36
Pleuronichthys decurrens	curlfin sole	83	56	200	91	33.27	48.41
Pleuronichthys ritteri	spotted turbot	3	72	176	119	34.41	34.44
Pleuronichthys verticalis	hornyhead turbot	36	60	212	91	32.76	37.81
Psettichthys melanostictus	sand sole	19	56	87	66	36.68	47.36
Xystreurys liolepis	fantail sole	5	60	93	76	33.15	34.43
Osteichthyes (class)							
fish unident.	fish, unid.	5	212	1082	729	33.38	48.03
Porifera (phylum)							
Porifera	sponge, unid.	72	65	1198	478	32.58	48.35
Porifera (segregated 1)	sponge, unid. (segregated 1)	3	268	942	553	33.23	34.88

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Porifera (segregated 2)	sponge, unid. (segregated 2)	2	448	942	695	33.23	34.88
Porifera - vase sponges	vase sponge, unid.	15	76	1208	691	32.70	47.71
Porifera -clay pipe sponges	white claypipe sponge, unid.	11	168	987	537	32.58	47.96
Hexactinellida	glass sponge, unid.	2	630	987	808	46.83	47.96
Demospongiae	demosponge, unid.	3	99	866	363	45.88	47.48
Acanthascus sp.	chimney sponges	2	448	778	613	34.88	43.79
Aphrocallistes vastus	clay pipe sponge	47	100	1208	610	32.59	48.06
Chonelasma calyx	goblet sponge	8	399	1010	782	41.37	43.79
Farrea convolulus	crusty tube sponge	3	752	942	828	33.10	33.25
Hyalonema sp.	fiber optic sponges, unid.	16	347	1160	860	32.66	47.96
Leucandra heathi	spiny vase sponge	6	409	1123	781	32.87	45.02
Mycale sp.	demosponge, unid.	1	942	942	942	33.23	33.23
Rhabdocalyptus sp.	cloud sponge, unid.	2	230	264	247	38.72	46.03
Staurocalyptus sp.	spiny vase sponges, unid.	13	168	1062	789	32.59	48.11
Suberites ficus	hermit sponge	2	86	212	149	32.76	33.59
Tethya sp.	ball sponge	11	71	1052	304	32.66	34.21
Scyphozoa (class)							
Scyphozoa	jellyfish, unid.	152	60	1250	410	32.70	48.08
Aequorea sp.		2	665	839	752	33.15	33.85
Atolla sp	wheel jellies	33	592	1235	941	32.63	48.07
Aurelia sp.	moon jellies, unid.	16	64	798	199	34.25	45.00
Aurelia labiata		5	63	620	296	40.53	46.37
Chrysaora sp.	chrysaora jellyfish, unid.	19	64	975	355	32.66	48.11
Chrysaora fuscens	sea nettle	9	60	839	178	33.85	46.43
Chrysaora melanaster	sunrise jelly	3	81	122	103	44.56	45.80
Pelagia colorata	purple striped jellyfish	1	110	110	110	36.73	36.73
Periphylla periphylla	purple cone jelly	14	409	1133	810	34.63	48.00
Phacellophora camtschatica	egg-yolk jellyfish	17	64	1213	378	33.08	48.07
Anthozoa (class)							
Anthozoa	purple striated anemone, unid.	16	246	1010	595	35.10	47.96
Anthozoa	red striated anemone, unid.	24	346	1072	831	32.93	48.08
Actiniaria	sea anemone, unid.	16	64	1090	473	33.04	48.06
Actinoscyphia	sea whip anemones	2	468	1082	775	42.64	46.64
Antipatharia (order)	black coral, unid.	1	1107	1107	1107	32.97	32.97
Gorgonacea	gorgonian coral, unid.	7	84	513	286	33.59	48.34
Hormathiidae	hormathiid anemones, unid.	61	158	1235	788	32.75	48.07
Hormathiidae sp. A	pink hormathiid anemones	3	448	862	716	32.92	34.88
Pennatulacea	sea pen, unid.	15	78	1198	503	33.23	48.03
Virgulariidae	sea whip, unid.	1	468	468	468	46.64	46.64
Actinauge verrilli	reticulated anemone	37	184	1215	675	32.93	48.11
Actinernus spp.	lava anemones	13	333	1160	877	32.86	48.07
Actinostola sp.		2	1052	1133	1092	34.21	35.71
Acanthoptilum gracile	sea pen	19	76	1062	195	36.73	47.63

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Adelogorgia phyllosclera	thick red gorgonian	1	484	484	484	33.51	33.51
Anthomastus ritteri	mushroom coral	6	230	683	464	34.88	46.03
Anthopleura xanthogrammica	green anemone	31	56	208	105	38.58	47.80
Anthoptilum grandiflorum	fleshy sea pen	53	293	1235	779	32.87	48.06
Bathypathes sp.	quill black corals	4	322	1010	665	32.93	48.35
Corallimorphus sp.	club tipped anemones	2	829	1066	948	35.22	48.03
Chrysopathes sp.	black coral, unid.	9	92	1208	569	34.88	48.07
Dendrophyllia californica	California cup coral	1	74	74	74	33.26	33.26
Distichoptilum gracile	deep-sea sea whip	1	98	98	98	34.71	34.71
Eugorgia rubens	purple gorgonian	2	77	92	84	34.10	34.43
Funiculina quadrangularis	tall sea pen	8	481	1090	918	34.21	47.71
Halipteris sp.	sea pen, unid.	33	88	991	252	34.08	47.89
Halipteris sp. (deepsea)	deepsea sea pen, unid.	7	485	1235	954	35.28	47.71
Halipteris californica		1	102	102	102	38.24	38.24
Halipteris willemoesi		1	167	167	167	41.27	41.27
Isidella sp.	articulated bamboo corals	1	1213	1213	1213	44.97	44.97
Leptogorgia chilensis	red gorgonian	1	77	77	77	34.43	34.43
Liponema brevicornis	pom pom anemone	86	99	1235	617	32.72	48.11
Metridium sp.		4	92	193	152	34.82	47.00
Metridium farcimen	giant anemone	240	56	585	146	33.19	48.33
Oractis diomedeae	grape anemone	8	93	968	713	32.87	47.99
Paractinostola faeculenta	rough anemone	253	246	1250	690	32.70	48.08
Paragorgia sp.	peppermint corals	1	115	115	115	47.10	47.10
Pennatula phosphorea	branched sea pen	1	890	890	890	43.62	43.62
Ptilosarcus gurneyi	orange sea pen	5	63	202	94	34.26	45.50
Sicyonis sp.	orange actinistolid, unid.	12	935	1250	1068	32.94	47.71
Stachyptilum superbum		1	939	939	939	42.14	42.14
Stomphia sp.		5	62	303	152	32.59	37.81
Stomphia coccinea	swimming anemone	19	63	1082	385	33.48	47.00
Swiftia sp.	red sea fans	4	119	322	246	34.29	48.35
Swiftia simplex		1	76	76	76	33.27	33.27
Umbellula sp.	flower sea pens	16	586	1090	870	39.31	47.92
Urticina sp.		3	63	232	120	33.92	47.36
Urticina columbiana	Columbian anemone	19	67	212	101	33.56	47.70
Urticina crassicornis	painted anemone	1	197	197	197	40.05	40.05
Hydrozoa (class)							
Dromalia alexandri	pineapple benthic siphonophore	13	183	759	408	32.70	35.18
Brachiopoda (phylum)							
Brachiopoda	lampshells, unid.	6	93	1250	405	36.73	48.11
Aplacophora (class)							
Neomenia sp.	solenogasters	11	124	1024	515	34.13	47.93
Bivalvia (class)							
Bivalvia	bivalve, unid.	1	524	524	524	34.25	34.25

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Pectinidae	scallop, unid.	1	84	84	84	47.56	47.56
Acesta sphoni	sphons giant file clam	3	741	1123	878	32.81	33.87
Delectopecten vancouverensis	glass scallop	9	678	1198	903	32.86	47.77
Macoma calcarea	chalky macoma	1	1213	1213	1213	44.97	44.97
Patinopecten caurinus	weather vane scallop	8	72	125	95	45.67	47.76
Solemya reidi	gutless awningclam	2	339	1072	705	43.57	44.58
Vesicomya pacifica	cold seep clam	4	114	524	410	34.17	36.89
Cephalopoda (phylum)							
Teuthida (order)	squid, unid.	6	67	830	452	32.70	47.87
Cranchiidae	glass squids	2	513	568	541	32.78	34.17
Octopodidae	octopus, unid.	1	131	131	131	36.96	36.96
Benthoctopus spp.	benthoctopus, unid.	37	116	1250	496	33.21	48.05
Benthoctopus leioderma	smooth octopus, unid.	7	213	1059	516	33.51	44.72
Berryteuthis magister	magistrate armhook squid	5	357	1107	575	32.97	47.57
Chiroteuthis calyx	chiroteuthid squid	6	485	1145	729	35.10	43.69
Cranchia scabra	sandpaper squid	6	432	829	745	32.66	48.07
Doryteuthis opalescens	California market squid	136	59	935	126	32.58	47.36
Enteroctopus dofleini	giant Pacific octopus	17	66	620	406	35.18	48.08
Galiteuthis phyllura	arrow squid	1	890	890	890	43.62	43.62
Gonatopsis borealis	North Pacific armhook squid	12	197	582	440	33.08	48.00
Gonatus sp.	squid, unid.	3	201	516	401	32.73	45.17
Gonatus onyx	clawed armhook squid	23	329	1072	610	32.94	45.47
Graneledone sp.	deep-sea octopus, unid.	1	1200	1200	1200	36.66	36.66
Histioteuthis heteropsis	jewel squid	55	170	1213	558	32.72	46.81
Histioteuthis hoylei	long armed jewel squid	3	124	520	386	36.02	42.26
Japetella diaphana	yellow ringed octopus	23	516	1215	875	32.73	46.37
Moroteuthis robusta	robust clubhook squid	15	293	1009	524	33.38	47.93
Octopoteuthis deletron	octopus squid	58	340	1176	791	32.63	47.96
Octopus sp.	octopus, unid.	2	98	387	243	34.46	43.08
Octopus californicus	North Pacific bigeye octopus	34	108	492	289	32.59	38.82
Octopus rubescens	red octopus	4	61	213	120	33.99	41.43
Onychoteuthis banksi	common clubhook squid	1	416	416	416	33.08	33.08
Opisthoteuthis californiana	flapjack devilfish	52	284	1072	618	33.38	48.07
Rossia pacifica	bobtail squid	47	62	1000	161	33.59	47.73
Taonius pavo	cone squid	1	630	630	630	46.83	46.83
Vampyroteuthis infernalis	vampire squid	20	340	1133	868	32.63	47.96
Gastropoda (class)							
Gastropoda	snail, unid.	11	84	1235	922	32.93	47.71
Gastropoda	empty gastropod shells, unid.	2	183	665	424	33.15	34.05
Nudibranchia (order)	nudibranch, unid.	5	68	502	205	32.70	46.00
Nudibranchia sp. A	nudibranch sp. A, unid.	2	130	158	144	43.70	43.75
Carinariidae	heteropod, unid.	7	158	1213	780	33.23	45.72
Anisodoris nobilis	Pacific sea lemon	3	93	147	112	34.71	44.39

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Armina californica	striped tongue nudibranch	2	64	71	68	44.27	45.00
Bathybembix bairdii	green top snail	90	499	1200	842	32.66	48.07
Buccinum sp.	whelk, unid.	4	939	1118	1058	41.24	42.14
Buccinum viridum	turban whelk	1	1208	1208	1208	45.00	45.00
Calinaticina oldroydii	Oldroyd`s moonsnail	16	76	364	181	33.27	45.85
Carinaria cristata	glassy nautilus	6	272	753	489	42.13	45.53
Colus sp.	whelk, unid.	4	425	907	561	34.63	45.04
Cryptonatica russa	rusty moonsnail	1	477	477	477	40.20	40.20
Euspira lewisii	moon snail	11	84	238	125	33.90	47.56
Exilioidea rectirostris	spindle shell	1	1024	1024	1024	47.71	47.71
Fusitriton oregonensis	Oregon triton	10	119	478	282	42.49	48.35
Neptunea sp.	neptune, unid.	108	184	1250	741	33.14	48.08
Neptunea amianta	deep-sea whelk	30	321	1198	688	32.93	47.92
Neptunea humboldtiana	Humboldt whelk	1	683	683	683	36.25	36.25
Philine bakeri	ocean won ton	6	85	384	196	33.88	36.37
Pleurobranchaea californica	California sea slug	106	64	448	152	33.15	42.06
Tritonia diomedea	rosy tritonia	174	64	1250	395	32.97	48.07
Class Rhynchonellata							
Laqueus californianus	California lamp shell	2	126	207	167	43.39	43.95
Sipuncula (phylum)							
Sipuncula	peanut worm unid.	4	93	436	323	42.92	44.72
Nematoda (phylum)							
Nematoda	nematode worm, unid.	2	630	866	748	46.83	47.48
Polychaeta (phylum)							
Annelida	worm, unid.	4	87	222	138	35.28	45.87
Polychaeta	tube worm, unid.	1	82	82	82	44.44	44.44
Polychaeta	polychaeta worm, unid.	3	167	1067	752	41.41	47.71
Aphrodita sp.	sea mouse, unid.	21	89	1107	447	32.63	48.12
Pycnogonida (class)							
Pycnogonida sp.	sea spider, unid.	1	1235	1235	1235	40.01	40.01
Malacostraca (class)							
Thoracica (superorder)	barnacle, unid.	1	65	65	65	42.86	42.86
Amphipoda (order)	amphipod, unid.	1	831	831	831	33.89	33.89
Euphausiacea (order)	deep sea red shrimps, unid.	1	783	783	783	40.18	40.18
Isopoda (order)	sea cockroaches, unid.	10	60	1192	192	32.62	44.52
Lophogastrida (order)	crested red mysids, unid.	1	598	598	598	35.52	35.52
Dendrobrachiata (suborder)	shrimp, unid.	3	89	866	552	36.92	47.48
Galatheoidea (super family)	squat lobsters, pinch bugs, unid.	4	516	1107	909	32.63	35.74
Cancridae	rock crabs, unid.	1	79	79	79	46.44	46.44
Galatheidae	squat lobsters, unid.	2	598	907	752	34.63	35.52
Hemisquillidae	mantis shrimps, unid.	1	65	65	65	33.15	33.15
Paguridae	hermit crab, unid.	40	89	1200	423	34.08	48.11
Pasiphaeidae	pasiphaeid shrimp, unid.	14	513	1192	779	32.62	43.62

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Acanthephyra curtirostris	peaked shrimp	1	1002	1002	1002	41.72	41.72
Acantholithodes hispidus	fuzzy crab	1	173	173	173	46.86	46.86
Anuropus bathypelagicus	giant isopod	2	787	1133	960	32.95	35.71
Calocarides sp.	deep-sea shrimps, unid.	7	355	546	456	34.31	36.02
Cancer antennarius	Pacific rock crab	2	74	84	79	35.06	37.52
Cancer anthonyi	yellow rock crab	16	65	184	99	33.15	39.35
Cancer gracilis	graceful cancer crab	1	291	291	291	34.16	34.16
Metacarcinus magister	Dungeness crab	262	56	737	141	34.16	47.89
Cancer productus	red rock crab	35	67	428	145	33.19	47.70
Chionoecetes angulatus	triangle tanner crab	2	683	780	732	36.21	36.25
Chionoecetes bairdi	Bairds tanner crab	2	210	315	263	47.88	48.11
Chionoecetes hybrid	hybrid tanner crab	1	513	513	513	42.26	42.26
Chionoecetes tanneri	grooved tanner crab	213	339	1250	778	32.66	48.08
Chorilia longipes	long horned decorator crab	42	65	1123	622	32.75	47.63
Crangon sp.	Crangon, unid.	12	63	155	102	41.43	47.47
Crangon communis	twospine crangon	3	61	114	89	41.43	45.00
Eualus sp.	eualid, unid.	4	419	1208	801	33.17	47.57
Eualus biunguis	deepsea eualid	2	399	593	496	40.09	45.57
Eualus macrophthalmus	big eyed eualid	19	364	1207	653	34.56	48.08
Glyptolithodes cristatipes	deep-sea rock crab	15	74	1200	407	32.72	36.66
Lithodes couesi	scarlet king crab	58	291	1200	925	32.62	48.07
Lopholithodes sp.	box crab, unid.	2	125	203	164	46.74	48.39
Lopholithodes foraminatus	brown box crab	49	87	399	190	32.58	48.34
Loxorhynchus crispatus	masking crab	4	83	173	133	32.58	34.43
Loxorhynchus grandis	sheep crab	5	69	238	110	33.29	34.42
Munida hispida		4	416	516	480	32.70	33.08
Munida quadrispina	pinch bug	6	210	1035	457	33.48	35.91
Munidopsis sp.	thorny pinch bug, unid.	2	780	1108	944	36.21	43.56
Munidopsis hystrix		4	65	789	589	32.86	33.52
Munidopsis quadrata	pale rough pinch bug	1	87	87	87	33.10	33.10
Munidopsis sp. A	thorny pinch bugs sp.A	2	1056	1192	1124	32.62	33.38
Neognathophausia sp.	red mysids, unid.	6	457	1200	913	32.62	36.66
Neognathophausia gigas		1	1108	1108	1108	43.56	43.56
Neognathophausia ingens	giant red mysid	11	448	1133	842	33.15	36.36
Neolithodes diomedeae	spiky king crab	1	975	975	975	33.38	33.38
Paguristes turgidus	hermit crab	6	183	552	277	33.99	47.31
Pagurus brandti	sponge hermit	3	90	183	122	33.29	34.09
Pandalopsis ampla	smooth shrimp	18	935	1213	1059	32.62	44.97
Pandalopsis dispar	sidestripe shrimp	2	242	260	251	48.12	48.33
Pandalus danae	dock shrimp	1	63	63	63	46.37	46.37
Pandalus hypsinotus	coonstriped shrimp	1	164	164	164	48.43	48.43
Pandalus jordani	ocean shrimp	80	82	971	189	33.04	48.43
Pandalus platyceros	spot prawn	42	78	361	222	33.48	48.39

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Paralithodes californiensis	California king crab	22	155	320	251	33.19	36.97
Paralithodes rathbuni	spiny king crab	13	183	761	304	32.72	38.25
Paralomis manningi	deep-sea spider crab	1	1079	1079	1079	35.48	35.48
Paralomis multispina	hair crab	27	122	1235	982	32.62	48.03
Parapasiphae sulcatifrons	grooveback shrimp	1	907	907	907	34.63	34.63
Pasiphaea pacifica	glass shrimp	82	242	942	513	32.72	48.12
Pasiphaea tarda	crimson pasiphaeid	48	222	1235	904	32.62	47.71
Platymera gaudichaudii	shame faced crab	100	64	428	136	32.58	44.07
Pleuroncodes planipes	pelagic red crab	15	67	303	192	33.45	34.57
Polycheles sculptus	deep-sea lobster	10	935	1192	1041	32.62	36.13
Pugettia richii	cryptic kelp crab	1	111	111	111	33.81	33.81
Sergestes sp.		8	201	1213	641	40.20	45.18
Sergestes similis	Pacific sergestid	20	231	1235	559	32.66	48.00
Sicyonia ingentis	razor-back prawn	33	60	992	169	32.76	36.23
Asteroidea (class)							
Ampheraster marianus	pink star	26	386	1198	765	33.43	48.03
Anteliaster sp.	soft star, unid.	1	419	419	419	47.57	47.57
Asteronyx loveni	giant serpent star	11	82	1200	686	33.52	47.71
Asthenactis fisheri	slimy deep sea sun star	1	942	942	942	33.23	33.23
Astropecten sp.	sand star, unid.	2	83	104	93	34.39	36.42
Astropecten californicus	California sand star	30	60	782	159	34.00	39.49
Astropecten ornatissimus	ornate sand star	2	69	158	113	33.69	33.82
Brisingella sp.		3	409	805	615	45.02	46.83
Brisingella exilis	lacy-armed star	11	592	1235	770	35.77	45.99
Ceramaster sp.	cookie sea star, unid.	5	492	937	752	32.94	35.74
Ceramaster leptoceramus	California cookie star	16	333	1009	696	32.86	45.07
Ceramaster patagonicus	orange cookie star	1	125	125	125	48.39	48.39
Cheiraster dawsoni	fragile star	6	293	824	471	44.49	47.92
Crossaster borealis	grooved sun star	70	124	1207	829	32.63	48.07
Crossaster papposus	rose star	1	1207	1207	1207	46.14	46.14
Cryptopeltaster lepidonotus	grainy star	11	122	1107	652	32.70	43.05
Ctenodiscus crispatus	mud star	8	329	826	465	35.58	47.96
Dermasterias imbricata	leather star	15	63	260	107	37.79	47.36
Diplopteraster multipes	pincushion sea star	14	344	1198	619	32.86	48.11
Dipsacaster sp.	sand star, unid.	2	608	1052	830	34.21	35.03
Dipsacaster eximius	broad sand star	35	269	1213	750	32.66	44.97
Henricia sp.	henricia, unid.	4	82	942	514	32.59	44.44
Henricia aspera	smooth henricia	3	98	791	348	44.38	48.08
Heterozonias alternatus	pink sun star	153	125	1250	789	32.97	48.39
Hippasteria sp.	spiny sea star, unid.	1	1080	1080	1080	36.06	36.06
Hippasteria californica	deep-sea spiny star	113	86	1235	673	32.66	48.39
Hippasteria spinosa	spiny star	58	56	1213	276	32.58	48.41
Hymenaster sp.	pancake stars, unid.	2	754	1235	995	40.01	40.17

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Leptychaster arcticus	Arctic sand star	1	745	745	745	40.02	40.02
Lophaster furcilliger	pink crested star	10	98	1250	692	35.49	47.48
Lophaster vexator	crested star	1	987	987	987	47.96	47.96
Luidia asthenosoma	pretty mud star	1	321	321	321	42.26	42.26
Luidia foliolata	flat mud star	271	56	942	161	33.26	48.41
Mediaster sp.		1	74	74	74	33.26	33.26
Mediaster aequalis	equal armed star	65	65	865	234	33.85	48.41
Myxoderma platyacanthum	red star	98	141	1065	543	33.05	47.99
Myxoderma sacculatum	snakehead star	23	659	1250	1017	32.94	47.87
Nearchaster aciculosus	deep-sea fragile star	53	78	1215	910	32.70	48.08
Pisaster brevispinus	short-spinedpink star	10	61	147	92	43.91	44.52
Poraniopsis flexilis	flexible thorny star	3	114	789	554	32.75	36.89
Poraniopsis inflata	thorny star	9	77	778	217	34.10	48.24
Pseudarchaster sp.	Pseudarchaster, unid.	2	145	287	216	46.89	48.11
Pseudarchaster alascensis	Alaskan pseudarchaster	7	303	798	450	40.12	44.72
Pteraster sp.	Slime star, unid.	1	589	589	589	40.27	40.27
Pteraster coscinopeplus	deepwater pteraster	1	144	144	144	43.42	43.42
Pteraster jordani	Jordans slime star	38	210	1215	718	32.80	47.96
Pteraster militaris	wrinkled slime star	7	68	1213	799	32.93	45.41
Pteraster tesselatus	slimy cushion star	2	77	432	255	34.43	45.11
Rathbunaster californicus	deep-sea sunflower star	58	66	600	262	34.59	48.33
Solaster sp.	orange sun stars, unid.	3	333	1133	603	35.71	47.93
Solaster exiguus	deep-sea sunstar	9	516	1213	998	32.73	44.97
Stylasterias forreri	fish-eating star	67	82	544	181	32.58	48.25
Thrissacanthias penicillatus	carpet star	129	125	1250	783	32.62	48.39
Zoroaster evermanni	slender star	85	125	1208	846	32.86	48.39
Zoroaster ophiurus		4	753	1160	985	39.95	47.57
Crinoidea (class)							
Crinoidea	crinoid, unid.	5	173	1090	843	44.97	47.71
Florometra serratissima	feather star	1	989	989	989	47.77	47.77
Echinoidea (class)							
Echinoidea (crushed urchin)	crushed urchin, unid.	55	125	935	424	32.72	48.39
Brisaster sp.	mud urchin, unid.	47	89	1235	350	33.10	48.12
Brisaster latifrons	mud urchin	207	98	1123	385	32.72	48.43
Brissopsis pacifica	oval sea biscuit	17	213	741	378	33.05	35.42
Lytechinus anamesus	white urchin	7	74	100	87	33.26	34.35
Spatangus californicus	giant sea biscuit	17	176	434	308	32.80	37.00
Strongylocentrotus sp.	sea urchin, unid.	1	68	68	68	44.53	44.53
Strongylocentrotus fragilis	fragile red sea urchin	228	64	1056	404	32.58	48.41
Strongylocentrotus pallidus	crowned sea urchin	4	76	90	84	32.76	34.00
Strongylocentrotus purpuratus	purple sea urchin	3	72	166	109	33.93	36.92
Holothuroidea (class)							
Holothuroidea	sea cucumber, unid.	3	84	838	558	33.10	47.56

Table 3 (continued). Frequency of occurrence, depth, and latitudinal range for fish and invertebrate species.

Family and scientific name	Common name	Freq. of occurrence (No. hauls)	Depth (m)			Latitudinal range	
			Min.	Max.	Mean	South	North
Synallactidae	deep sea papillose sea cucumbers	15	89	1082	781	32.70	42.64
Cucumaria fallax	sea football	1	-	-	-	32.87	32.87
Molpadia intermedia	purple sea potato	45	93	1207	532	32.63	48.41
Synallactes challengeri		4	343	665	508	32.80	35.03
Pannychia moseleyi	sloppy cucumber	12	467	1075	771	32.63	48.00
Parastichopus californicus	California cucumber	42	60	232	111	32.76	44.53
Parastichopus leukothele	giant soft cucumber	82	56	486	206	33.26	48.41
Pseudostichopus mollis	sandy sea cucumber	36	110	1107	555	32.93	48.35
Psolus squamatus	White-scaled cucumber	8	333	1066	770	32.70	48.03
Scotoplanes spp.	sea pigs, unid.	29	975	1250	1100	32.97	47.63
Ophiuroidea (class)							
Ophiurida (order)	brittlestars, unid.	4	119	1123	600	33.10	44.90
Amphiophiura sp.	southern armored brittle stars	1	1198	1198	1198	33.43	33.43
Asteronyx longifissus	long-slit serpent star	15	349	1082	566	34.13	46.37
Gorgonocephalus eucnemis	basket star	24	65	291	137	32.58	46.38
Ophiacantha diplasia	lacy brittle star	5	168	759	488	32.59	45.21
Ophiomusium jolliensis	red brittle star	5	486	979	696	39.16	48.00
Ophiopholis sp.		1	975	975	975	33.38	33.38
Ophioplocus esmarki	smooth brittle star	1	128	128	128	39.21	39.21
Ophiura sp.	brittlestars, unid.	3	114	971	419	32.58	36.89
Ophiura sarsi	notched brittle star	28	124	847	411	38.82	45.99
Stegophiura ponderosa	giant armored brittle star	16	409	1133	747	33.11	47.99
Tunicata (subphylum)							
Thaliacea	salps, unid.	153	61	1235	405	32.72	48.11
Halocynthia igaboja	piny tunicate	4	134	1052	584	33.23	44.06
Pyrosoma sp.	sea tongue, unid.	4	167	890	414	41.27	44.77
Pyrosoma atlanticum	sea tongue	273	56	1235	459	32.63	46.37
Thetys vagina	rabbit-eared salp	33	60	1213	442	33.38	46.19
Kingdom Animalia							
Animalia	unsorted shab	261	59	1250	523	32.58	48.43
Invertebrata	invertebrate, unid.	22	60	1213	498	32.78	48.21

Table 4. Number of length-frequency measurements collected by depth stratum for the most frequently sampled groundfish species during the 2021 West Coast Groundfish Bottom Trawl Survey for the areas north and south of Pt. Conception combined (U.S.–Canada border to U.S.–Mexico border).

Species	Shallow (55–183 m)	Mid-Depth (184–549 m)	Deep (550–1280 m)	Total
Pacific spiny dogfish	496	263	0	759
California skate	473	11	0	484
longnose skate	1211	1869	168	3248
spotted ratfish	1516	978	1	2495
arrowtooth flounder	662	740	7	1409
curlfin sole	473	3	0	476
deepsea sole	0	14	1049	1063
Dover sole	1968	2294	1403	5665
English sole	2343	319	0	2662
Pacific sanddab	2251	92	0	2343
petrale sole	3407	362	0	3769
rex sole	2206	1807	116	4129
sablefish	1772	2512	2056	6340
Pacific grenadier	0	6	1000	1006
giant grenadier	0	2	903	905
lingcod	1272	203	0	1475
Pacific hake	724	1690	69	2483
shortspine thornyhead	4	2912	1831	4747
longspine thornyhead	0	790	3626	4416
aurora rockfish	0	1537	21	1558
blackgill rockfish	0	604	2	606
bocaccio	397	282	0	679
canary rockfish	650	11	0	661
chilipepper	1068	315	0	1383
darkblotched rockfish	429	689	0	1118
greenstriped rockfish	1534	502	0	2036
halfbanded rockfish	939	39	0	978
Pacific ocean perch	179	642	0	821
rosethorn rockfish	424	355	0	779
sharpchin rockfish	237	671	0	908
shortbelly rockfish	589	189	0	778
splitnose rockfish	90	1909	0	1999
stripetail rockfish	1373	1141	0	2514
yellowtail rockfish	427	66	0	493
grooved tanner crab	0	157	723	880

Table 5. Number of length-frequency measurements collected by depth stratum for the most frequently sampled groundfish species during the 2021 West Coast Groundfish Bottom Trawl Survey north of Pt. Conception (lat 48°10′N to lat 34°30′N).

Species	Shallow (55–183 m)	Mid-Depth (184–549 m)	Deep (550–1280 m)	Total
Pacific spiny dogfish	474	202	0	676
California skate	384	11	0	395
longnose skate	1205	1640	168	3013
spotted ratfish	1310	725	1	2036
arrowtooth flounder	662	740	7	1409
curlfin sole	449	0	0	449
deepsea sole	0	13	1014	1027
Dover sole	1893	1845	1234	4972
English sole	1951	207	0	2158
Pacific sanddab	1893	13	0	1906
petrale sole	3391	333	0	3724
rex sole	2173	1527	116	3816
sablefish	1736	2471	1962	6169
Pacific grenadier	0	4	925	929
giant grenadier	0	2	879	881
lingcod	1237	196	0	1433
Pacific hake	613	1152	68	1833
shortspine thornyhead	4	2572	1669	4245
longspine thornyhead	0	662	3027	3689
aurora rockfish	0	1354	21	1375
blackgill rockfish	0	391	2	393
bocaccio	338	271	0	609
canary rockfish	650	11	0	661
chilipepper	812	281	0	1093
darkblotched rockfish	429	689	0	1118
greenstriped rockfish	1472	466	0	1938
halfbanded rockfish	325	0	0	325
Pacific ocean perch	179	642	0	821
rosethorn rockfish	359	328	0	687
sharpchin rockfish	237	663	0	900
shortbelly rockfish	398	166	0	564
splitnose rockfish	47	1450	0	1497
stripetail rockfish	933	905	0	1838
yellowtail rockfish	427	66	0	493
grooved tanner crab	0	132	637	769

Table 6. Number of length-frequency measurements collected by depth stratum for the most frequently sampled groundfish species during the 2021 West Coast Groundfish Bottom Trawl Survey south of Pt. Conception (lat 34°30′N to lat 32°30′N).

Species	Shallow (55–183 m)	Mid-Depth (184–549 m)	Deep (550–1280 m)	Total
Pacific spiny dogfish	22	61	0	83
California skate	89	0	0	89
longnose skate	6	229	0	235
spotted ratfish	206	253	0	459
arrowtooth flounder	0	0	0	0
curlfin sole	24	3	0	27
deepsea sole	0	1	35	36
Dover sole	75	449	169	693
English sole	392	112	0	504
Pacific sanddab	358	79	0	437
petrale sole	16	29	0	45
rex sole	33	280	0	313
sablefish	36	41	94	171
Pacific grenadier	0	2	75	77
giant grenadier	0	0	24	24
lingcod	35	7	0	42
Pacific hake	111	538	1	650
shortspine thornyhead	0	340	162	502
longspine thornyhead	0	128	599	727
aurora rockfish	0	183	0	183
blackgill rockfish	0	213	0	213
bocaccio	59	11	0	70
canary rockfish	0	0	0	0
chilipepper	256	34	0	290
darkblotched rockfish	0	0	0	0
greenstriped rockfish	62	36	0	98
halfbanded rockfish	614	39	0	653
Pacific ocean perch	0	0	0	0
rosethorn rockfish	65	27	0	92
sharpchin rockfish	0	8	0	8
shortbelly rockfish	191	23	0	214
splitnose rockfish	43	459	0	502
stripetail rockfish	440	236	0	676
yellowtail rockfish	0	0	0	0
grooved tanner crab	0	25	86	111

Temperature Data

Near-bottom temperatures ranged from 3.2°C to 12.1°C (average: 7.1°C) during the May–July 2021 portion of the survey, and from 3.0°C to 11.5°C (average: 6.9°C) during the August–October 2021 portion of the survey. The mean bottom temperature was 6.7°C north of Pt. Conception (range: 3.01–11.9°C) and 8.22°C south of Pt. Conception (range: 3.55–12.1°C; Figure 5). Sea surface temperatures ranged from 9.1°C to 21.2°C (average: 13.8°C) during the May–July 2021 portion of the survey, and from 8.8°C to 22.6°C (average: 14.2°C) during the August–October 2021 portion of the survey (Figure 6). The overall mean sea surface temperature was 14.0°C.

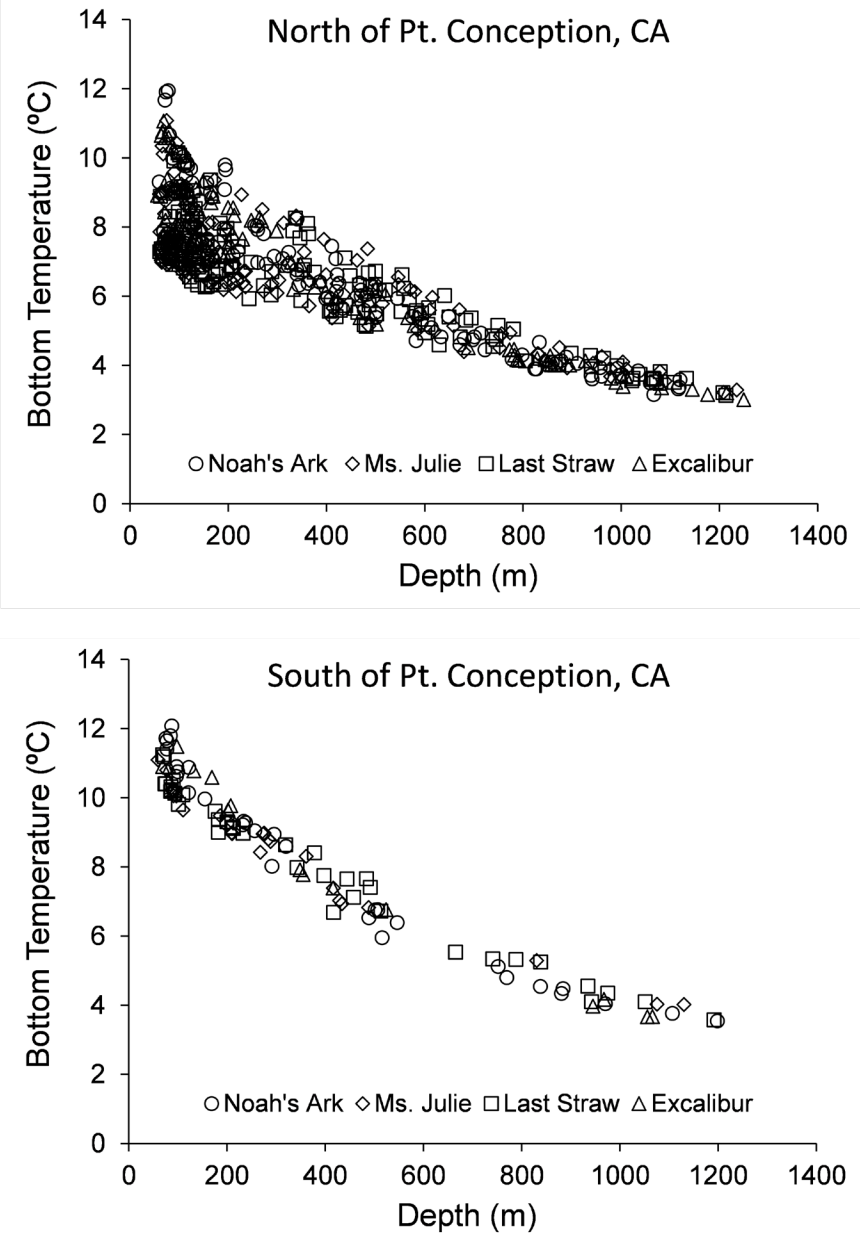


Figure 5. Near-bottom temperature (°C) observed at the mouth of the net for each tow conducted during the 2021 West Coast Groundfish Bottom Trawl Survey. We grouped observations by region and plotted relative to haul depth (m).

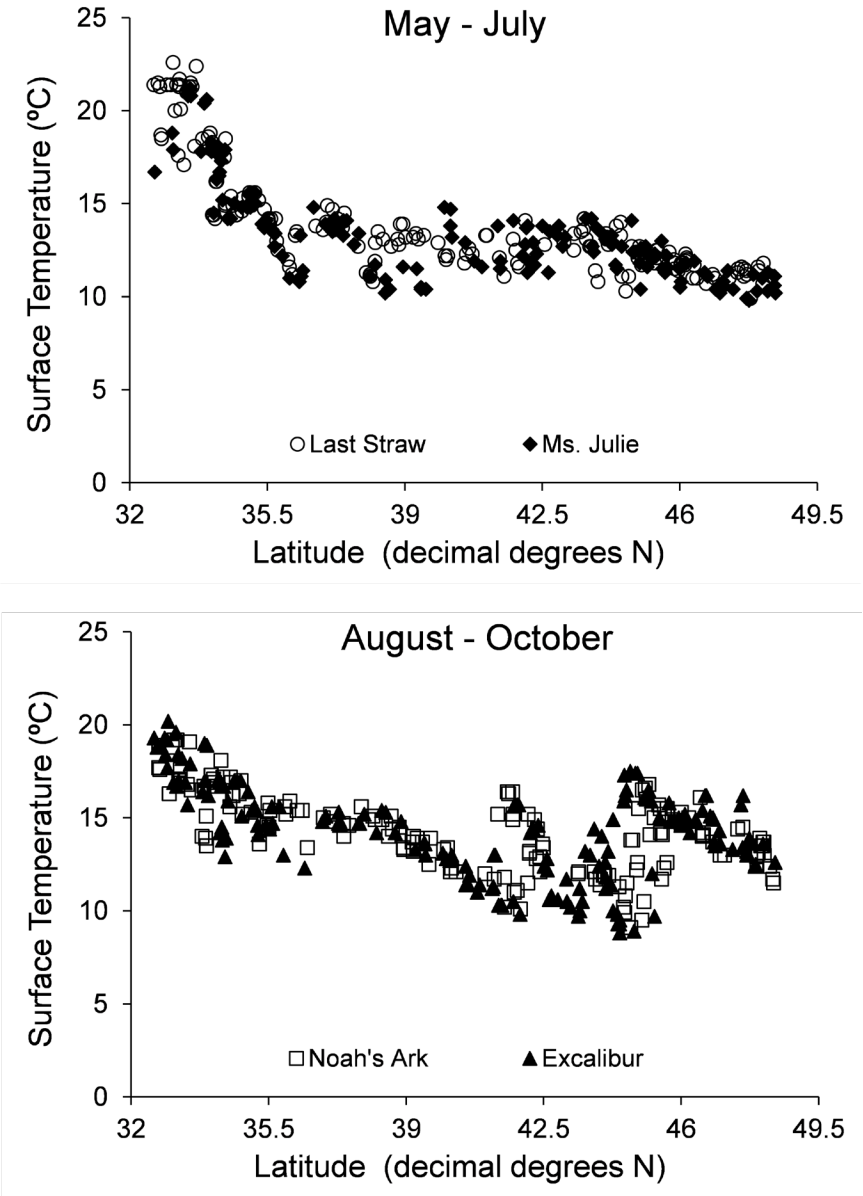


Figure 6. Sea surface temperature observed at the start of each tow during the 2021 West Coast Groundfish Bottom Trawl Survey. Observations are grouped by date (first pass from 14 May to 23 July 2021; second pass from 16 August to 26 October 2021), and plotted relative to latitude.

Relative Density and Distribution of Species

We show charts describing the geographical distribution and relative abundance (CPUE in kg/ha) of select groundfish species created with ArcGIS Software (Environmental Systems Research Institute Inc., Redlands, California; Figures 7–44). The charts display the location of hauls where we captured each species. We categorized catch rates as: 1) no catch, 2) catch greater than zero but less than or equal to the mean CPUE, 3) catch greater than the mean CPUE but less than or equal to one standard deviation from the mean, 4) catch between one and two standard deviations greater than the mean CPUE, and 5) catch more than two standard deviations greater than the mean CPUE. Larger circles indicate areas with higher catch rates; we represented zero catch using a + sign.

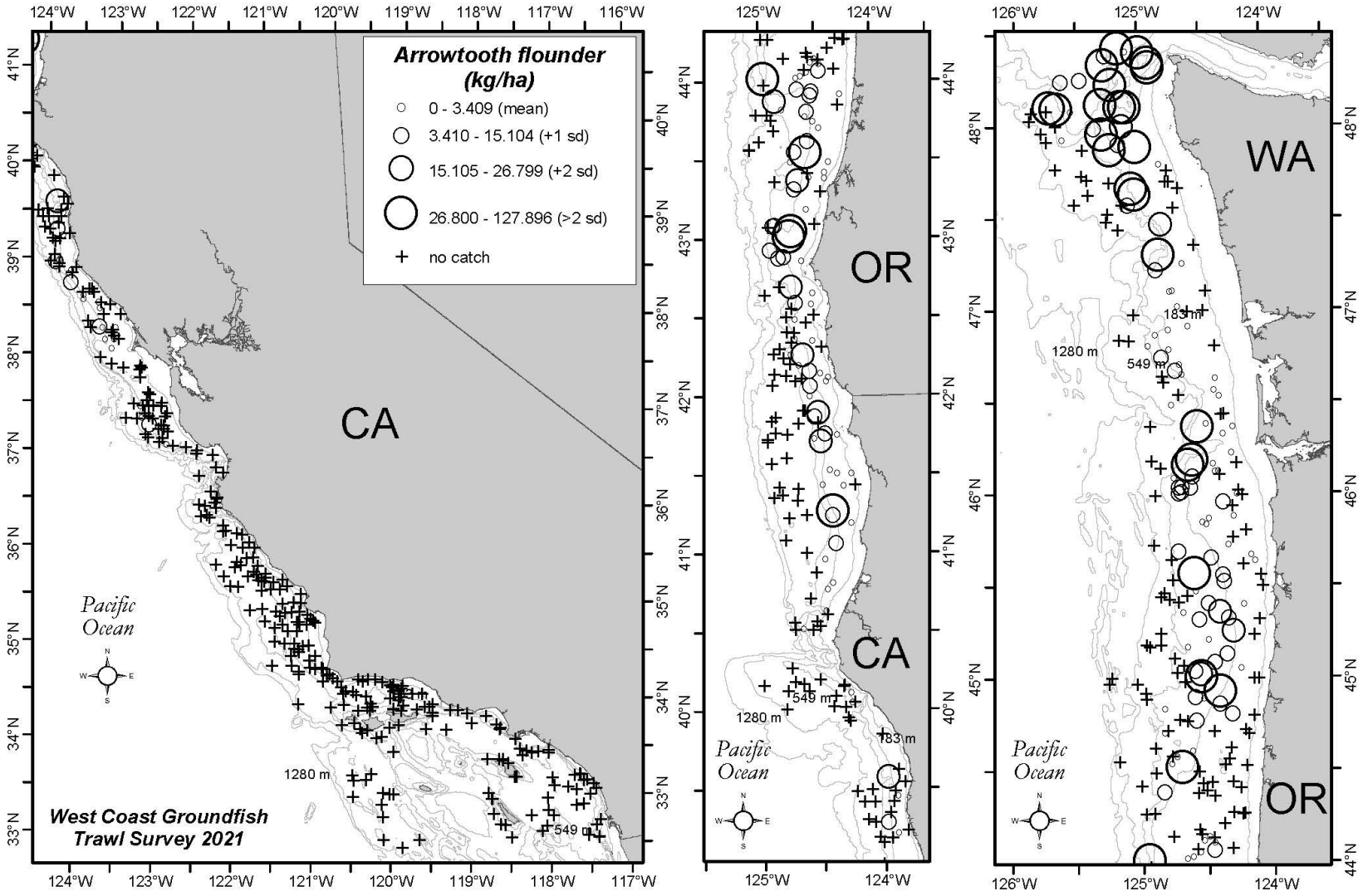


Figure 7. Arrowtooth flounder (*Atheresthes stomias*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

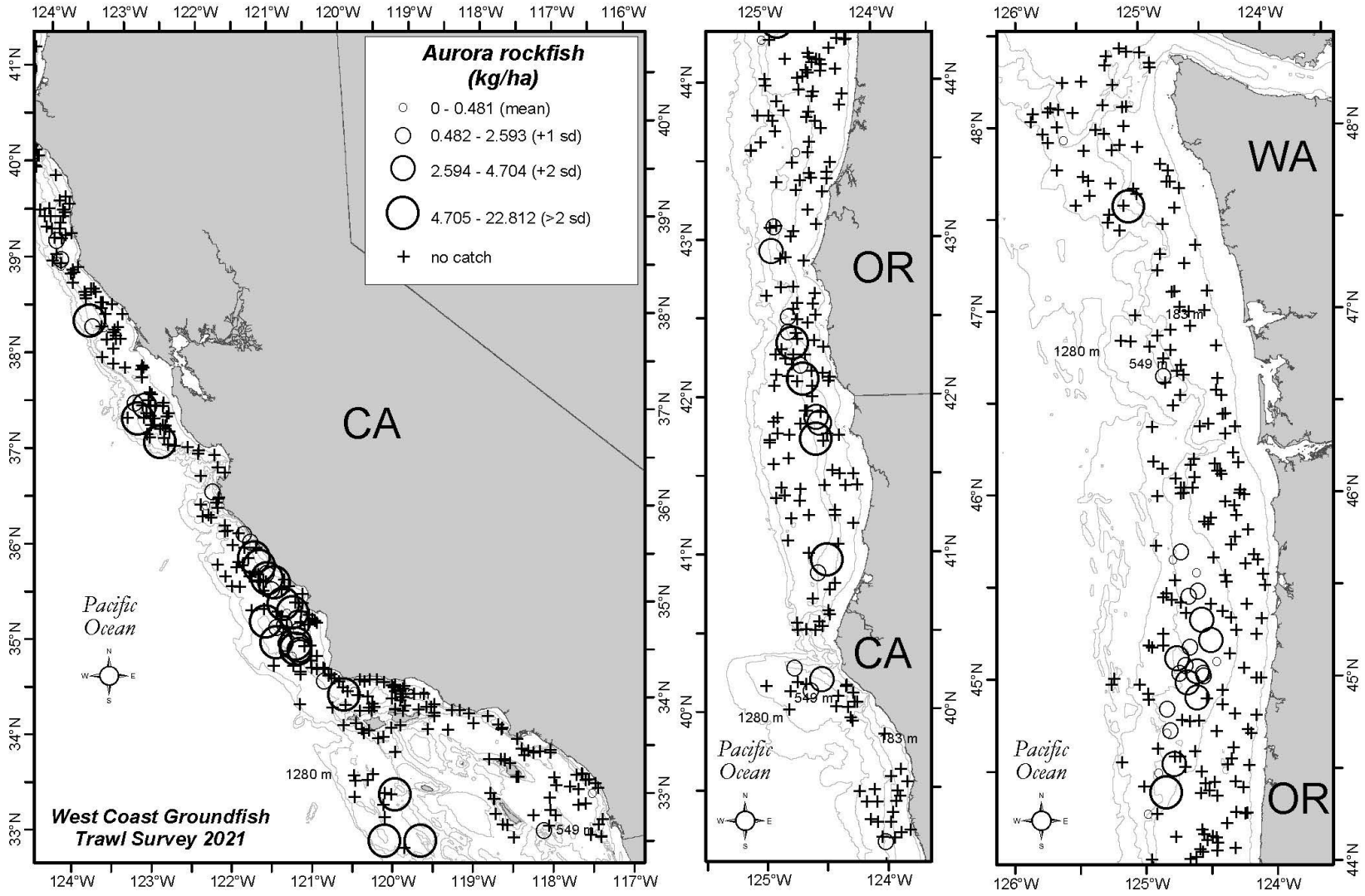


Figure 8. Aurora rockfish (*Sebastes aurora*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

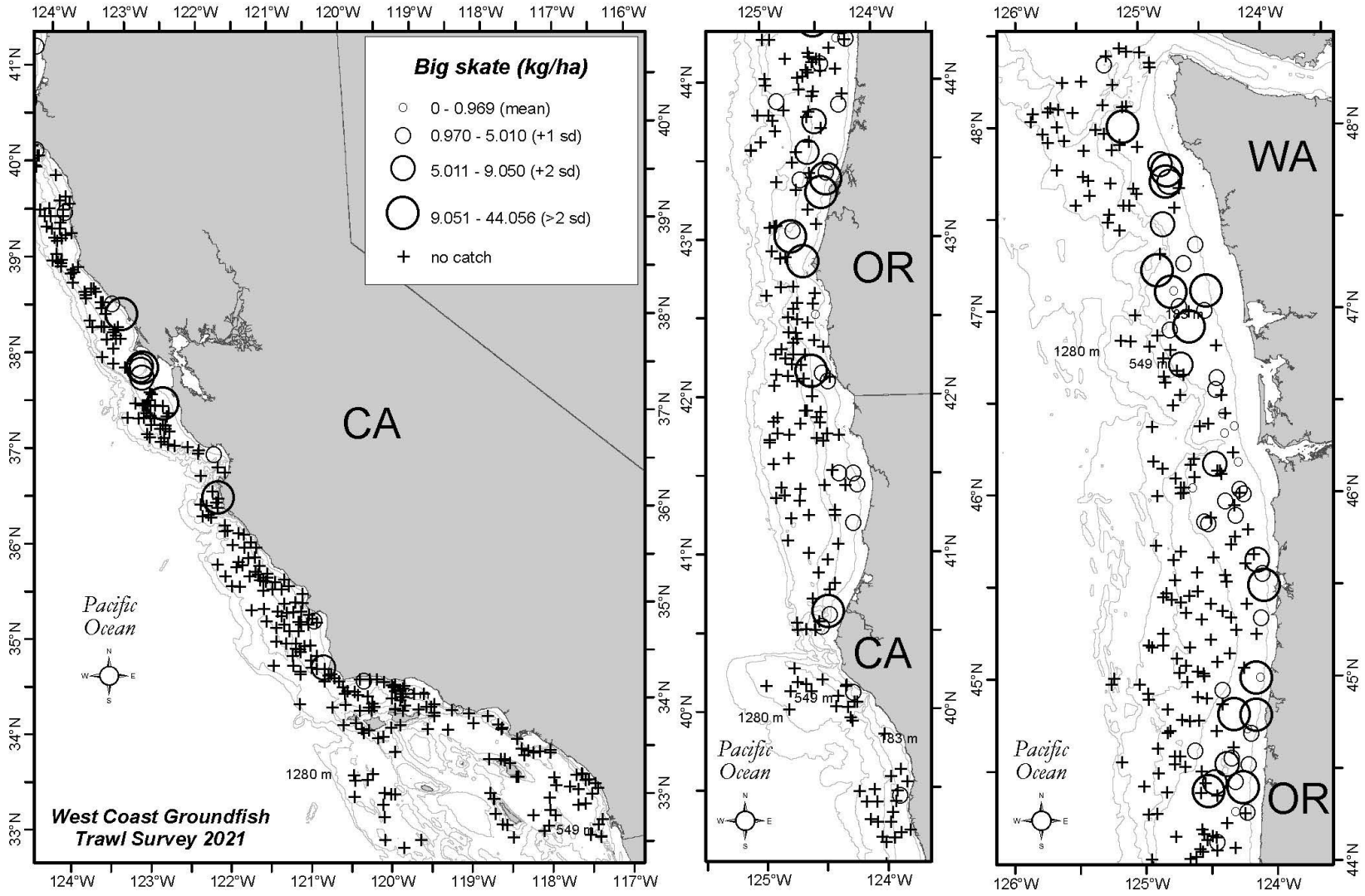


Figure 9. Big skate (*Beringraja binoculata*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

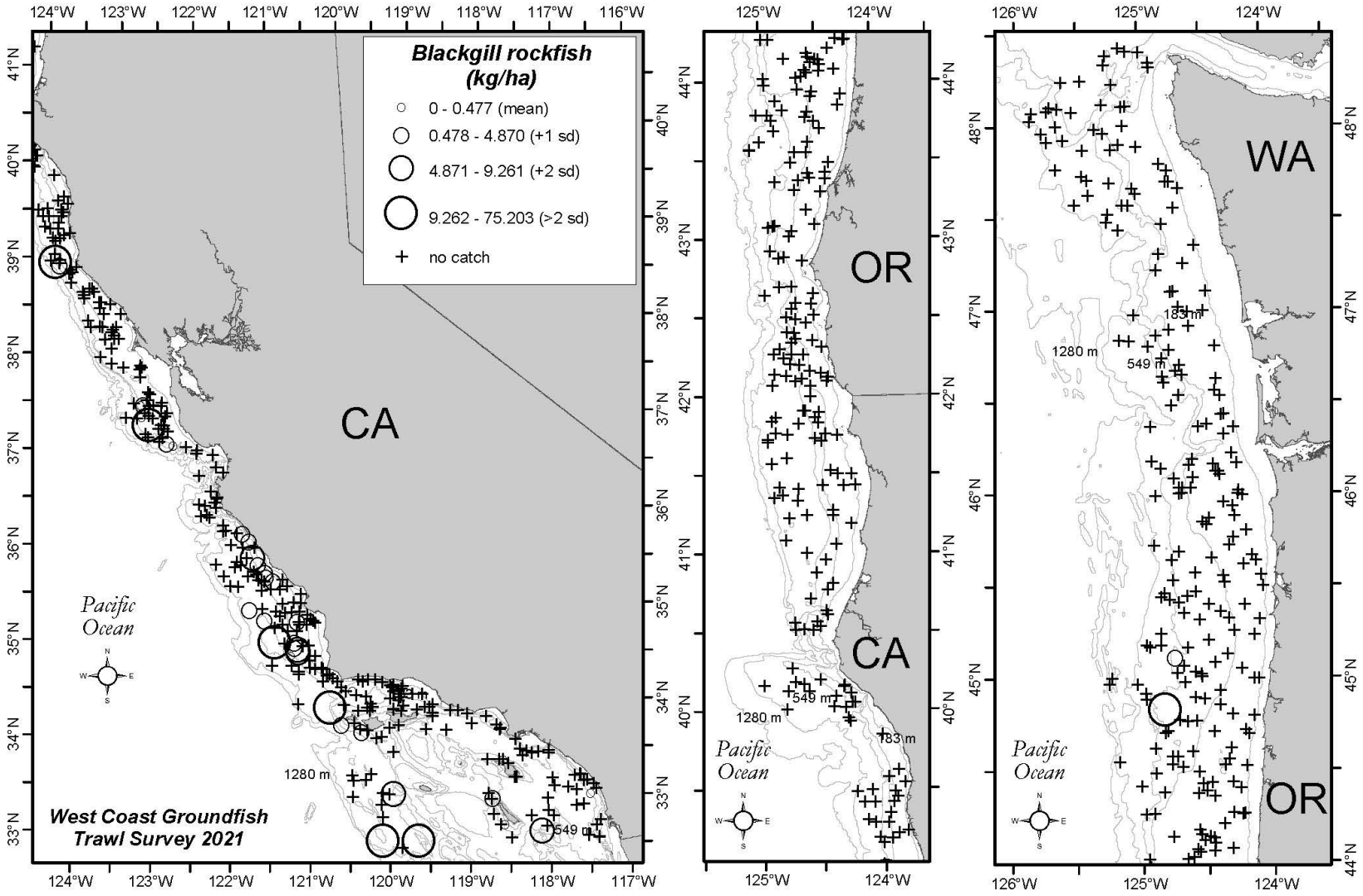


Figure 10. Blackgill rockfish (*Sebastes melanostomus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

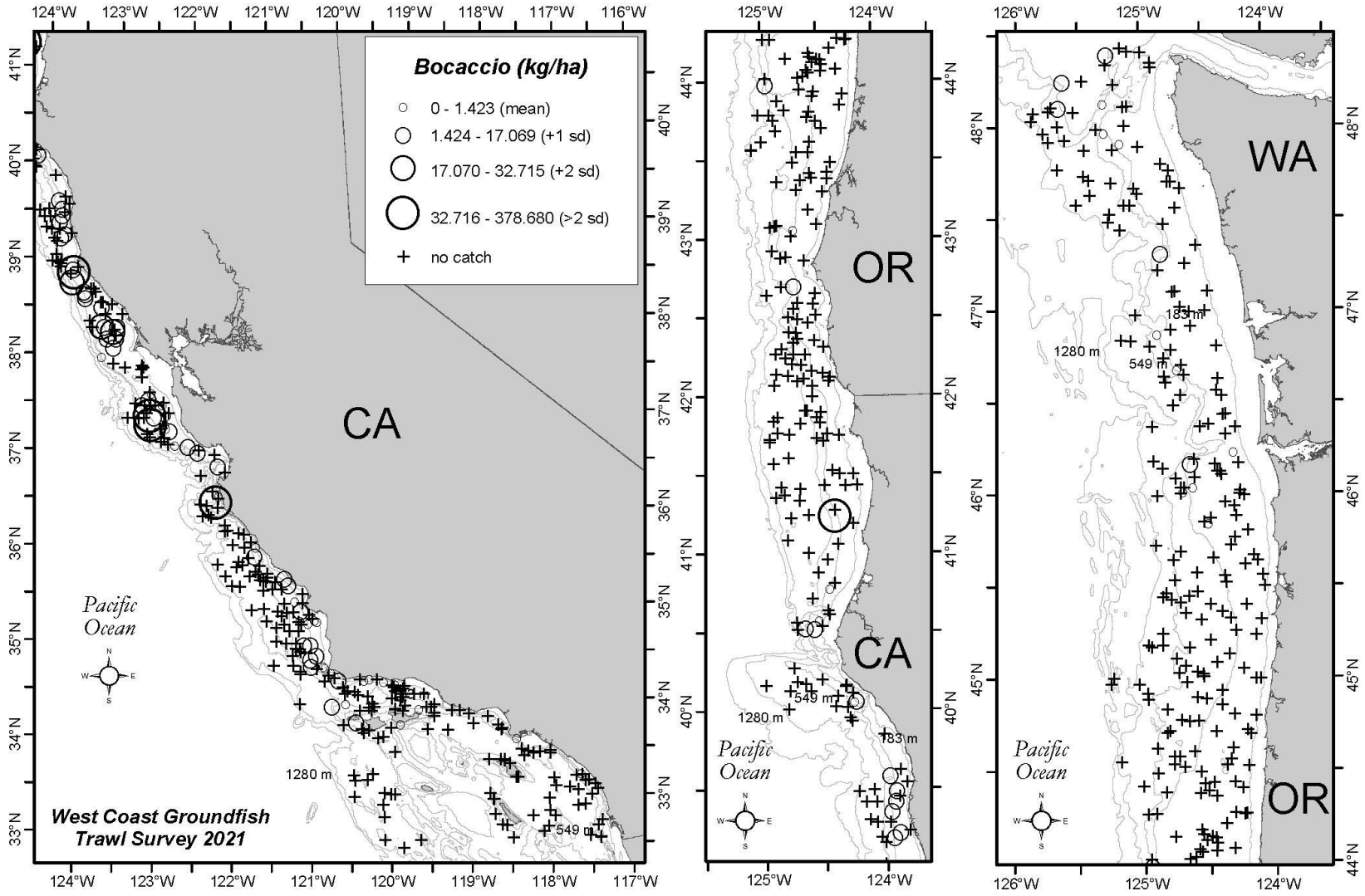


Figure 11. Bocaccio (*Sebastes paucispinis*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

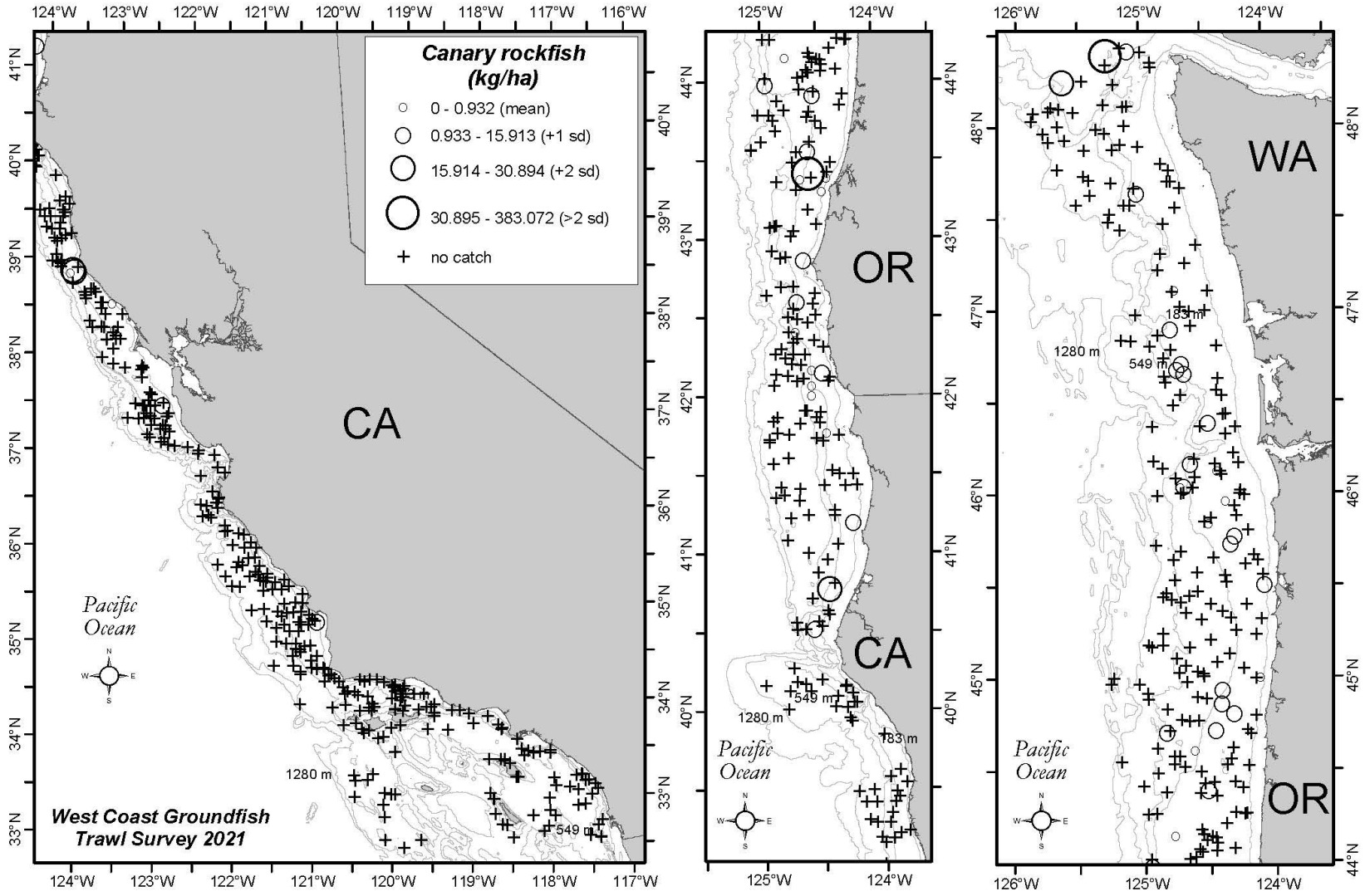


Figure 12. Canary rockfish (*Sebastes pinniger*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

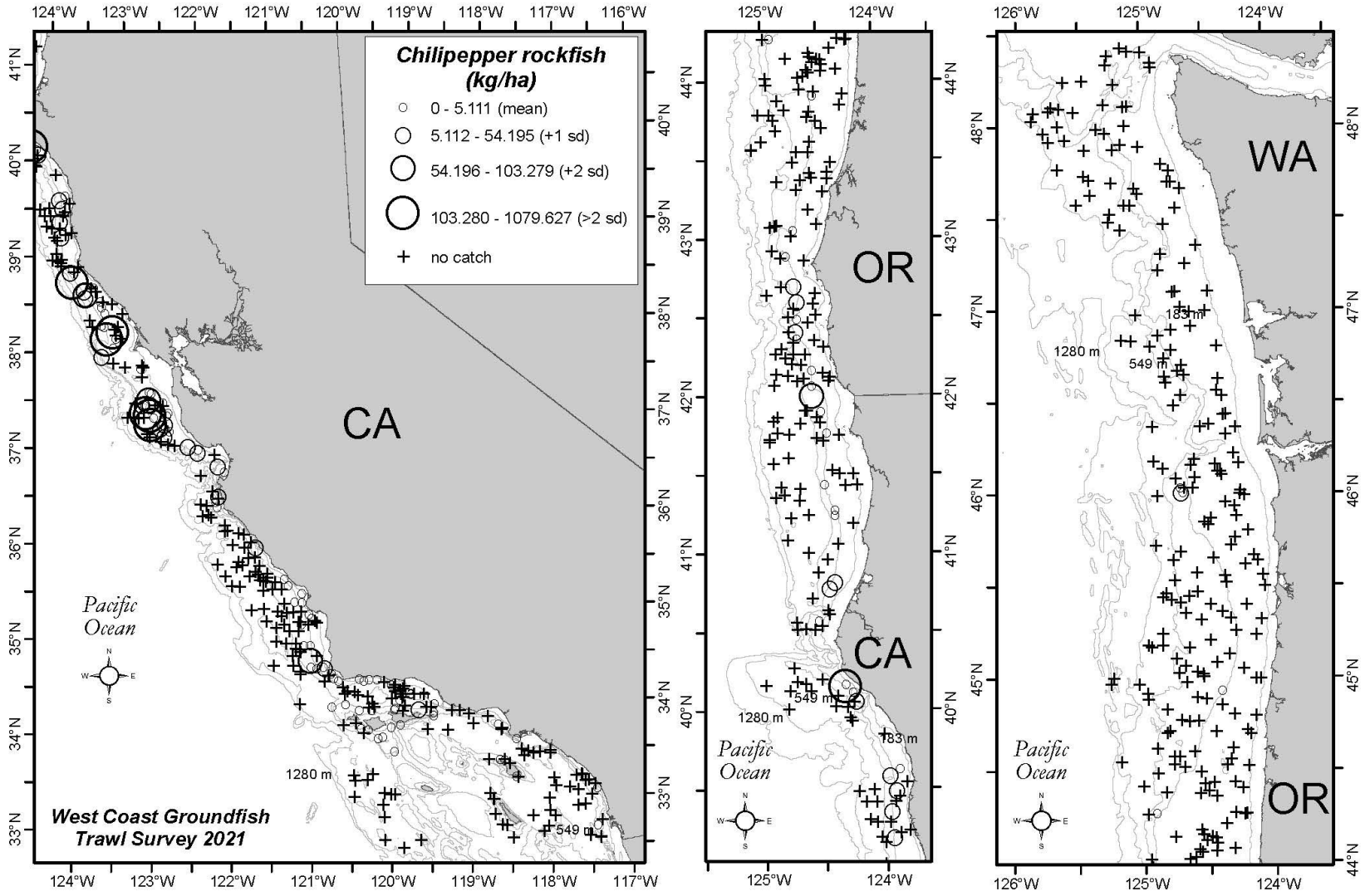


Figure 13. Chilipepper rockfish (*Sebastes goodei*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

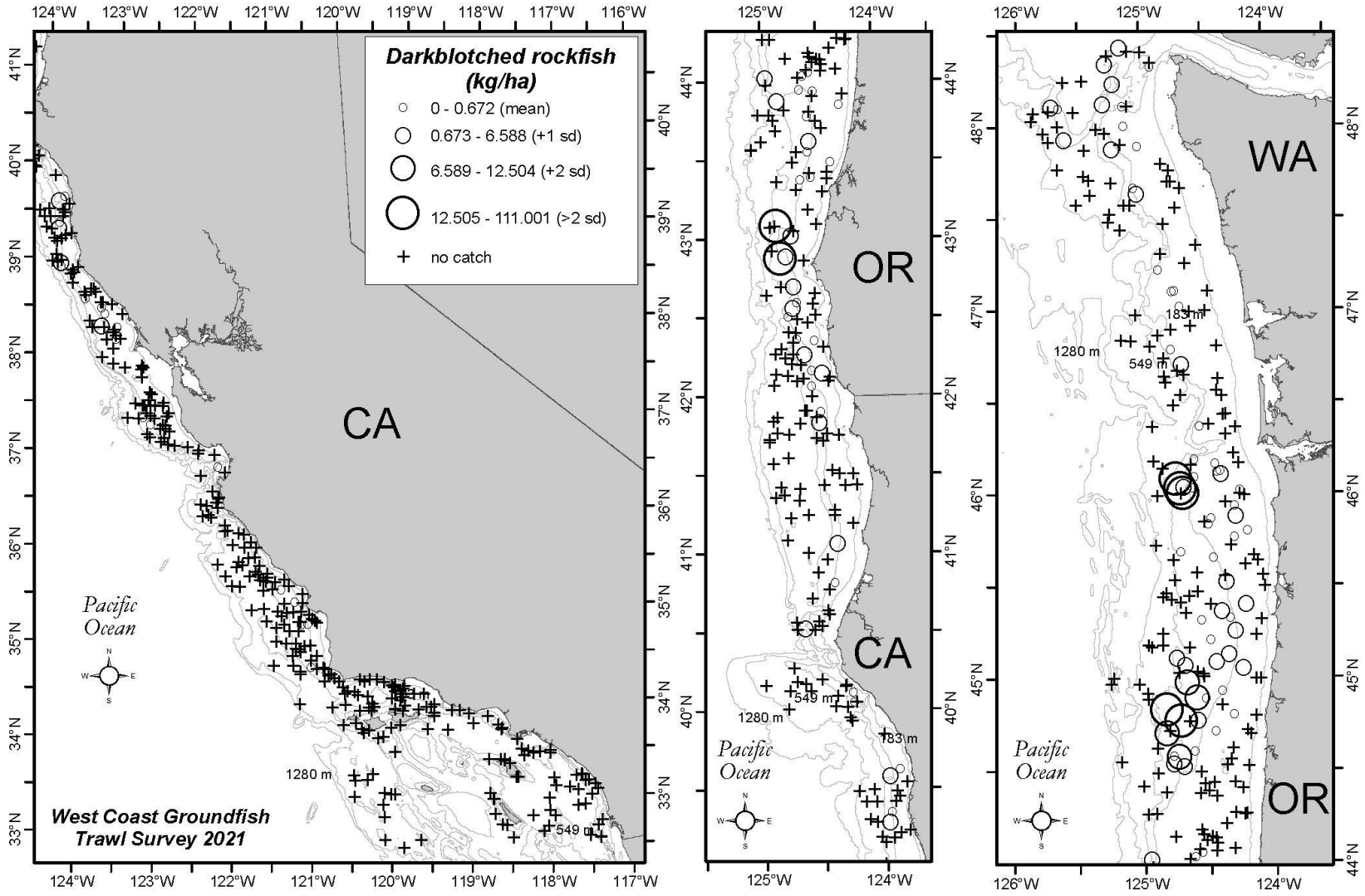


Figure 14. Darkblotched rockfish (*Sebastes crameri*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

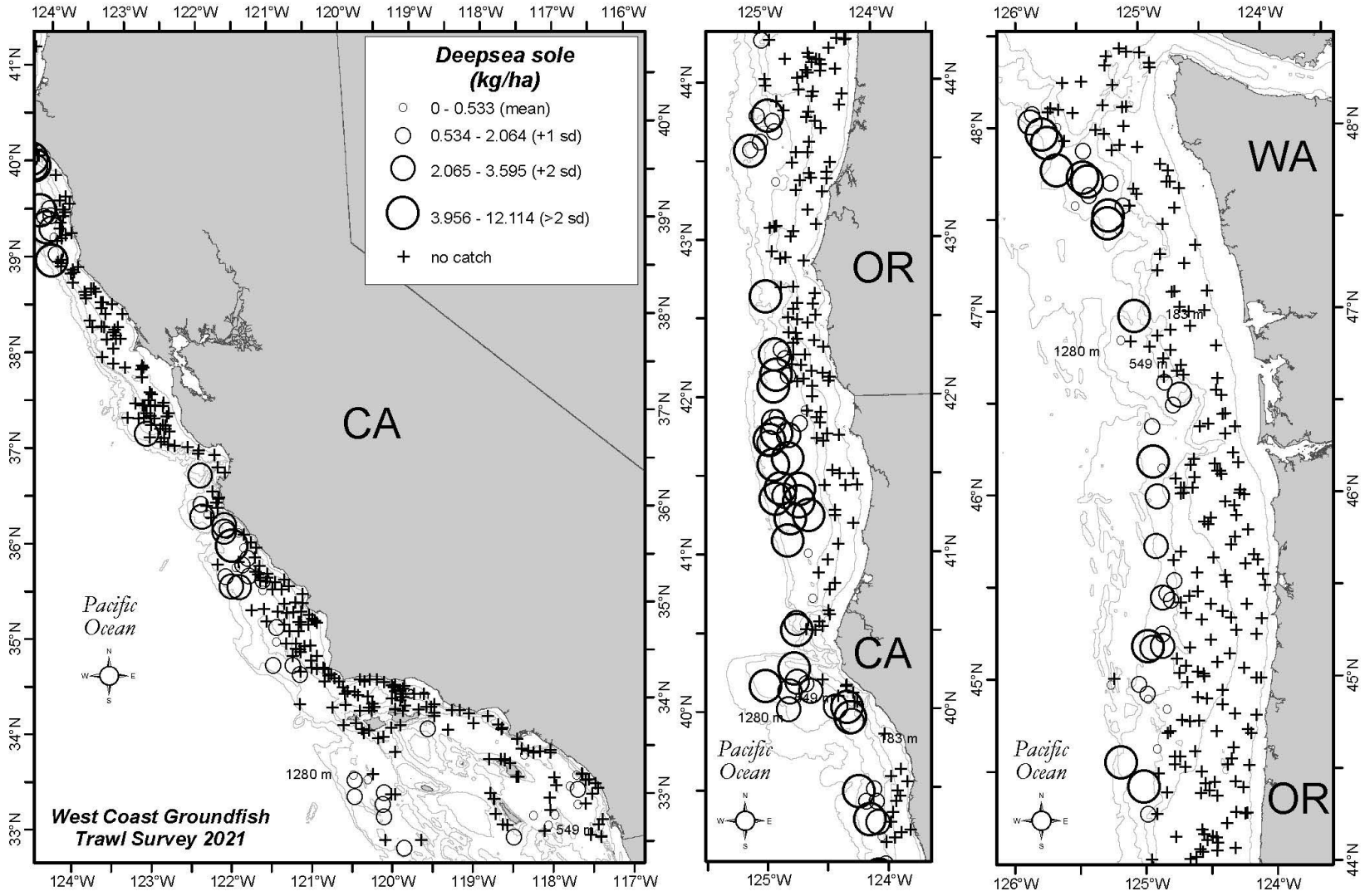


Figure 15. Deepsea sole (*Embassichthys bathybius*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

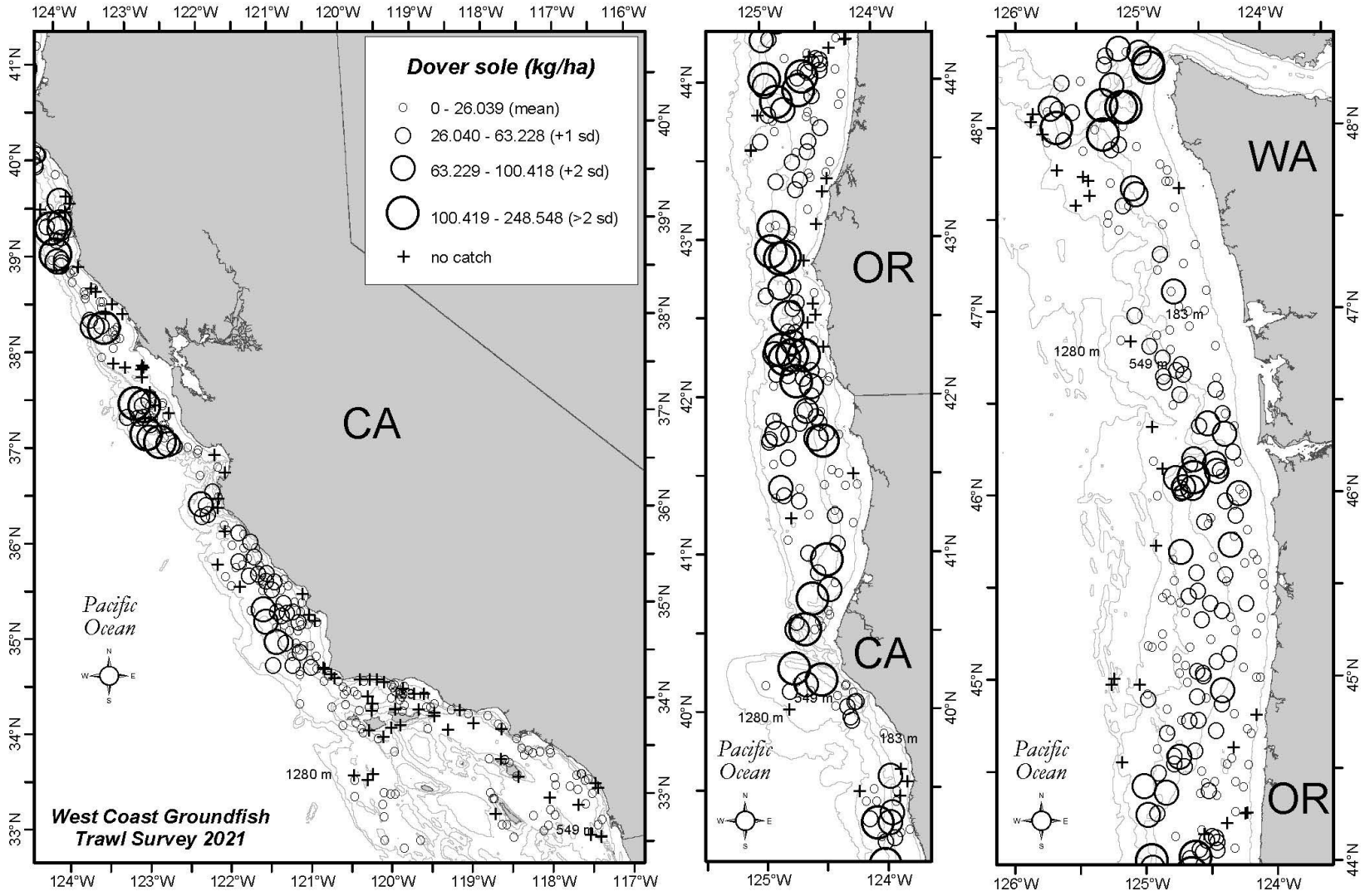


Figure 16. Dover sole (*Microstomus pacificus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

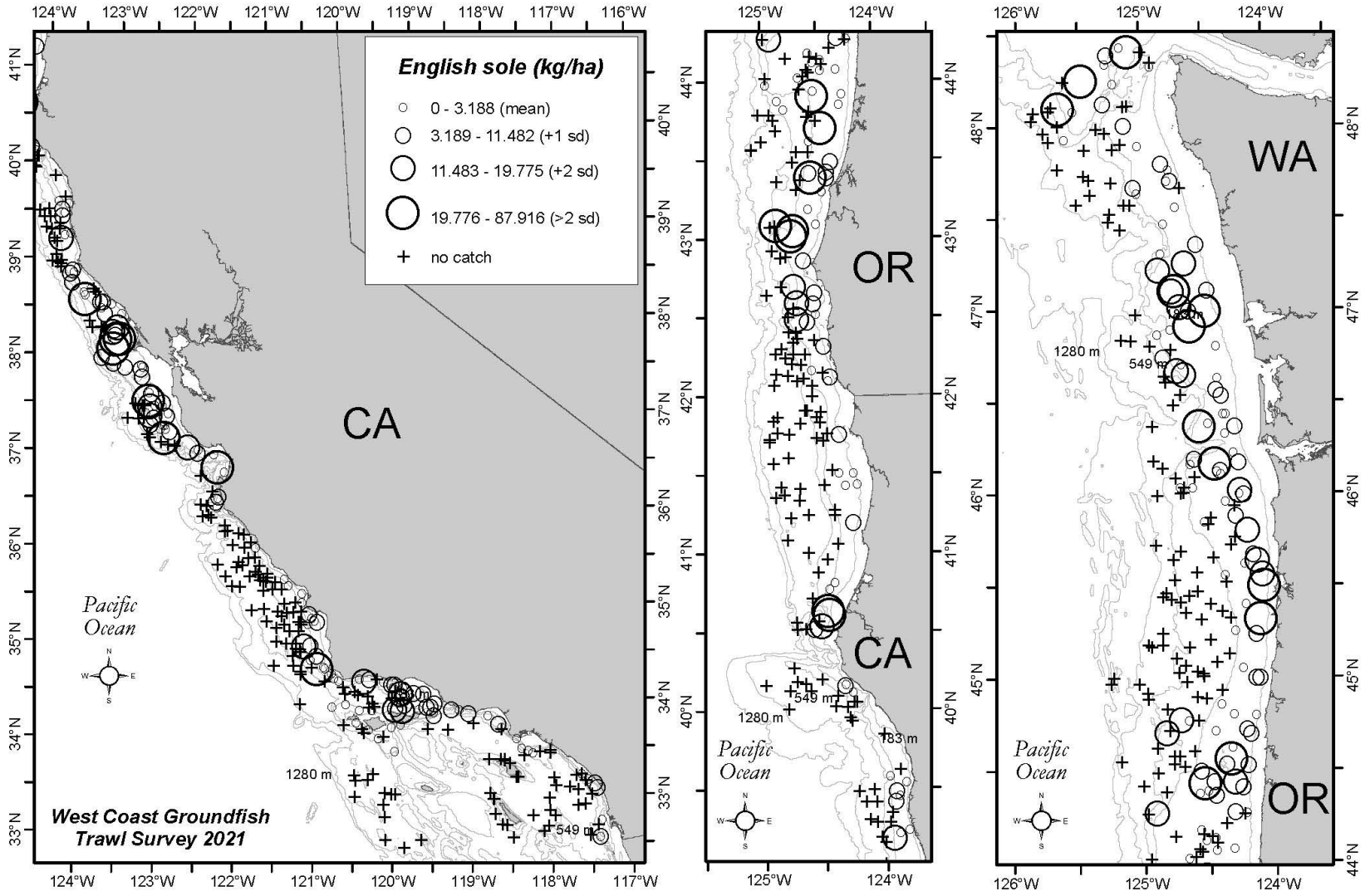


Figure 17. English sole (*Parophrys vetulus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

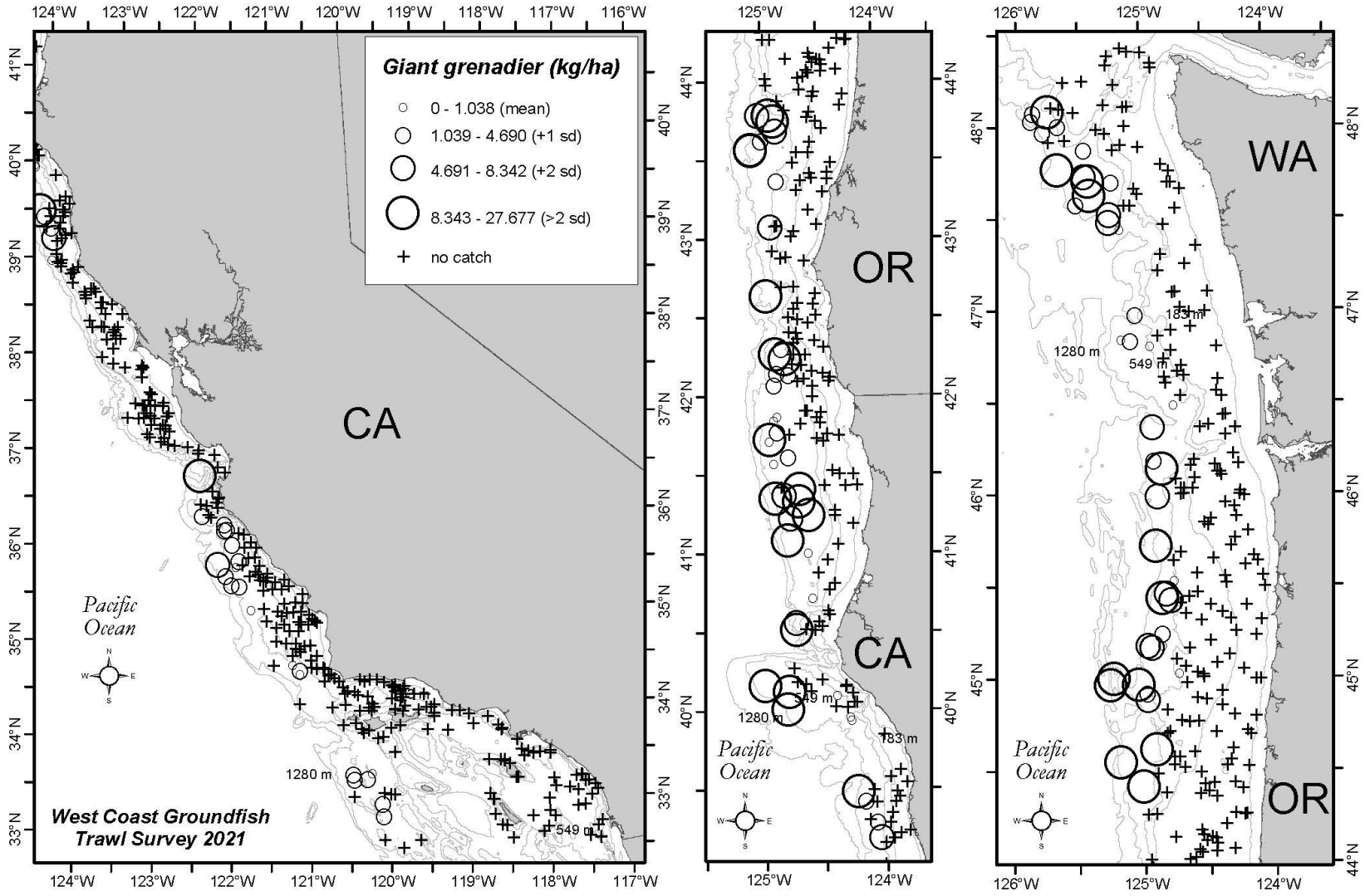


Figure 18. Giant grenadier (*Albatrossia pectoralis*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

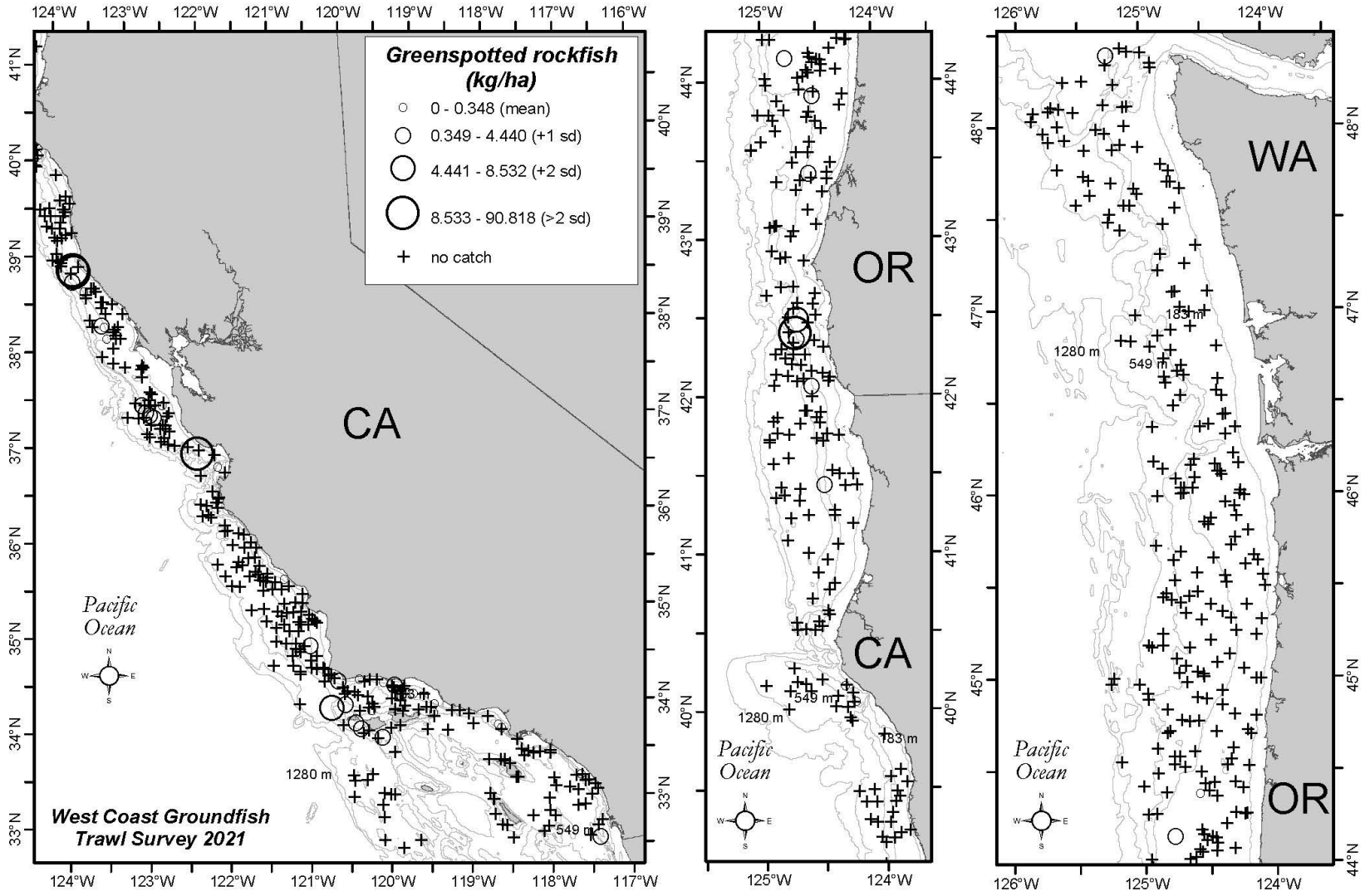


Figure 19. Greenspotted rockfish (*Sebastes chlorostictus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

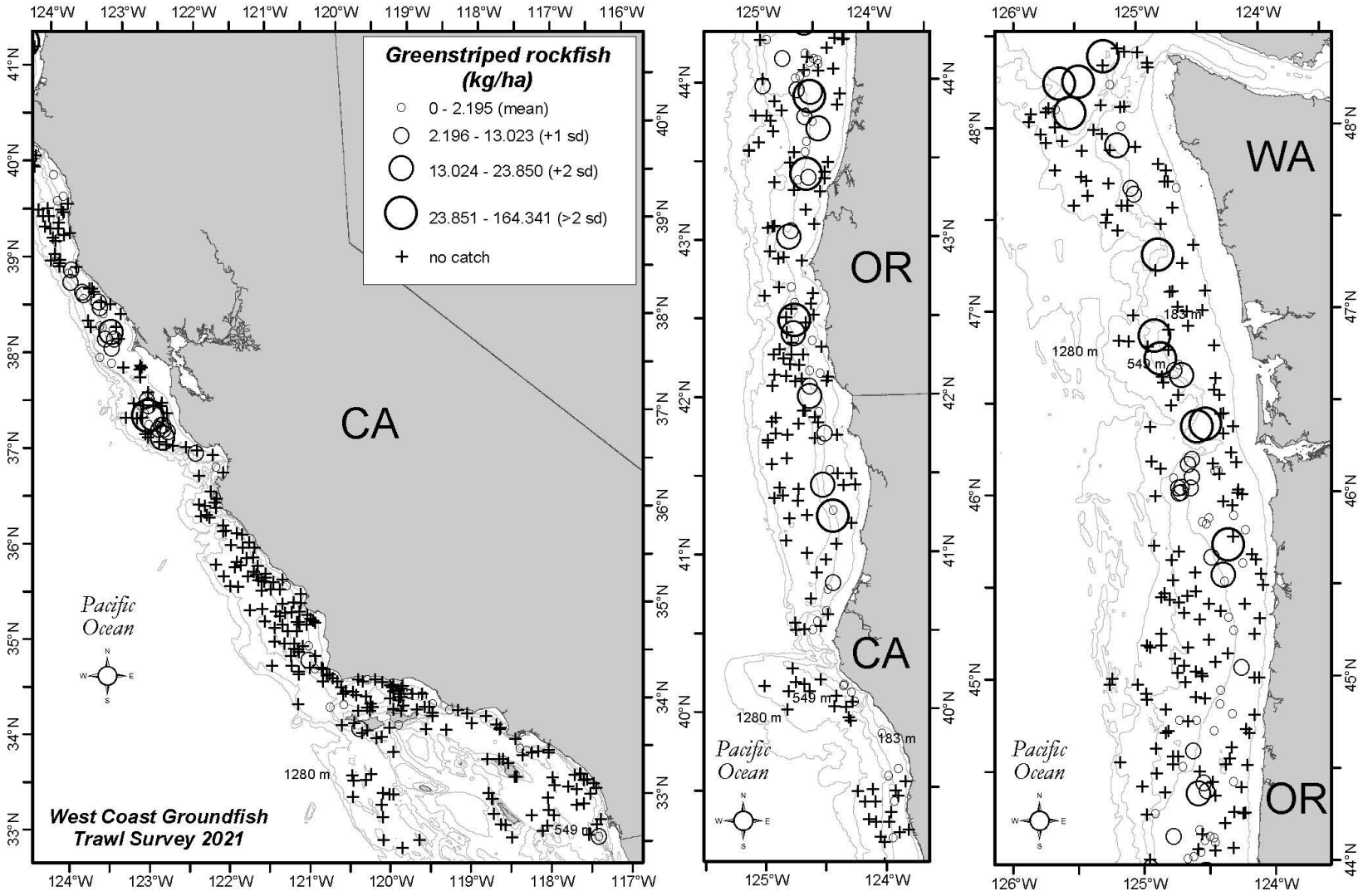


Figure 20. Greenstriped rockfish (*Sebastes elongatus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

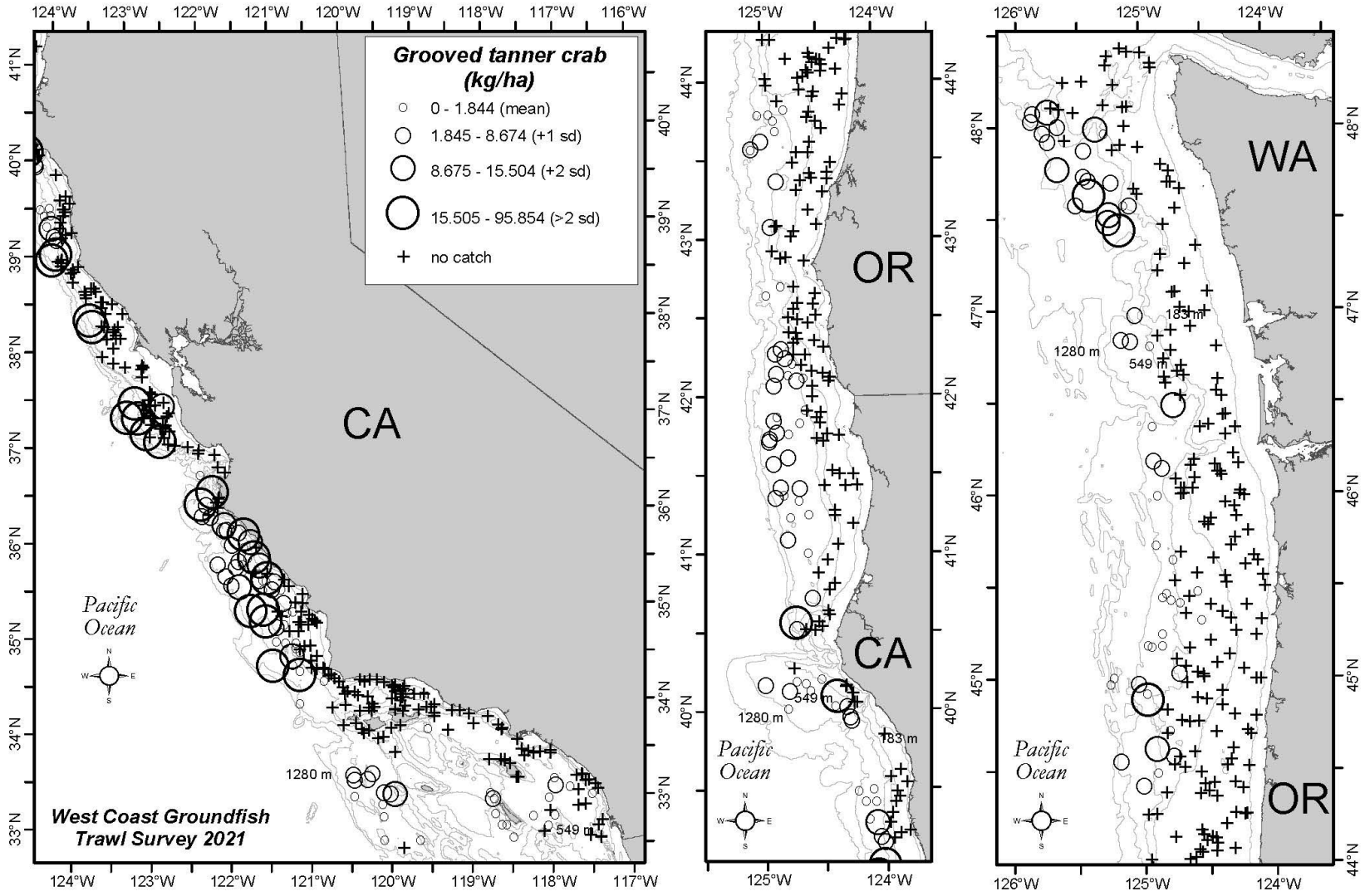


Figure 21. Grooved tanner crab (*Chionocetes tanneri*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

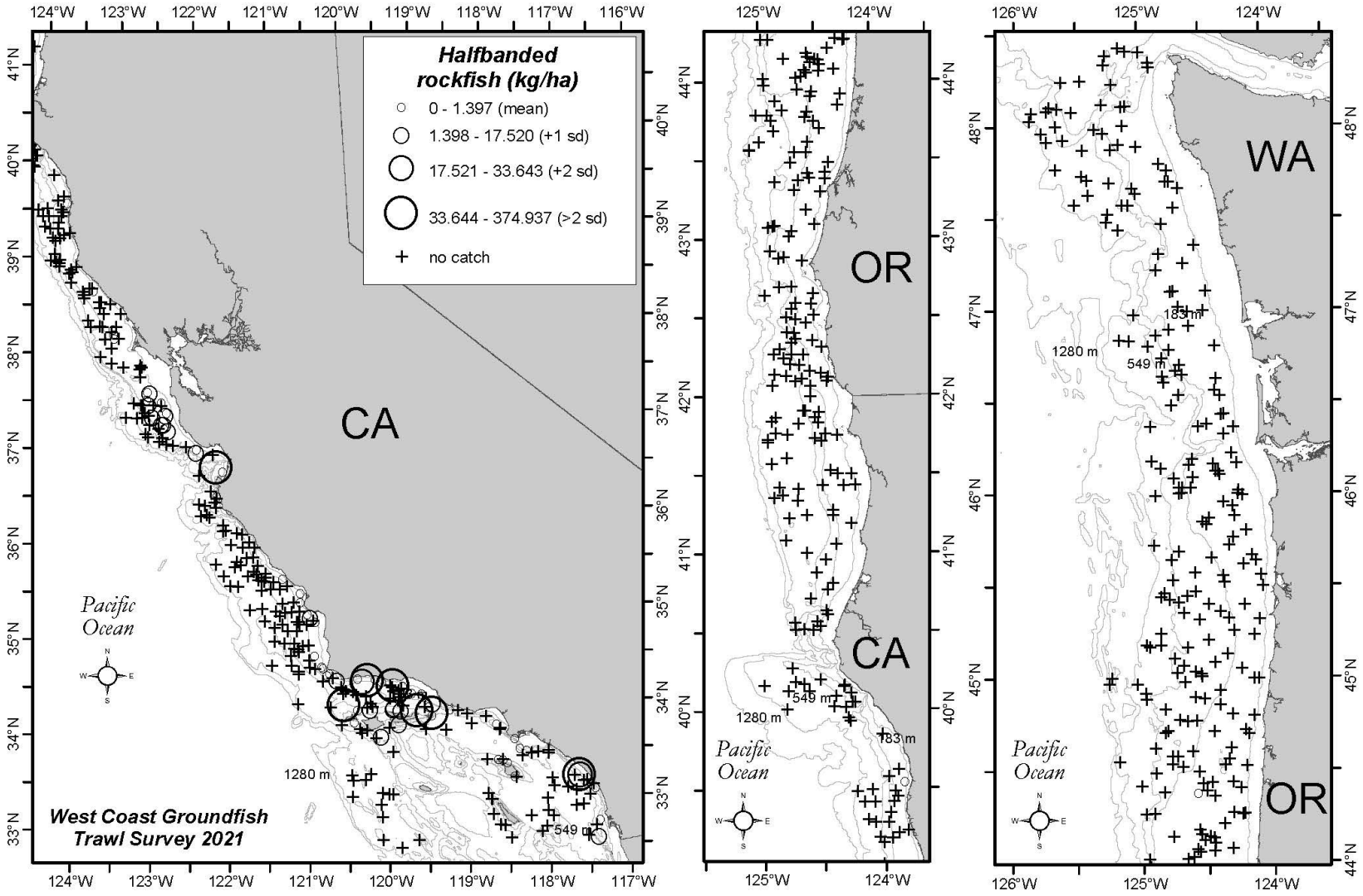


Figure 22. Halfbanded rockfish (*Sebastes semicinctus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

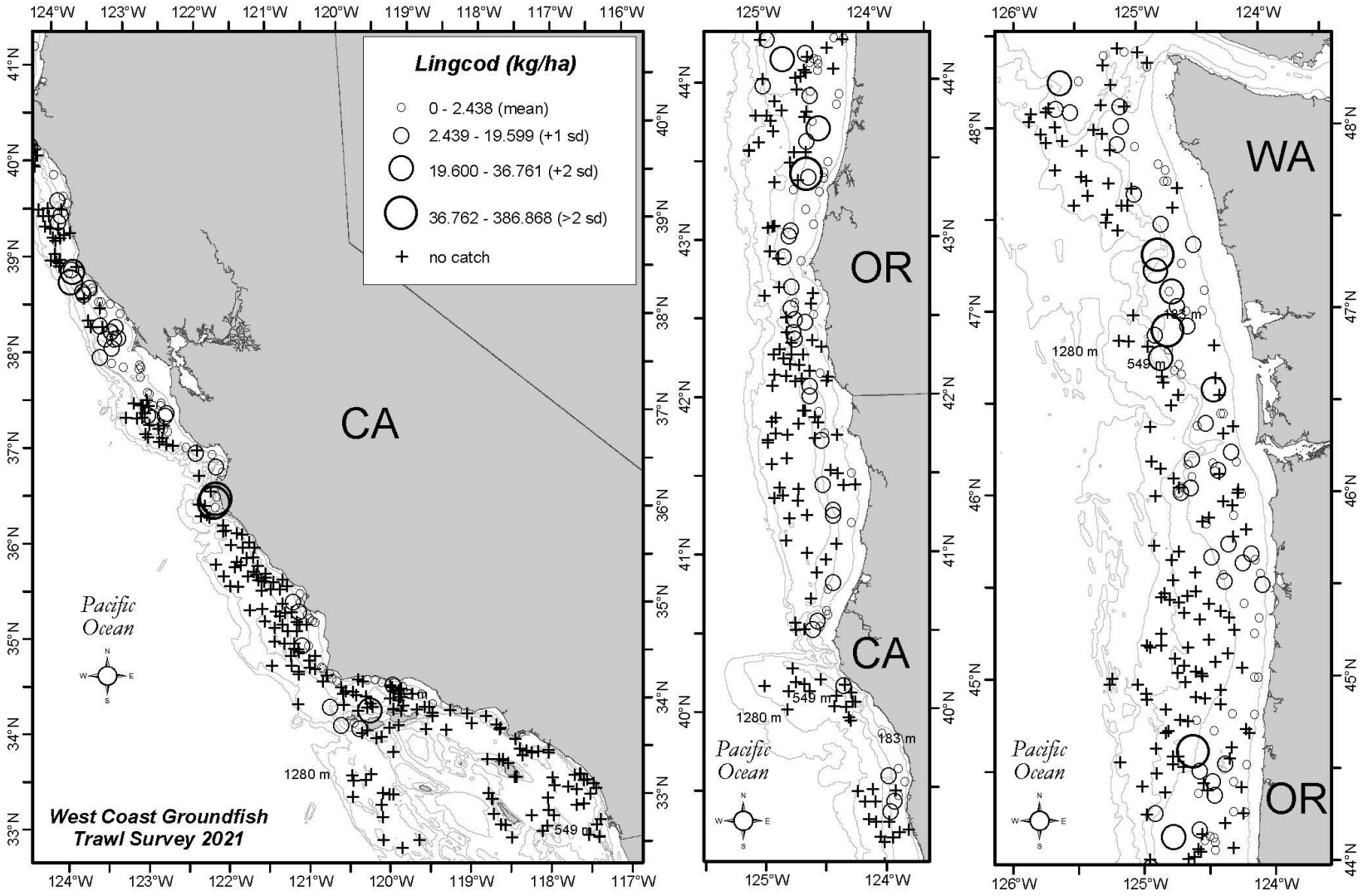


Figure 23. Lingcod (*Ophiodon elongatus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

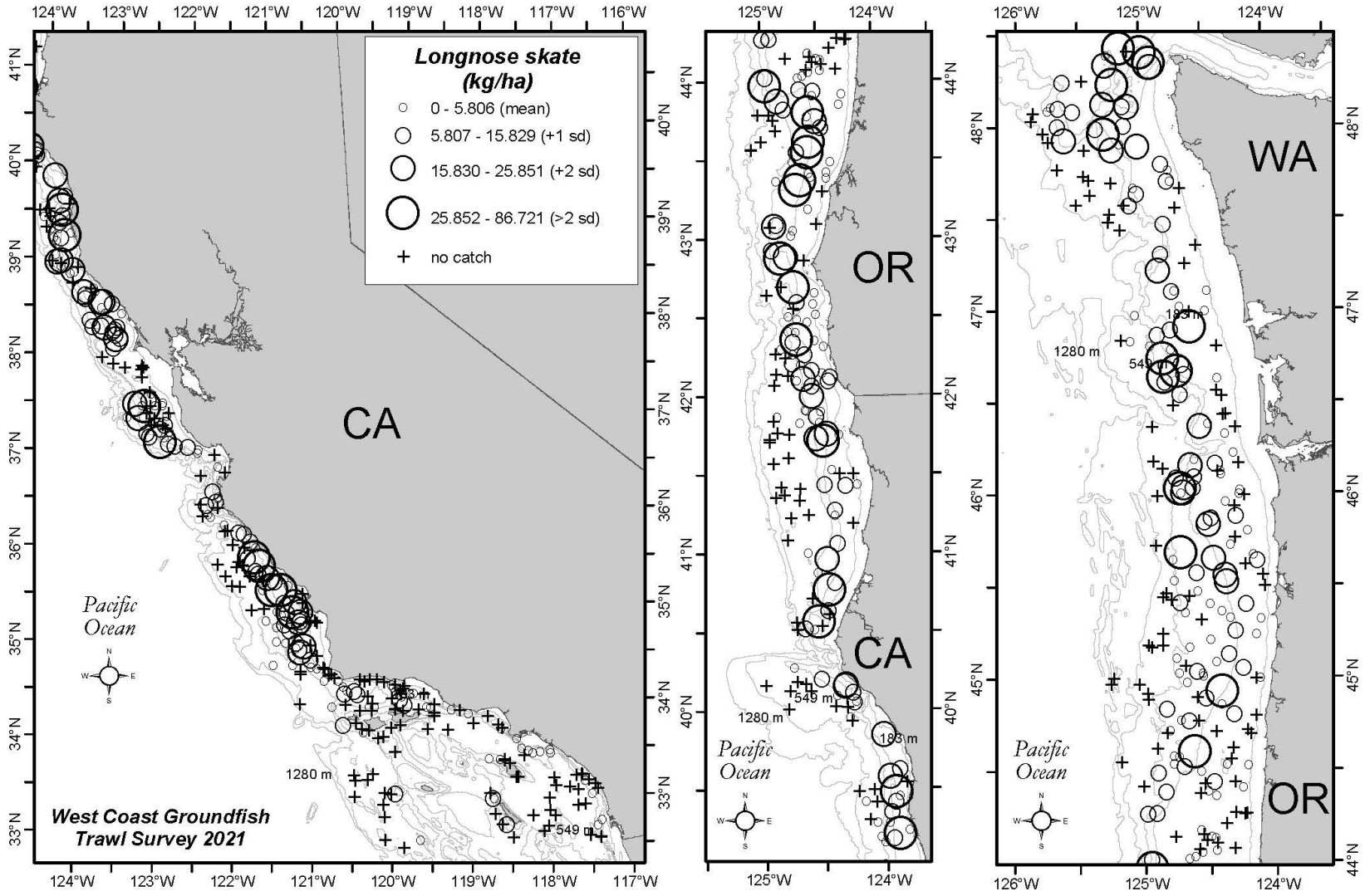


Figure 24. Longnose skate (*Beringraja rhina*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

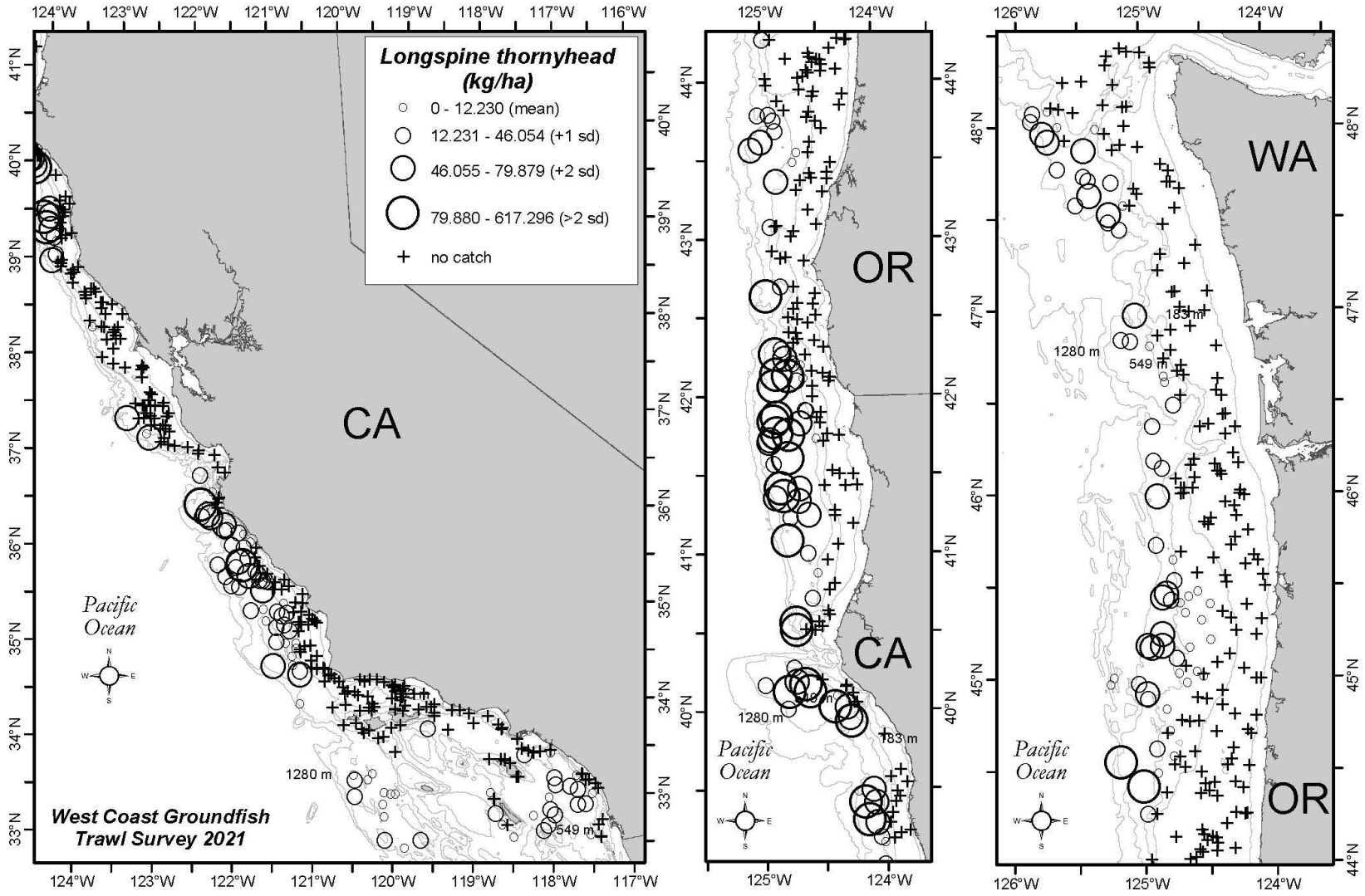


Figure 25. Longspine thornyhead (*Sebastolobus altivelus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

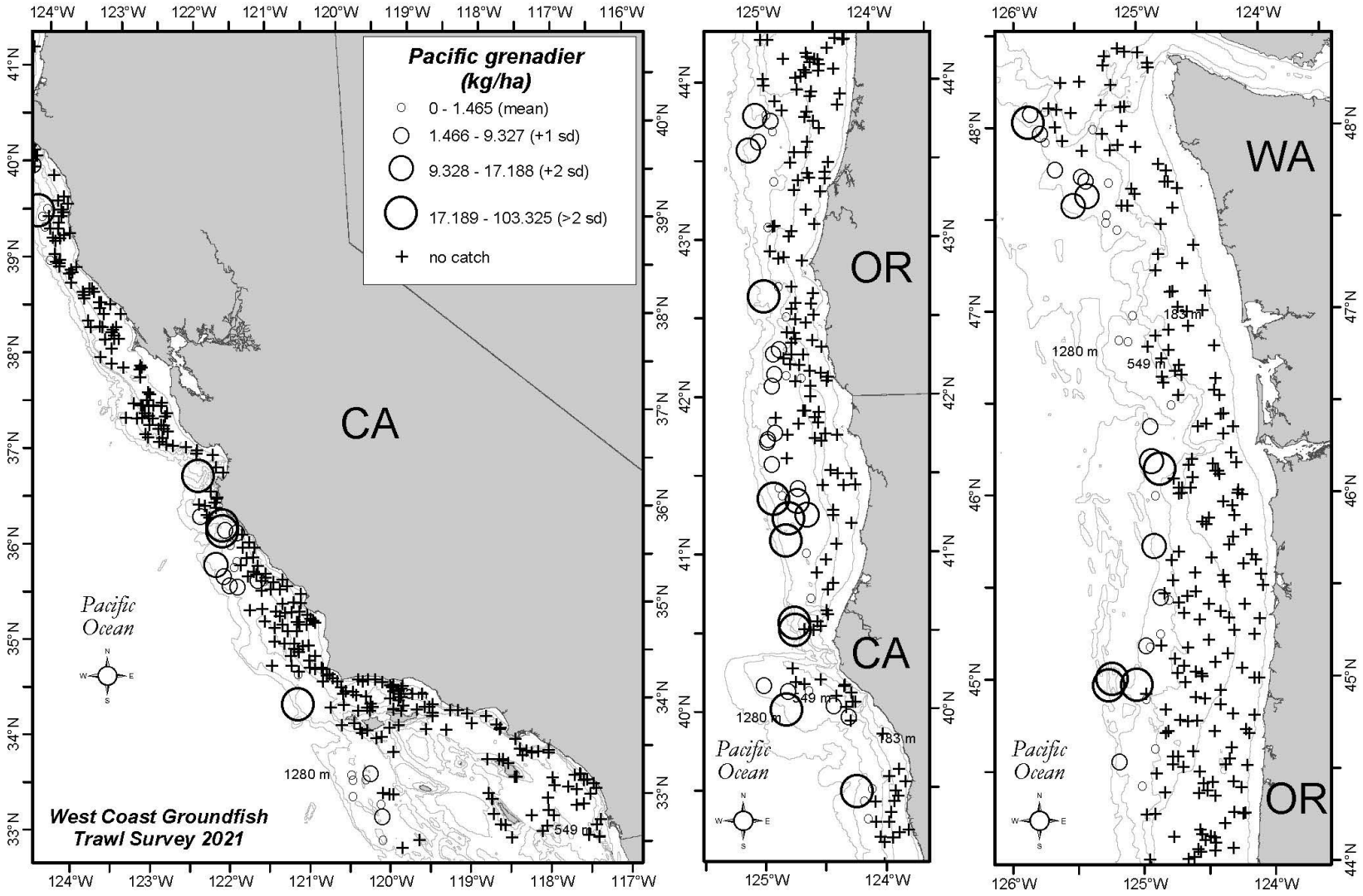


Figure 26. Pacific grenadier (*Coryphaenoides acrolepis*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

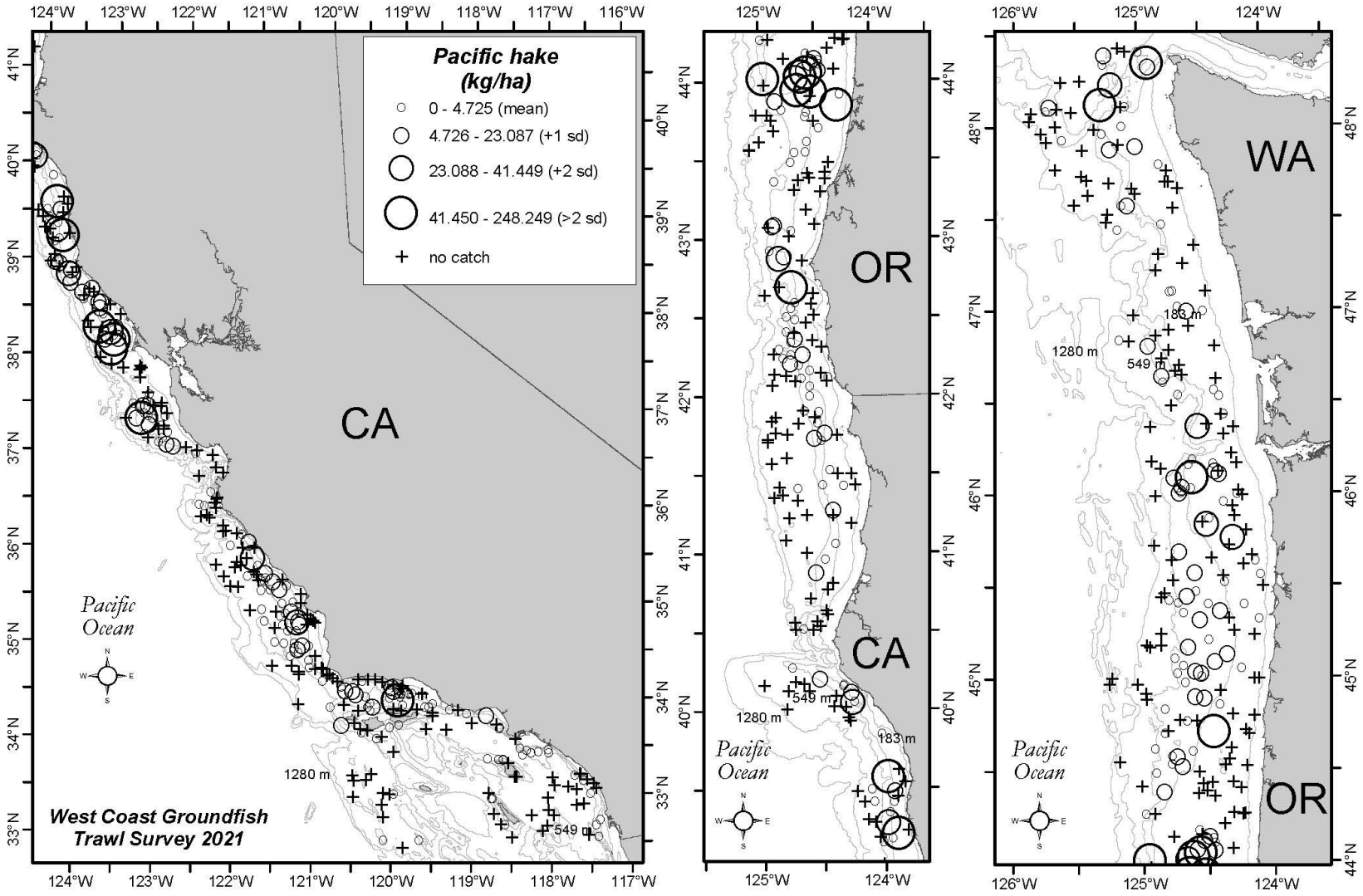


Figure 27. Pacific hake (*Merluccius productus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

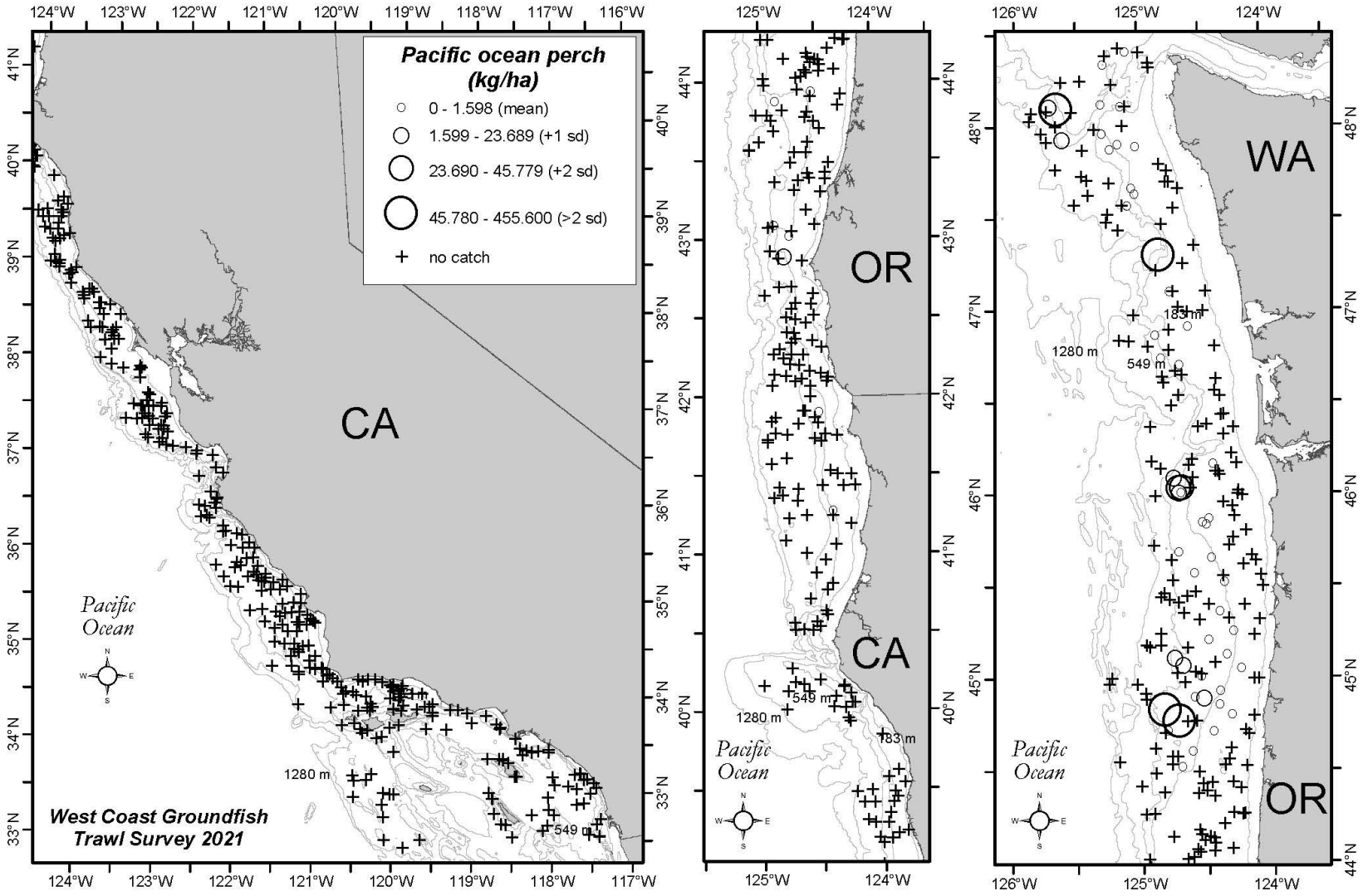


Figure 28. Pacific ocean perch (*Sebastes alutus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

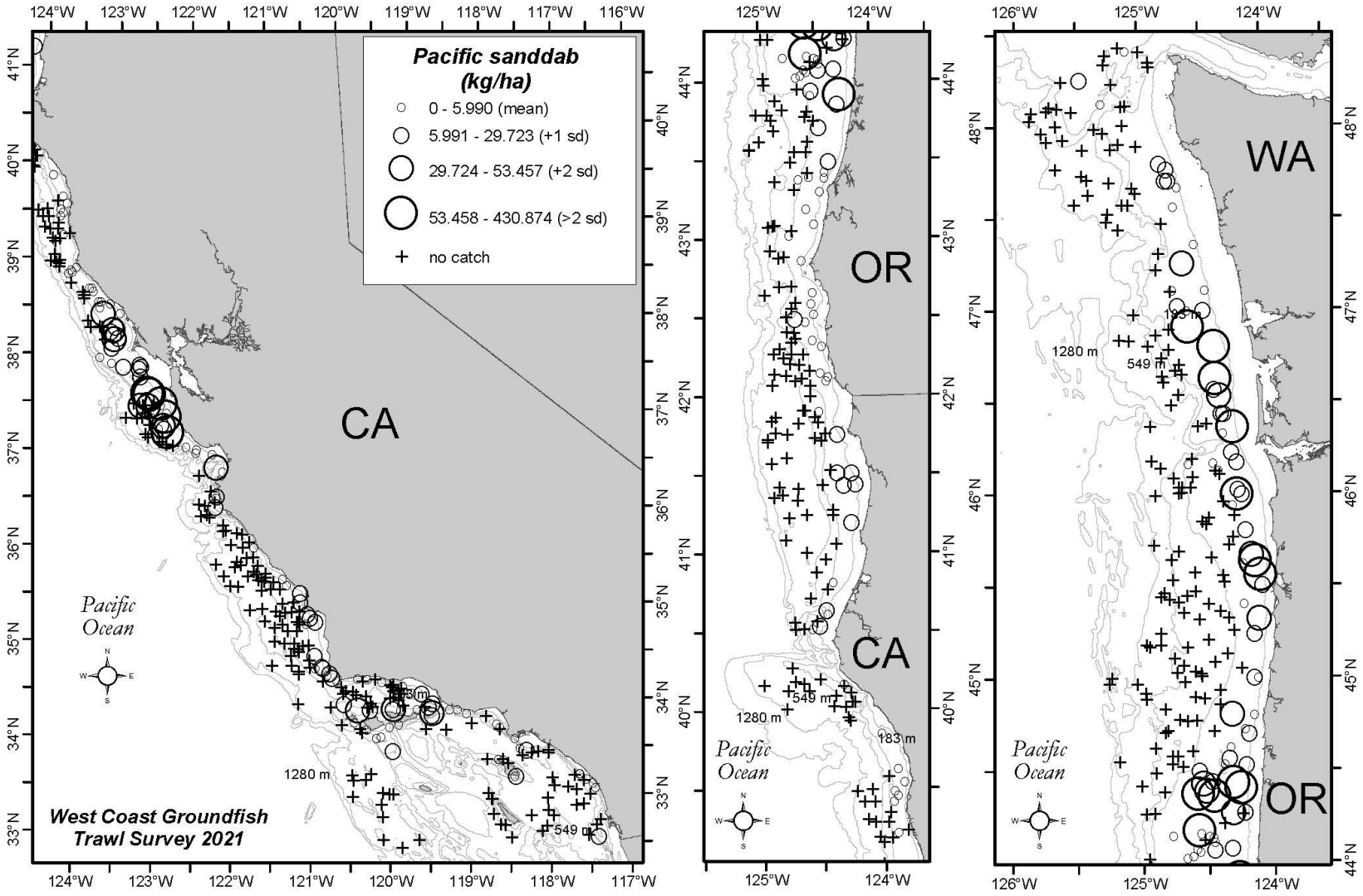


Figure 29. Pacific sanddab (*Citharichthys sordidus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

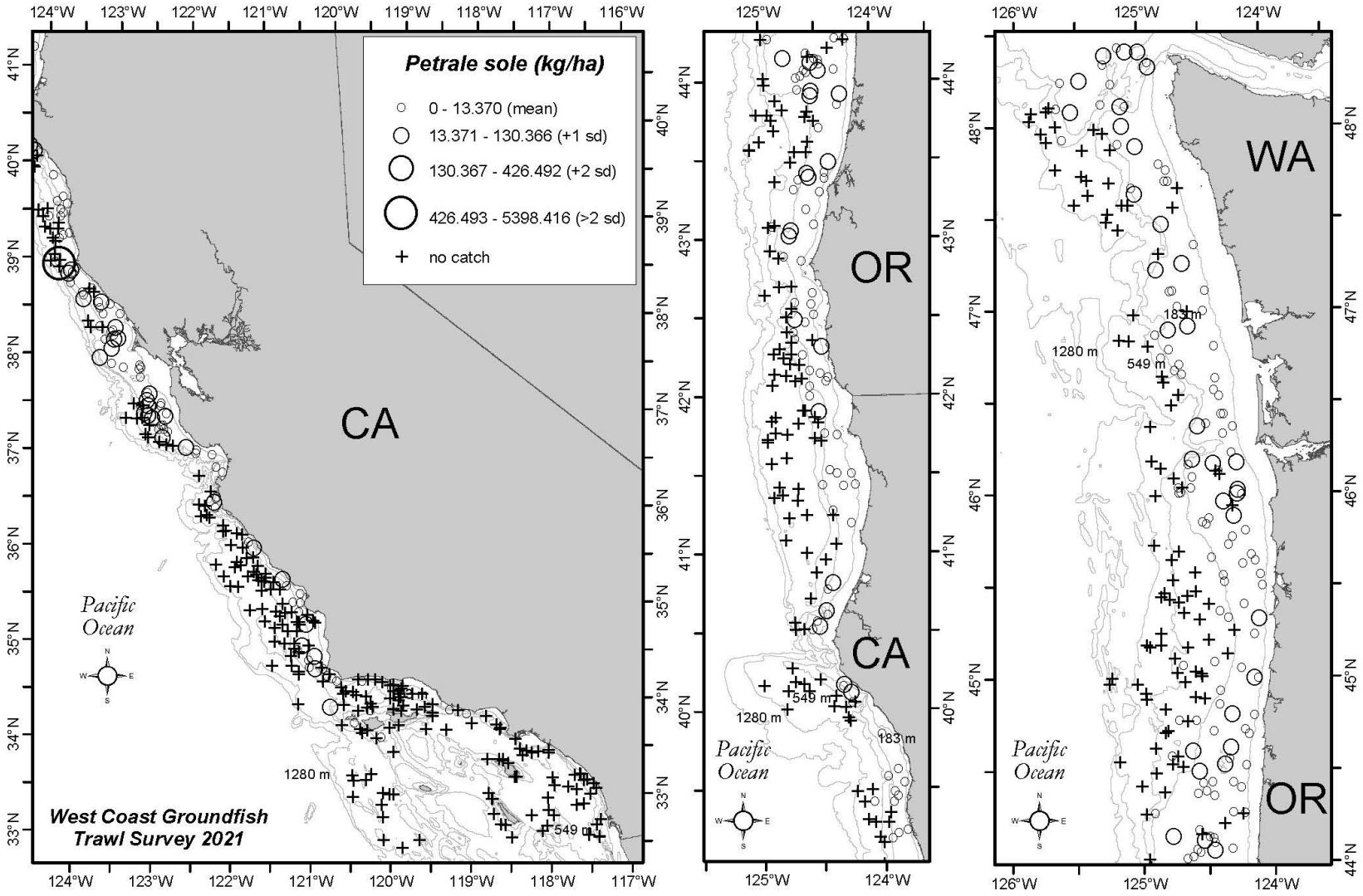


Figure 30. Petrale sole (*Eopsetta jordani*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

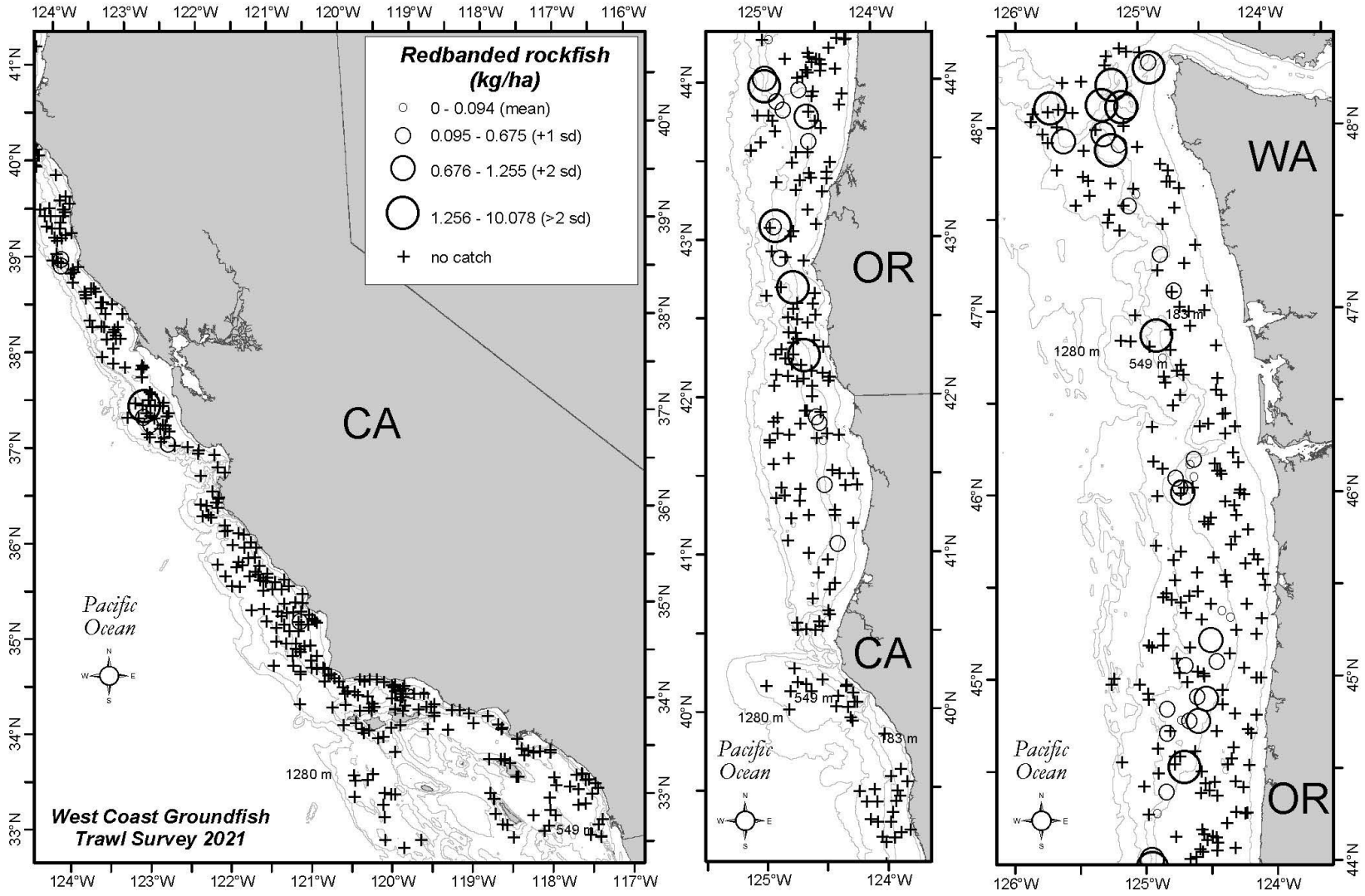


Figure 31. Redbanded rockfish (*Sebastes babcocki*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

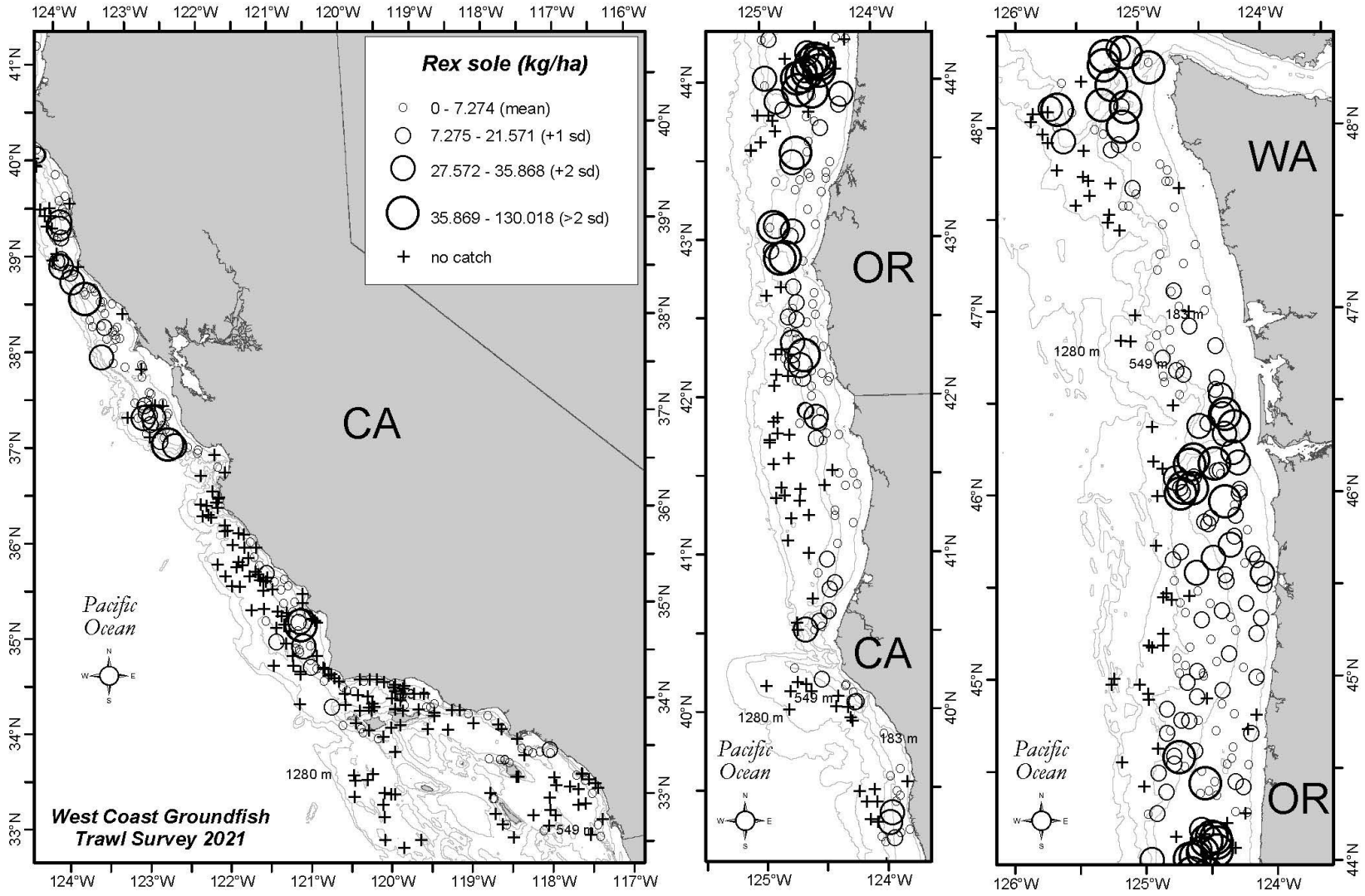


Figure 32. Rex sole (*Glyptocephalus zachirus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

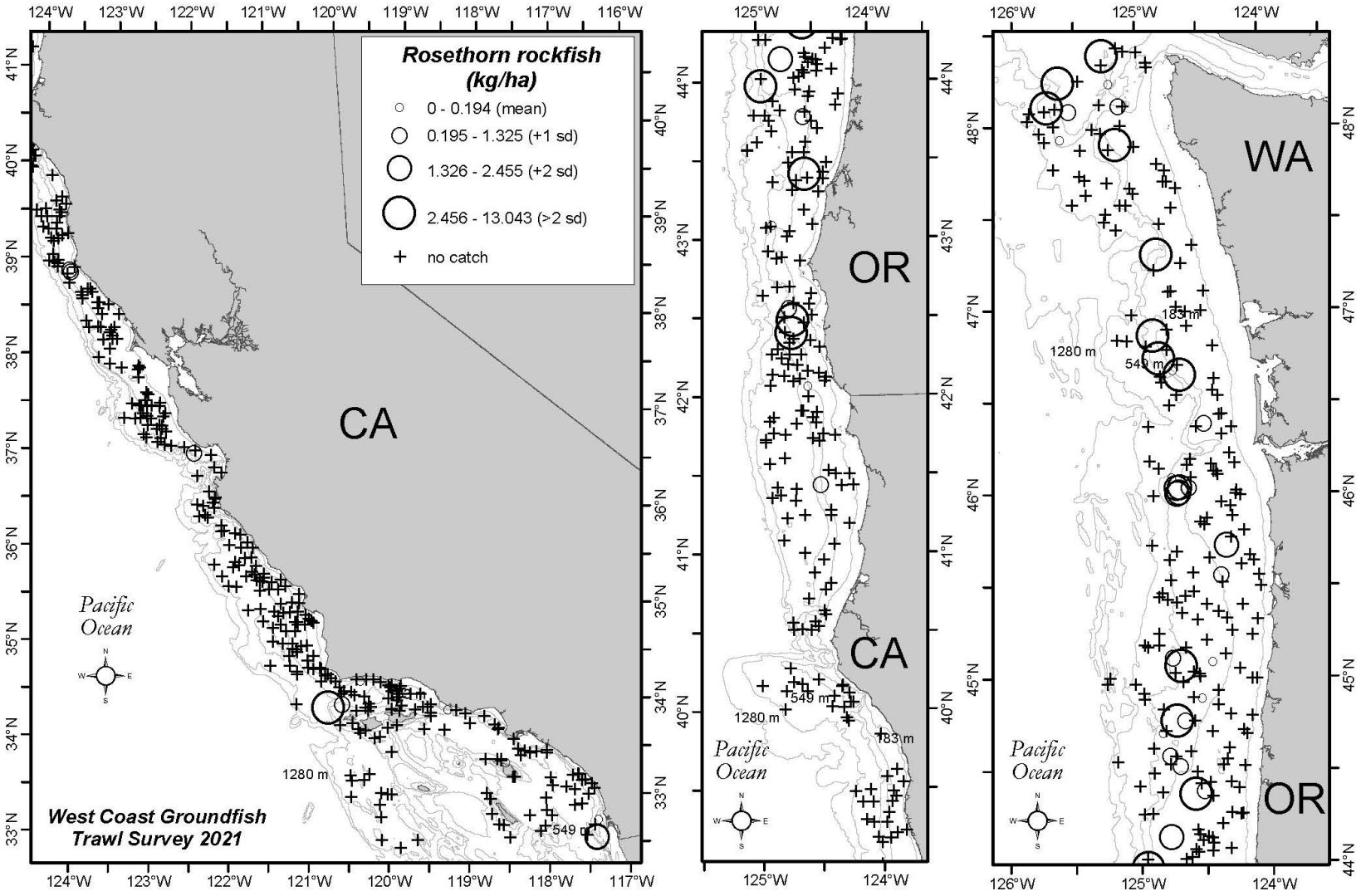


Figure 33. Rosethorn rockfish (*Sebastes helvomaculatus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

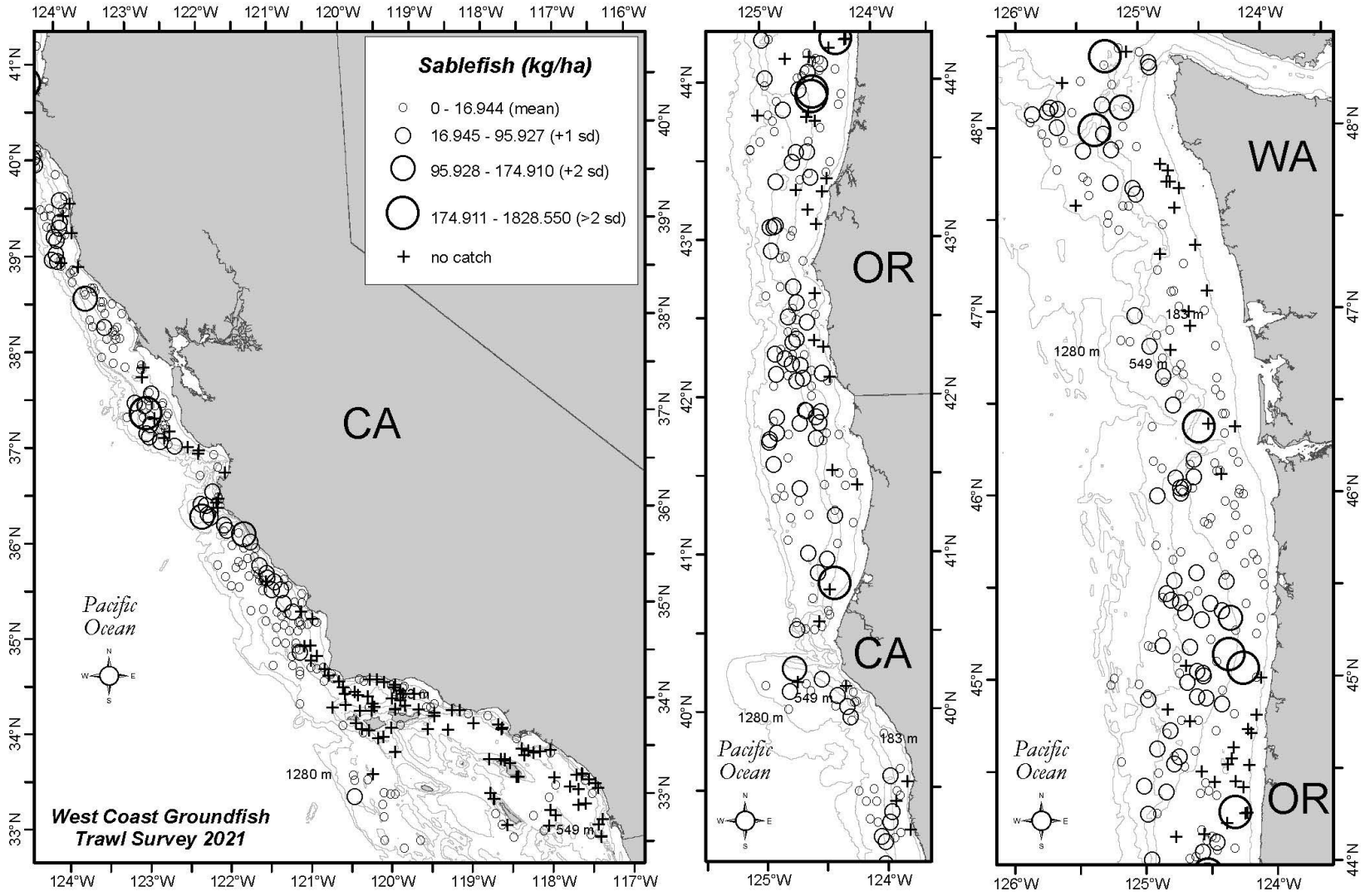


Figure 34. Sablefish (*Anoplopoma fimbria*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

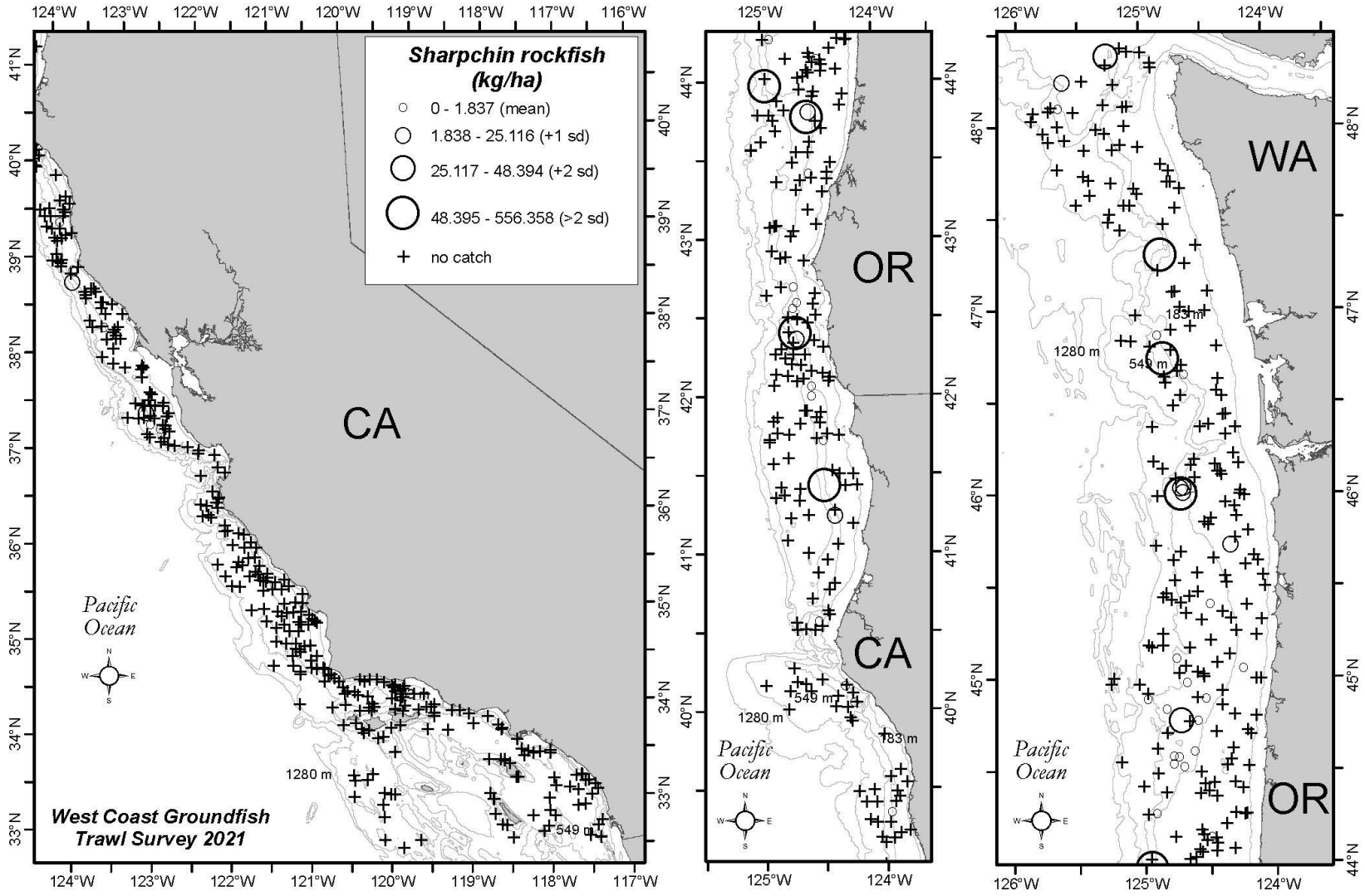


Figure 35. Sharpchin rockfish (*Sebastes zacentrus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

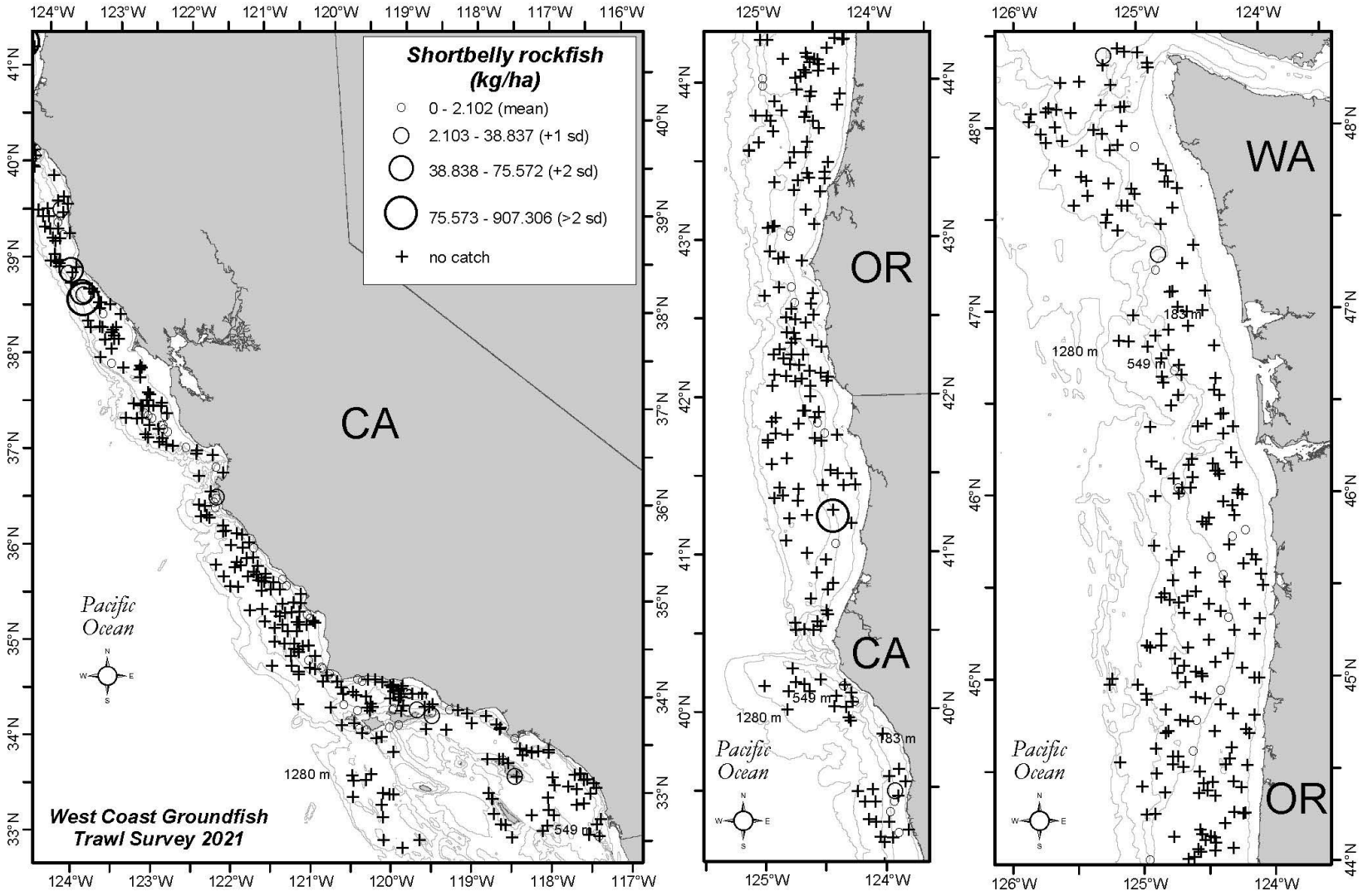


Figure 36. Shortbelly rockfish (*Sebastes jordani*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

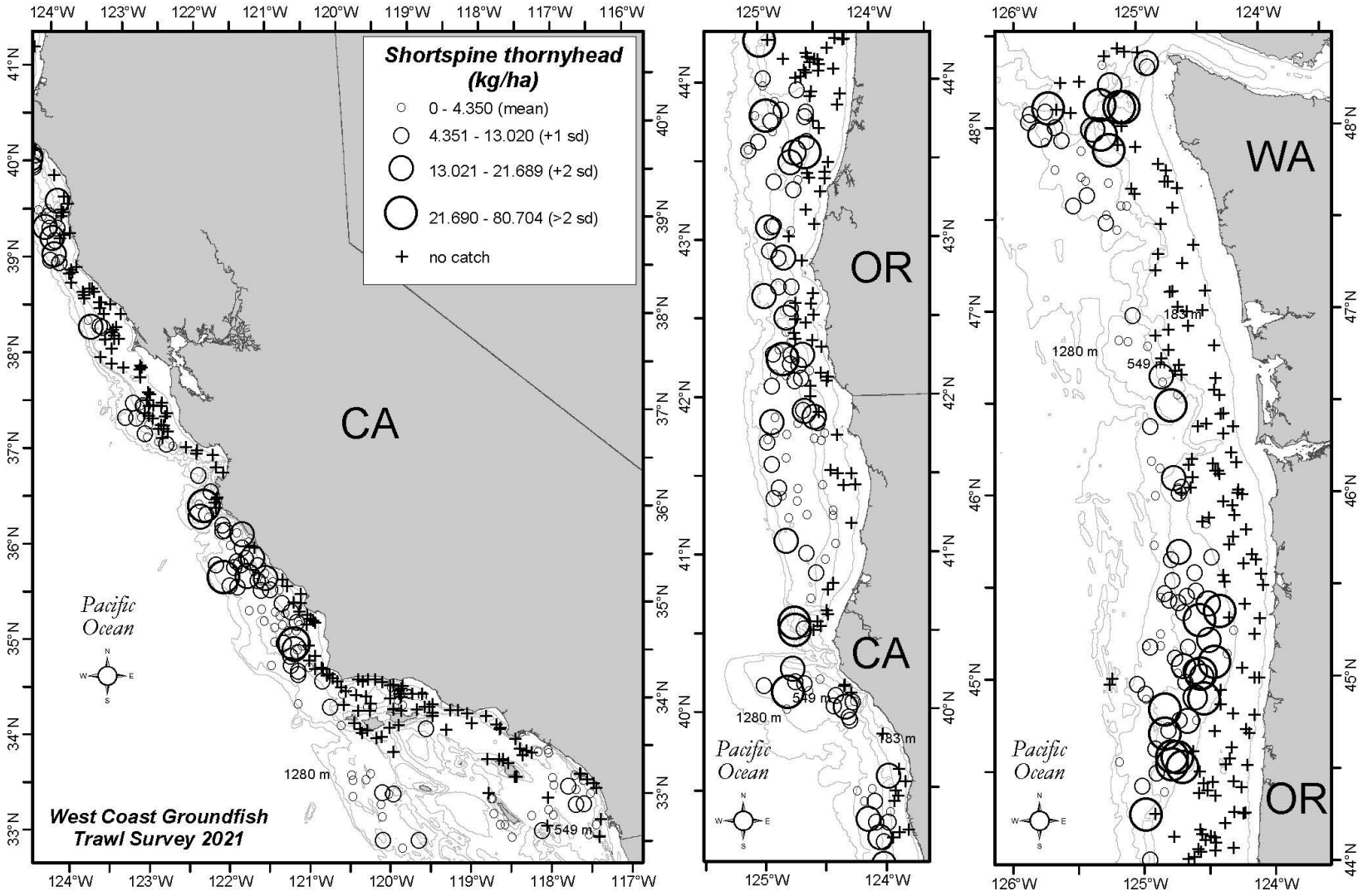


Figure 37. Shortspine thornyhead (*Sebastolobus alascanus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

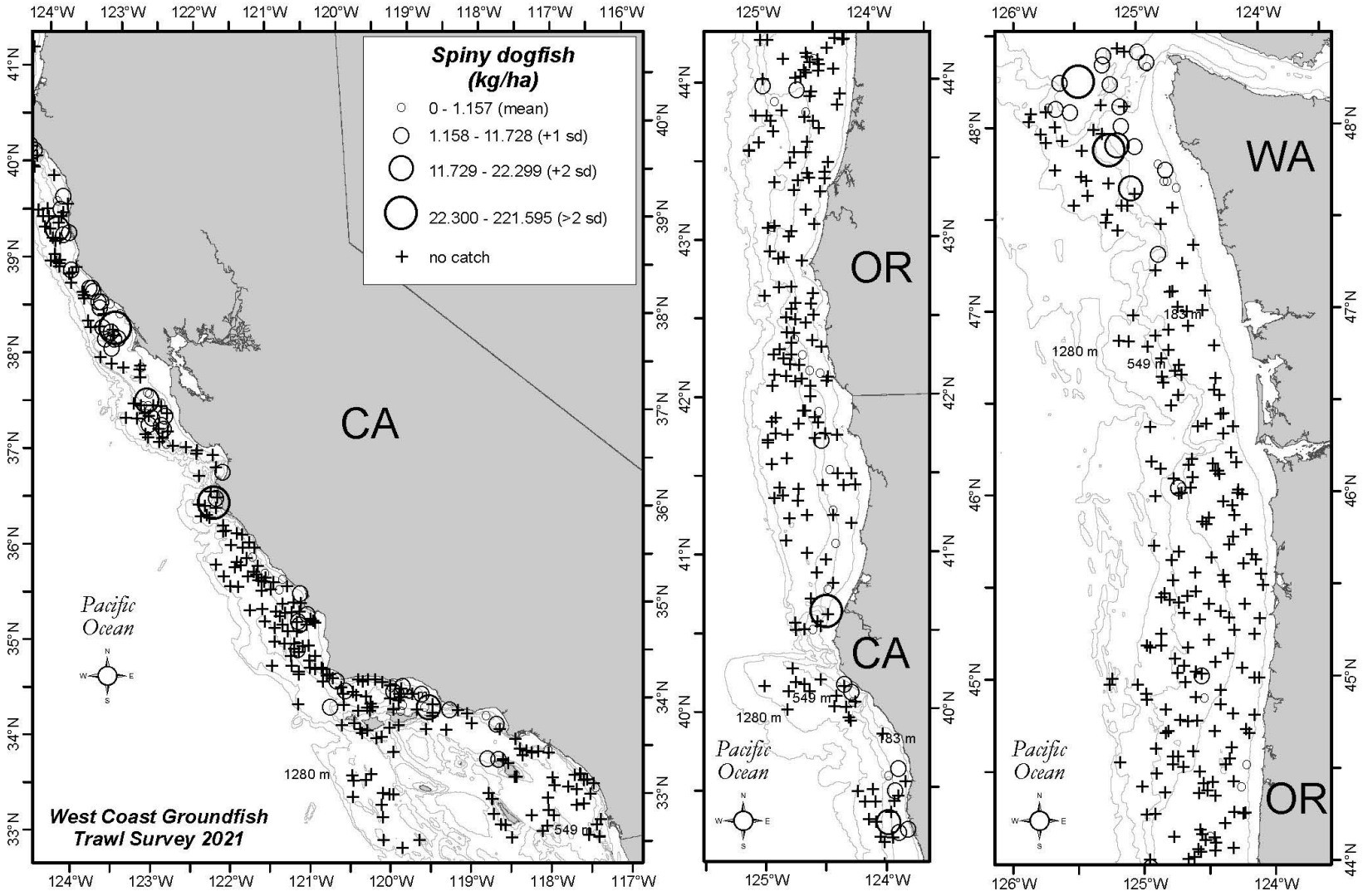


Figure 38. Spiny dogfish (*Squalus suckleyi*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

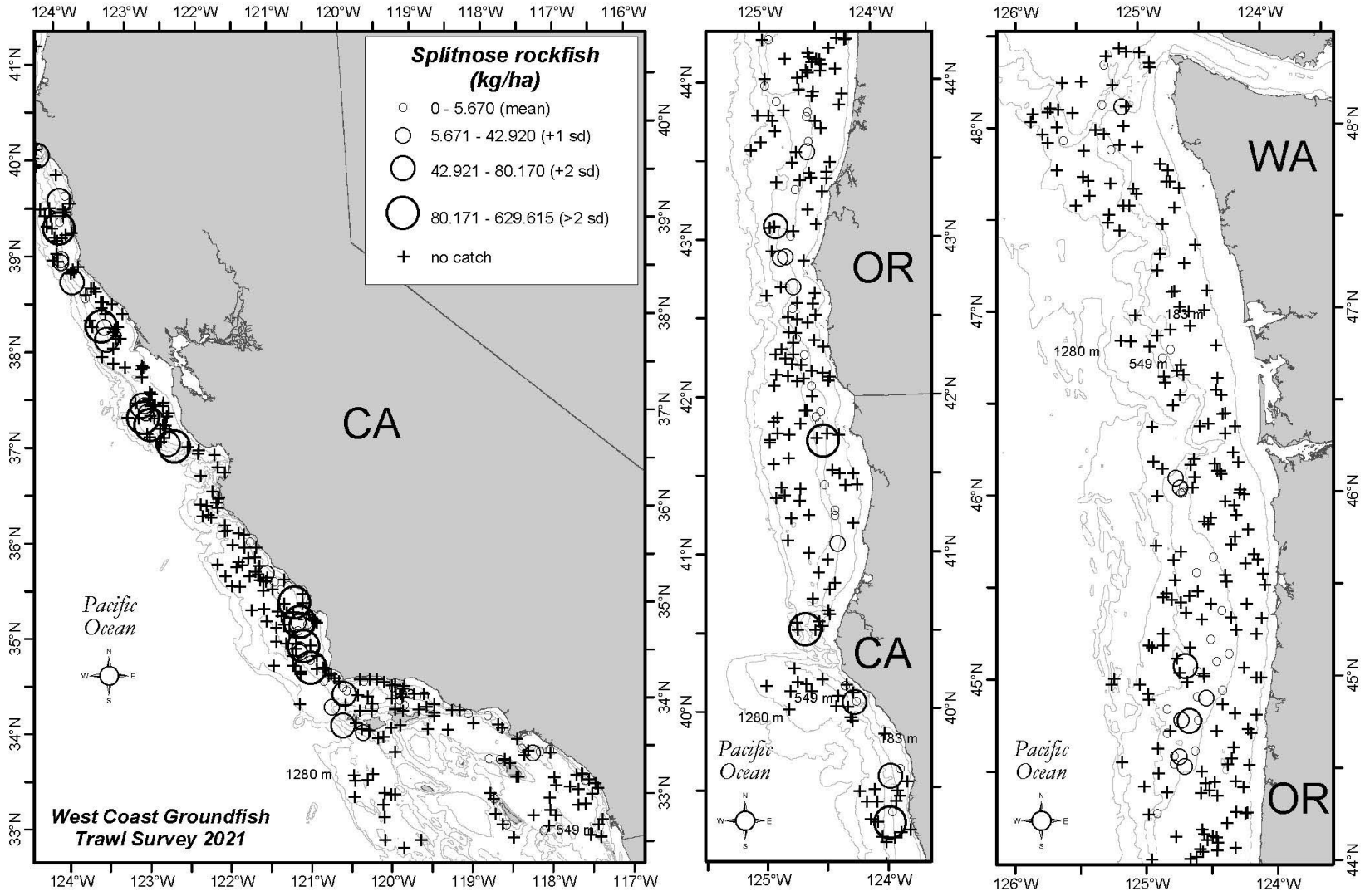


Figure 39. Splitnose rockfish (*Sebastes diploproa*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

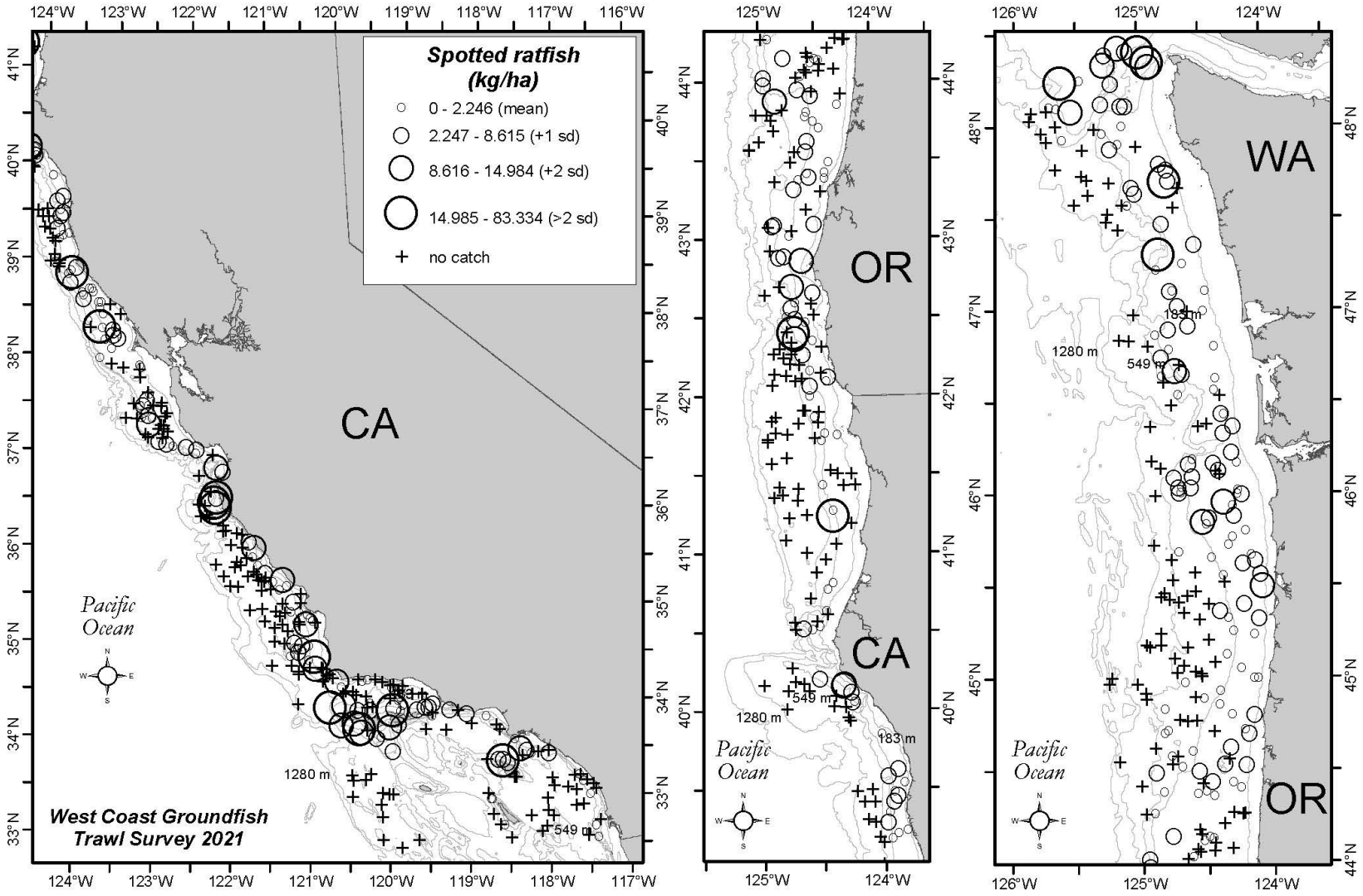


Figure 40. Spotted ratfish (*Hydrolagus colliei*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

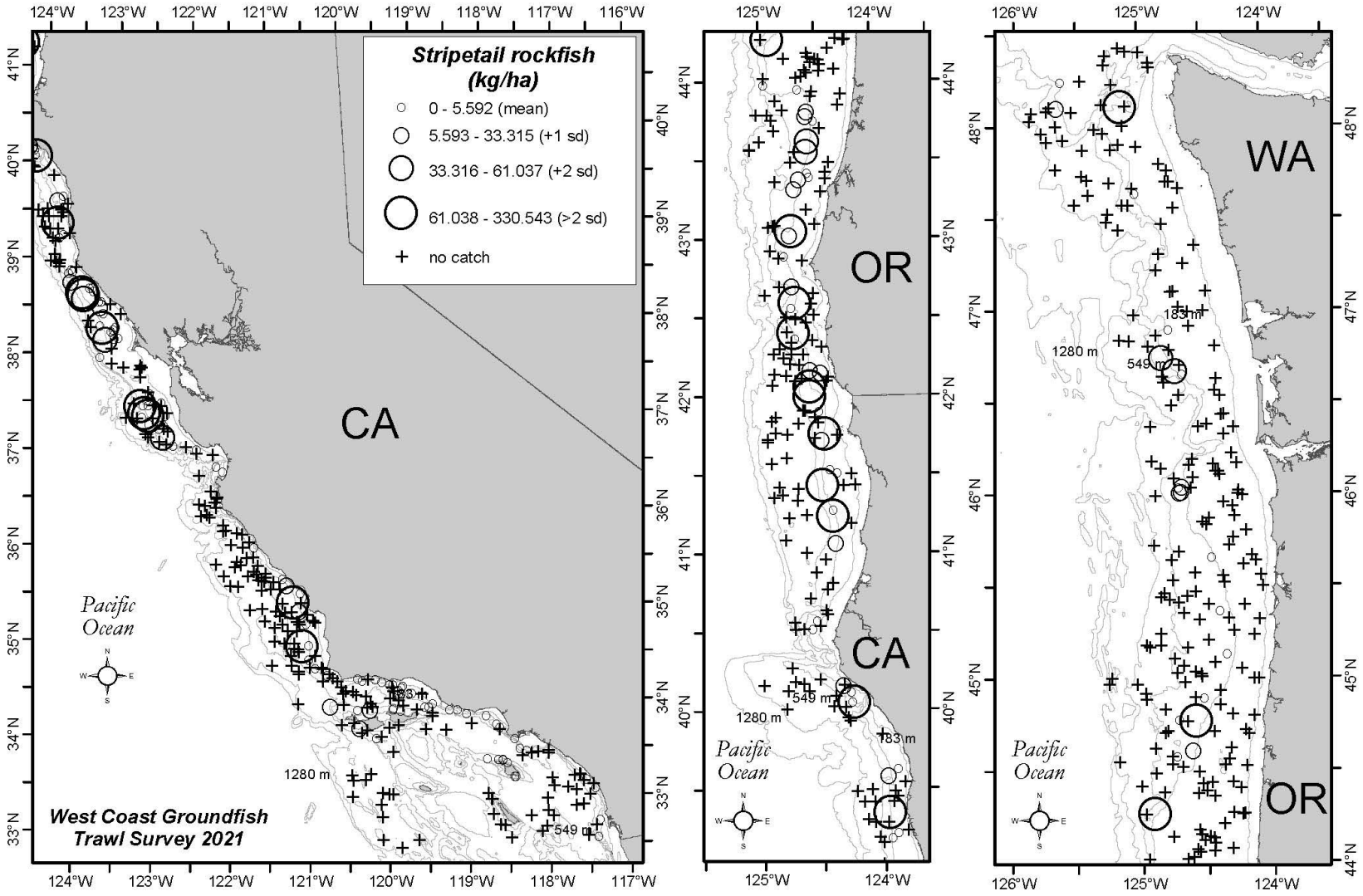


Figure 41. Stripetail rockfish (*Sebastes saxicola*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

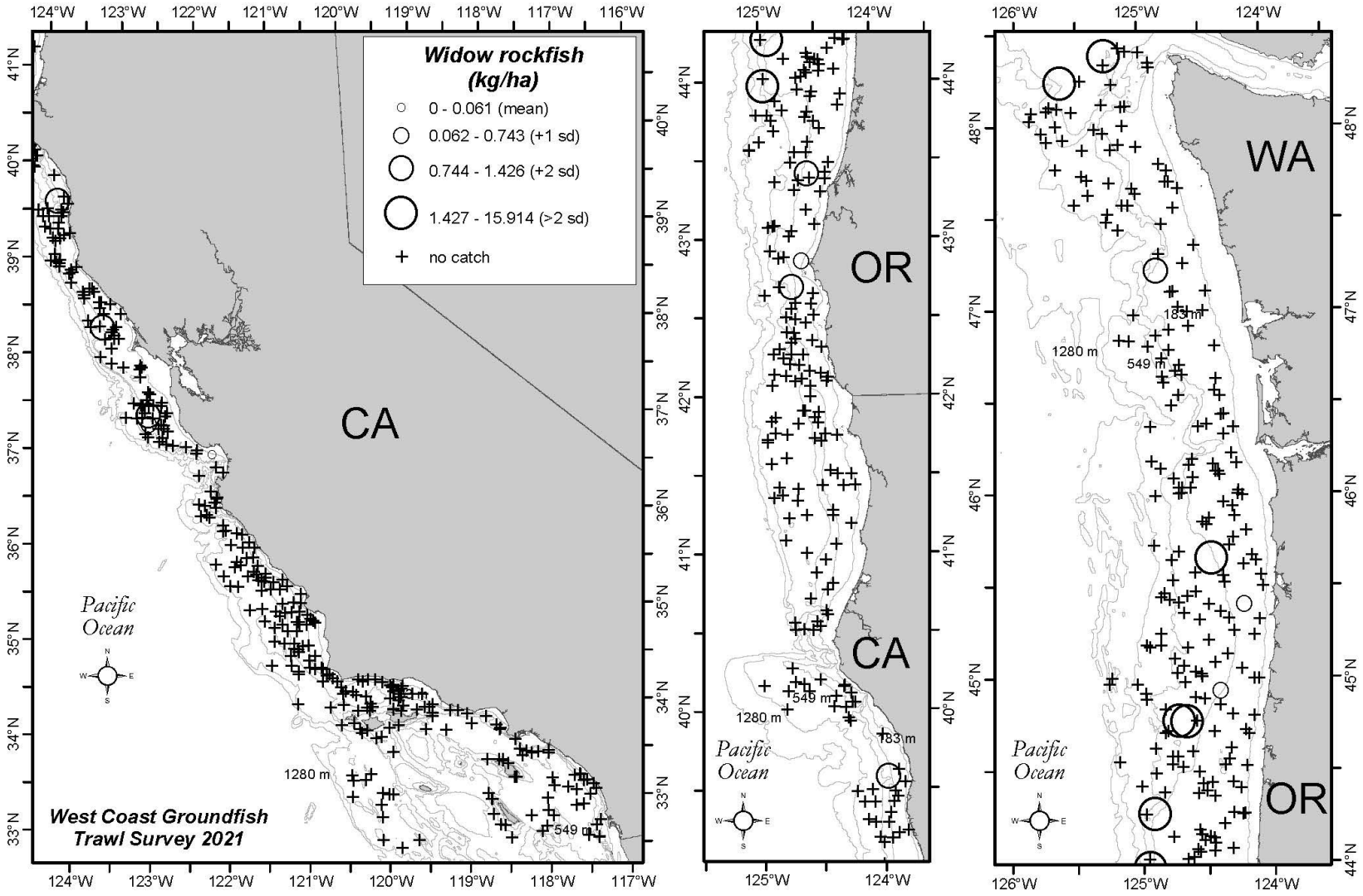


Figure 42. Widow rockfish (*Sebastes entomelas*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

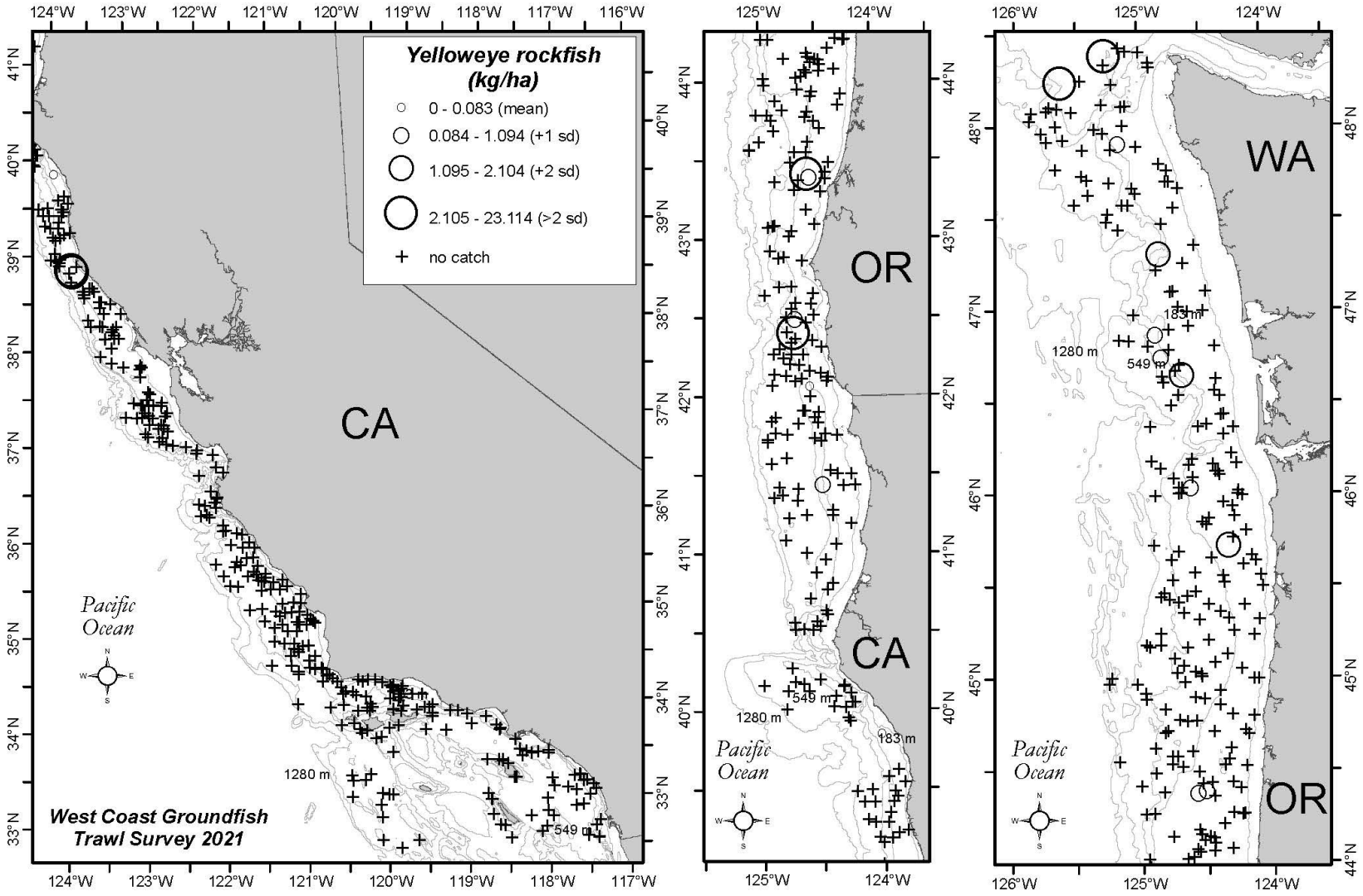


Figure 43. Yelloweye rockfish (*Sebastes ruberrimus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

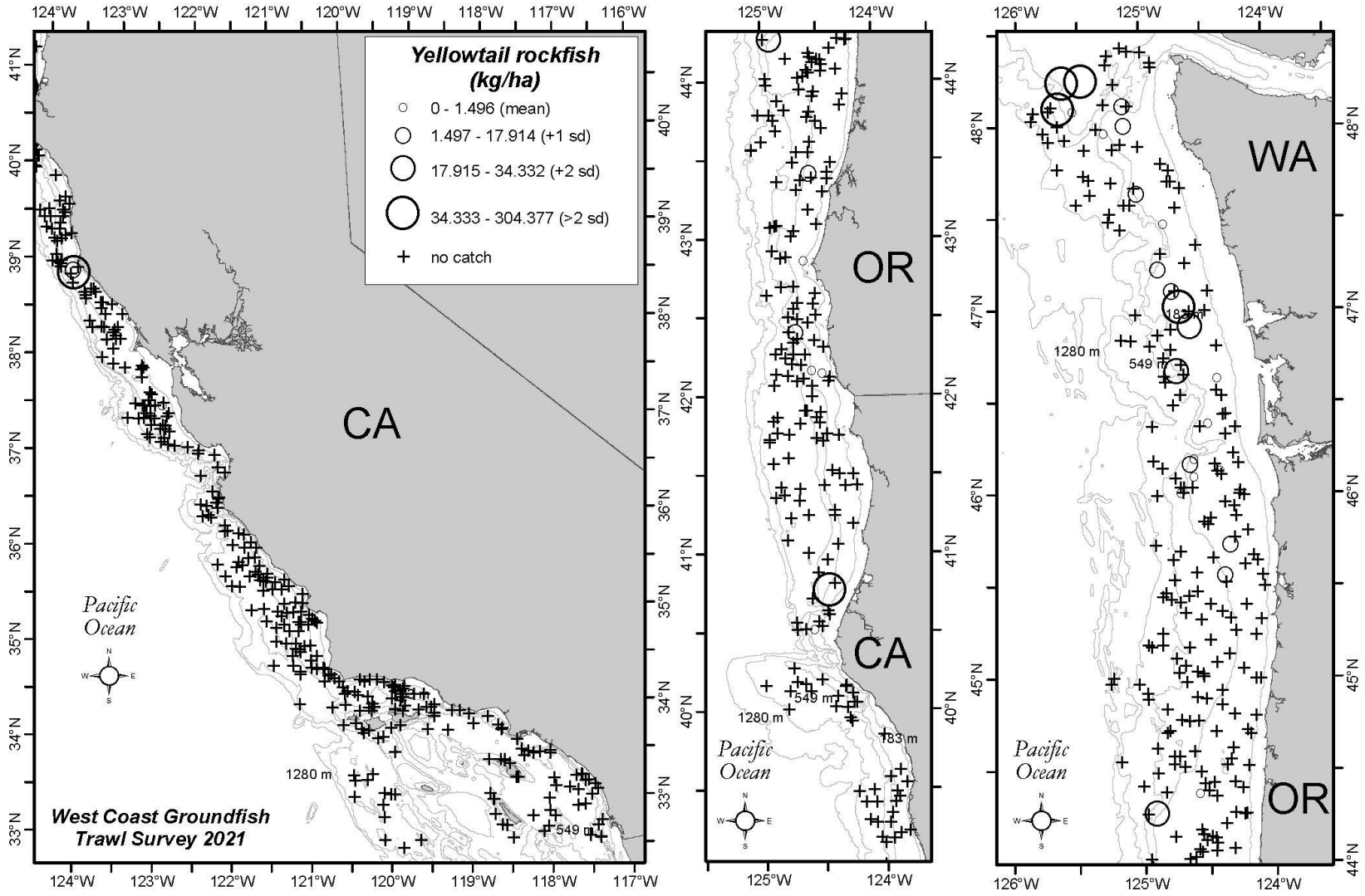


Figure 44. Yellowtail rockfish (*Sebastes flavidus*) distribution and relative abundance (kg/ha) from the 2021 West Coast Groundfish Bottom Trawl Survey.

We also present the mean CPUE (in kg/ha) of abundant groundfish and selected crab species (Dungeness crab, *Metacarcinus magister*, and grooved tanner crab) in Table 7. We compared catch for all areas (U.S.–Canada border to U.S.–Mexico border), north of Pt. Conception (lat 48°10′N to lat 34°30′N), and south of Pt. Conception (lat 34°30′N to lat 32°30′N) for depth strata combined (55–1,280 m). The list of abundant species varied based on geographic area. In 2021, the top five species for combined depth strata (overall) and north of Pt. Conception were Dover sole, longspine thornyhead, sablefish, petrale sole, and rex sole. The rank order of abundance within these regions varied as mean CPUE decreased beyond the top five most commonly caught groundfishes. South of Pt. Conception, the species with the highest mean CPUE for depth strata combined were longspine thornyhead, halfbanded rockfish (*Sebastes semicinctus*), California slickhead (*Alepocephalus tenebrosus*), Dover sole, and shortspine thornyhead, with sablefish, a valuable commercial groundfish, ranking sixth. As seen in Table 7, by design, a considerably greater number of hauls occurred north of Pt. Conception.

We further examined CPUE (kg/ha) for the top 30 most abundant groundfish across all geographic areas by depth strata (Table 8). Within the shallow depth stratum (55–183 m), we saw the highest catch rates for sablefish, Dungeness crabs, Pacific sanddab, Dover sole, and petrale sole. Within the mid-depth stratum (184–549 m), Dover sole, petrale sole, sablefish, splitnose rockfish (*Sebastes diploproa*), and longnose skate ranked highest. We noted elevated CPUE for longspine thornyhead, Dover sole, sablefish, shortspine thornyhead, and Pacific grenadier in the deep depth stratum (550–1,280 m). The number of hauls within each depth stratum decreased from $n = 290$ in shallow water to $n = 178$ at depth (Table 8). Although the rank order of abundance varied within the shallow and mid-depth strata, species composition appeared similar, with catch dominated by flatfish and rockfish. The composition of the top 30 species varied considerably in the deep depth stratum, with many species, such as slickheads, grenadiers, and eelpouts, found primarily within this region (Table 8). We further noted the occurrence of grooved tanner crabs from 184 to 1,280 m, with highest catch in the deep depth stratum. Mean catch rates (CPUE kg/ha) by depth strata north of Pt. Conception (Table 9) reflected the ranks we noted previously for the coastwide area (Table 8). Mean CPUE for the top five species varied only for the mid-depth stratum, where rex sole ranked fifth north of Pt. Conception but sixth for the overall sampling area. South of Pt. Conception we saw the highest catch rates for halfbanded rockfish, Pacific sanddab, English sole, spotted ratfish, and California scorpionfish (*Scorpaena guttata*) in the shallow depth stratum (55–183 m; Table 10). Halfbanded rockfish exhibited the highest CPUE (19.52 kg/ha) within southern waters regardless of depth, followed by longspine thornyhead in the deep depth stratum. The top rank catch at mid-depth included Dover sole, spotted ratfish, Pacific hake, splitnose rockfish, and filetail catshark (*Parmaturus xaniurus*; Table 10). Order of mean catch rates within the deepest depth stratum was similar to other areas, with longspine thornyhead, California slickhead, Dover sole, sablefish, and shortspine thornyhead dominating the catch. Within individual areas, the dominance of Dover sole, sablefish, and longspine thornyhead in the catch tended to decline in the southern portion of the survey (Tables 8–10). Spotted ratfish were equally abundant north and south of Pt. Conception, but shifted their peak distribution from the shallow to the mid-depth stratum in the southern portion of the survey (Tables 8–10).

Table 7. Mean CPUE (kg/ha) of abundant groundfish and selected crab species caught in all areas (U.S.–Canada border to U.S.–Mexico border), north of Pt. Conception (lat 48°10′N to lat 34°30′N), and south of Pt. Conception (lat 34°30′N to lat 32°30′N), for all depth strata (55–1,280 m) combined during the 2021 West Coast Groundfish Bottom Trawl Survey.

All areas Number of hauls = 684		**North of Pt. Conception Number of hauls = 557**		**South of Pt. Conception Number of hauls = 127**	
Species	**CPUE**	**Species**	**CPUE**	**Species**	**CPUE**
Dover sole	25.43	Dover sole	29.99	longspine thornyhead	7.47
longspine thornyhead	21.86	longspine thornyhead	20.99	halfbanded rockfish	3.10
sablefish	16.52	sablefish	20.19	California slickhead	2.95
petrale sole	9.28	petrale sole	12.78	Dover sole	2.85
rex sole	5.13	rex sole	7.11	shortspine thornyhead	1.81
shortspine thornyhead	4.92	Dungeness crab	6.86	sablefish	1.70
Dungeness crab	4.62	Pacific sanddab	5.84	Pacific sanddab	1.35
longnose skate	4.40	longnose skate	5.65	brown catshark	1.32
Pacific sanddab	4.25	stripetail rockfish	5.35	spotted ratfish	1.19
stripetail rockfish	3.89	shortspine thornyhead	5.26	grooved tanner crab	0.98
splitnose rockfish	3.86	chilipepper rockfish	5.16	Pacific hake	0.90
chilipepper rockfish	3.64	splitnose rockfish	4.91	Pacific grenadier	0.82
Pacific hake	3.40	Pacific hake	4.44	splitnose rockfish	0.79
Pacific grenadier	2.66	arrowtooth flounder	3.29	English sole	0.77
grooved tanner crab	2.63	English sole	3.07	filetail catshark	0.68
arrowtooth flounder	2.40	grooved tanner crab	2.64	longnose skate	0.67
English sole	2.30	Pacific grenadier	2.57	petrale sole	0.63
giant grenadier	1.89	lingcod	2.48	roughtail skate	0.43
spotted ratfish	1.76	greenstriped rockfish	2.30	blackgill rockfish	0.42
lingcod	1.75	shortbelly rockfish	1.92	rex sole	0.34
greenstriped rockfish	1.58	giant grenadier	1.86	stripetail rockfish	0.32
shortbelly rockfish	1.44	spotted ratfish	1.86	giant grenadier	0.27
sharpchin rockfish	1.26	sharpchin rockfish	1.70	slender sole	0.25
California slickhead	1.26	yellowtail rockfish	1.54	California scorpionfish	0.24
Pacific ocean perch	1.11	Pacific ocean perch	1.45	bigfin eelpout	0.23
yellowtail rockfish	1.06	bocaccio	1.35	deepsea sole	0.20
halfbanded rockfish	1.01	Pacific spiny dogfish	1.14	smooth grenadier	0.20
Bocaccio	1.00	big skate	1.04	twoline eelpout	0.19
brown catshark	0.99	slender sole	1.02	Pacific spiny dogfish	0.19
deepsea sole	0.96	canary rockfish	1.00	lingcod	0.18
Pacific spiny dogfish	0.82	deepsea sole	0.94	aurora rockfish	0.15
slender sole	0.76	California slickhead	0.87	California grenadier	0.11
big skate	0.70	brown catshark	0.86	threadfin slickhead	0.11
canary rockfish	0.68	sandpaper skate	0.66	deepsea skate	0.11
roughtail skate	0.65	darkblotched rockfish	0.62	vermilion/sunset rockfish	0.10

Table 8. Mean CPUE (kg/ha) of the 30 most abundant groundfish and selected crab species caught, by depth stratum, in all areas combined during the 2021 West Coast Groundfish Bottom Trawl Survey.

Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1,280 m)	
Species	**CPUE**	**Species**	**CPUE**	**Species**	**CPUE**
sablefish	15.01	Dover sole	44.05	longspine thornyhead	45.61
Dungeness crab	14.51	petrale sole	27.28	Dover sole	24.54
Pacific sanddab	13.86	sablefish	19.99	sablefish	16.40
Dover sole	13.55	splitnose rockfish	17.90	shortspine thornyhead	6.73
petrale sole	11.22	longnose skate	11.63	Pacific grenadier	5.62
rex sole	8.11	rex sole	11.47	grooved tanner crab	4.61
chilipepper rockfish	7.36	stripetail rockfish	10.68	giant grenadier	3.99
English sole	6.61	shortspine thornyhead	8.22	California slickhead	2.65
Pacific hake	5.24	Pacific hake	7.79	deepsea sole	2.01
stripetail rockfish	5.23	arrowtooth flounder	7.41	brown catshark	1.79
lingcod	4.47	chilipepper rockfish	6.30	roughtail skate	1.36
greenstriped rockfish	4.41	shortbelly rockfish	5.70	longnose skate	1.09
longnose skate	4.37	sharpchin rockfish	5.36	twoline eelpout	0.96
spotted ratfish	3.80	Pacific ocean perch	5.04	bigfin eelpout	0.48
halfbanded rockfish	3.29	spotted ratfish	2.84	snakehead eelpout	0.46
arrowtooth flounder	2.50	bocaccio	2.80	rex sole	0.43
yellowtail rockfish	2.40	darkblotched rockfish	2.01	filetail catshark	0.41
big skate	2.23	grooved tanner crab	1.97	aurora rockfish	0.29
canary rockfish	2.16	sandpaper skate	1.96	Pacific flatnose	0.21
Pacific spiny dogfish	2.15	lingcod	1.72	Pacific hake	0.17
slender sole	1.70	yellowtail rockfish	1.52	threadfin slickhead	0.14
bocaccio	1.27	blackgill rockfish	1.51	deepsea skate	0.12
redstripe rockfsh	1.09	filetail catshark	1.51	black eelpout	0.08
Pacific halibut	0.77	aurora rockfish	1.50	smooth grenadier	0.06
shortbelly rockfish	0.71	bigfin eelpout	1.47	California grenadier	0.04
California skate	0.65	English sole	1.21	sandpaper skate	0.03
flathead sole	0.35	longspine thornyhead	1.14	Pacific hagfish	0.03
sharpchin rockfish	0.34	slender sole	1.10	arrowtooth flounder	0.03
curlfin sole	0.28	greenstriped rockfish	1.03	blackgill rockfish	0.01
rosethorn rockfish	0.27	Pacific spiny dogfish	0.78	Dungeness crab	0.003
Number of hauls	**290**	**Number of hauls**	**216**	**Number of hauls**	**178**

Table 9. Mean CPUE (kg/ha) of the 30 most abundant groundfish and selected crab species caught, by depth stratum, north of Pt. Conception (lat 48°10′N to lat 34°30′N) during the 2021 West Coast Groundfish Bottom Trawl Survey.

Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1,280 m)	
Species	**CPUE**	**Species**	**CPUE**	**Species**	**CPUE**
sablefish	17.76	Dover sole	56.43	longspine thornyhead	52.78
Dungeness crab	17.17	petrale sole	34.86	Dover sole	29.05
Dover sole	16.01	sablefish	26.09	sablefish	19.30
Pacific sanddab	15.04	splitnose rockfish	22.38	shortspine thornyhead	7.65
petrale sole	13.24	rex sole	14.55	Pacific grenadier	6.53
rex sole	9.58	longnose skate	14.30	grooved tanner crab	5.29
chilipepper rockfish	8.65	stripetail rockfish	13.66	giant grenadier	4.74
English sole	7.20	shortspine thornyhead	10.30	deepsea sole	2.37
Pacific hake	6.15	arrowtooth flounder	9.71	California slickhead	2.22
stripetail rockfish	6.08	Pacific hake	8.98	brown catshark	1.73
greenstriped rockfish	5.19	chilipepper rockfish	8.23	roughtail skate	1.51
lingcod	5.16	shortbelly rockfish	7.45	longnose skate	1.31
longnose skate	5.15	sharpchin rockfish	7.01	twoline eelpout	1.10
spotted ratfish	3.37	Pacific ocean perch	6.60	snakehead eelpout	0.55
arrowtooth flounder	2.96	bocaccio	3.57	rex sole	0.52
yellowtail rockfish	2.84	darkblotched rockfish	2.63	filetail catshark	0.49
big skate	2.63	sandpaper skate	2.51	Pacific flatnose	0.25
canary rockfish	2.55	spotted ratfish	2.50	Pacific hake	0.21
Pacific spiny dogfish	2.45	grooved tanner crab	2.45	threadfin slickhead	0.13
slender sole	2.01	lingcod	2.17	deepsea skate	0.11
bocaccio	1.47	yellowtail rockfish	1.99	bigfin eelpout	0.06
redstripe rockfsh	1.29	aurora rockfish	1.74	black eelpout	0.05
Pacific halibut	0.91	bigfin eelpout	1.60	sandpaper skate	0.04
shortbelly rockfish	0.74	blackgill rockfish	1.38	California grenadier	0.04
California skate	0.69	greenstriped rockfish	1.30	aurora rockfish	0.04
flathead sole	0.42	English sole	1.27	arrowtooth flounder	0.03
sharpchin rockfish	0.41	longspine thornyhead	1.18	blackgill rockfish	0.01
curlfin sole	0.32	slender sole	1.10	Pacific hagfish	0.004
halfbanded rockfish	0.31	filetail catshark	1.03	Dungeness crab	0.004
rosethorn rockfish	0.30	big skate	1.00	smooth grenadier	0.001
Number of hauls	**245**	**Number of hauls**	**165**	**Number of hauls**	**147**

Table 10. Mean CPUE (kg/ha) of the most abundant groundfish and selected crab species caught, by depth stratum, south of Pt. Conception (lat 34°30′N to lat 32°30′N) during the 2021 West Coast Groundfish Bottom Trawl Survey.

Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1,280 m)	
Species	**CPUE**	**Species**	**CPUE**	**Species**	**CPUE**
halfbanded rockfish	19.52	Dover sole	3.97	longspine thornyhead	11.58
Pacific sanddab	7.45	spotted ratfish	3.94	California slickhead	4.71
English sole	3.45	Pacific hake	3.93	Dover sole	3.14
spotted ratfish	2.14	splitnose rockfish	3.61	sablefish	2.61
California scorpionfish	1.49	filetail catshark	3.05	shortspine thornyhead	2.37
lingcod	0.74	longnose skate	2.99	brown catshark	2.06
vermilion/sunset rockfish	0.65	petrale sole	2.73	grooved tanner crab	1.42
stripetail rockfish	0.63	blackgill rockfish	1.93	Pacific grenadier	1.31
shortbelly rockfish	0.59	shortspine thornyhead	1.51	roughtail skate	0.68
Pacific spiny dogfish	0.49	rex sole	1.49	snakehead eelpout	0.55
California skate	0.45	slender sole	1.12	giant grenadier	0.43
chilipepper rockfish	0.36	bigfin eelpout	1.04	deepsea sole	0.32
Pacific hake	0.28	English sole	1.04	smooth grenadier	0.32
California halibut	0.23	stripetail rockfish	1.04	twoline eelpout	0.30
petrale sole	0.23	longspine thornyhead	1.03	threadfin slickhead	0.18
bocaccio	0.17	Pacific sanddab	0.82	deepsea skate	0.17
greenstriped rockfish	0.17	aurora rockfish	0.70	Pacific hagfish	0.14
Dover sole	0.15	Pacific spiny dogfish	0.50	California grenadier	0.08
longnose skate	0.11	grooved tanner crab	0.41	filetail catshark	0.03
rex sole	0.09	California grenadier	0.31	Pacific flatnose	0.03
rosethorn rockfish	0.09	bocaccio	0.29	Pacific hake	0.004
sablefish	0.07	lingcod	0.28		
big skate	0.05	sablefish	0.26		
curlfin sole	0.05	black eelpout	0.21		
Dungeness crab	0.03	halfbanded rockfish	0.17		
slender sole	0.02	sandpaper skate	0.17		
splitnose rockfish	0.004	brown catshark	0.13		
bigfin eelpout	0.002	greenstriped rockfish	0.13		
		Pacific halibut	0.10		
		rosethorn rockfish	0.08		
Number of hauls	**45**	**Number of hauls**	**51**	**Number of hauls**	**31**

Biomass and Population Estimates

We present abundance estimates of biomass in metric tons (mt) along with associated CVs for the most abundant groundfish and crab species (Tables 11–13) based on geographic areas (overall, north of Pt. Conception, and south of Pt. Conception) and depth strata (55–183 m, 184–549 m, 550–1,280 m, and 55–1,280 m). Longspine thornyhead, sablefish, petrale sole, rex sole, and shortspine thornyhead followed Dover sole in decreasing order of biomass in all strata for the combined areas. Dover sole, longspine thornyhead, and sablefish exhibited their highest biomass in the deep stratum, while biomass for petrale and rex sole peaked in the mid-depth stratum (Table 11). Species with high biomass in the shallow stratum (>30,000 mt) included Dover sole, sablefish, petrale sole, rex sole, Dungeness crab, Pacific sanddab, and chilipepper rockfish. Within the mid-depth stratum, we saw high biomass (>50,000 mt) for Dover sole, sablefish, petrale sole, and splitnose rockfish. In addition to the high biomass noted for Dover sole, longspine thornyhead, and sablefish in the deep depth stratum, we saw elevated biomass for shortspine thornyhead, Pacific grenadier, grooved tanner crab, giant grenadier (*Albatrossia pectoralis*), and California slickhead. Stripetail rockfish, Pacific hake, and arrowtooth flounder (*Atheresthes stomias*) had moderately high levels of biomass in both the shallow and mid-depth strata, while English sole biomass was elevated in the shallow stratum. Shortbelly (*Sebastes jordani*) and sharpchin rockfish (*S. zacentrus*) were concentrated in the mid-depth stratum, while halfbanded rockfish, lingcod, and greenstriped rockfish predominated in the shallow depth stratum (Table 11).

For combined depth strata, Dover sole biomass ranked first for the combined geographic area and north of Pt. Conception, but fourth in the region south of Pt. Conception (Tables 11–13). Overall and north of Pt. Conception, Dover sole, longspine thornyhead, sablefish, petrale sole, rex sole, and shortspine thornyhead exhibited the highest biomass levels for combined depth strata. South of Pt. Conception, halfbanded rockfish and California slickhead joined longspine thornyhead, Dover sole, shortspine thornyhead, and sablefish as the species with highest estimated biomass across depth strata.

The depth distributions in the area north of Pt. Conception (Table 12) generally reflected the biomass estimates of dominant species in the combined area (Table 11). South of Pt. Conception, longspine thornyhead, California slickhead, Dover sole, shortspine thornyhead, and sablefish dominated the deep stratum. Halfbanded rockfish and Pacific sanddab exhibited high biomass in the shallow depth stratum, while spotted ratfish, Pacific hake, and splitnose rockfish appeared similar to Dover sole biomass in the mid-depth stratum (Table 13). In addition, brown catshark (*Apristurus brunneus*) and grooved tanner crab biomass were elevated in the deep stratum.

The calculated biomass estimates represent estimates, not absolute values. Herding caused by doors and bridles and escapement (beneath the footrope, around the net opening, and through net mesh) affect trawl effectiveness (Gunderson 1993). Abundance calculations assume that all fish in front of the trawl and between the wingtips have an equal chance of capture. The ability of a fish to avoid capture depends on the species, shape, size, speed, and reaction to encountering the net (Lauth 1999). Additionally, the survey does not cover the entire geographic range of many of the species caught.

Table 11. Estimates of fish biomass (in metric tons) and coefficients of variation (CV), by depth stratum, for the combined area (U.S.–Canada to U.S.–Mexico borders) of the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
Dover sole	55693	9	128670	7	155362	9	339725	5
longspine thornyhead	0		3342	20	288742	9	292084	11
sablefish	61694	45	58391	13	103823	11	223908	18
petrale sole	46116	10	79685	916	0		125801	59
rex sole	33334	10	33504	11	2722	44	69560	8
shortspine thornyhead	8	59	24011	10	42606	9	66625	8
Dungeness crab	59639	25	2045	23	19	75	61703	25
longnose skate	17953	9	33962	8	6875	18	58790	7
Pacific sanddab	56967	2	584	50	0		57551	15
stripetail rockfish	21505	30	31205	24	0		52710	19
splitnose rockfish	16	44	52286	25	0		52302	25
chilipepper rockfish	30251	52	18402	47	0		48653	37
Pacific hake	21537	26	22755	16	1076	31	45368	15
Pacific grenadier	0		15	81	35579	20	35594	21
grooved tanner crab	197	99	5754	31	29185	13	35136	14
arrowtooth flounder	10276	20	21645	16	165	96	32085	13
English sole	27168	10	3534	25	0		30703	10
giant grenadier	0		12	74	25259	12	25271	13
spotted ratfish	15619	12	8296	16	6	106	23921	11
lingcod	18373	33	5024	36	0		23397	27
greenstriped rockfish	18126	21	3009	31	0		21135	19
shortbelly rockfish	2918	42	16650	78	0		19568	67
sharpchin rockfish	1397	64	15657	64	0		17054	48
California slickhead	0		0		16776	12	16776	13
Pacific ocean perch	58	38	14722	53	0		14780	53
yellowtail rockfish	9864	43	4440	93	0		14304	42
halfbanded rockfish	13523	44	12	51	0		13535	44
bocaccio	5220	37	8179	64	0		13399	42
brown catshark	82	48	1864	18	11332	9	13278	9
deepsea sole	0		88	48	12725	9	12813	11
Pacific spiny dogfish	8837	43	2278	31	0		11115	35
slender sole	6987	16	3213	16	0		10200	12
big skate	9166	16	225	54	0		9391	16
canary rockfish	8878	62	146	43	0		9024	62
roughtail skate	0		96	58	8610	13	8706	15
filetail catshark	0		4411	26	2589	26	7000	22
sandpaper skate	806	17	5725	13	196	48	6727	12
darkblotched rockfish	358	24	5871	35	0		6229	34
aurora rockfish	0		4382	16	1836	4	6217	17
twoline eelpout	0		102	52	6096	21	6198	21

Table 11 (continued). Estimates of fish biomass and coefficients of variation, by depth stratum, for the combined area of the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
bigfin eelpout	74	31	4294	12	323	178	4691	12
redstripe rockfsh	4480	87	9	72	0		4489	87
Pacific halibut	3144	23	1329	34	0		4473	19
blackgill rockfish	0		4411	35	32	67	4442	35
snakehead eelpout	0		32	87	2899	16	2931	17
California skate	2672	15	29	71	0		2701	16
rosethorn rockfish	1110	30	759	32	0		1869	22
flathead sole	1439	61	380	47	0		1818	48
Pacific flatnose	0		6	76	1342	31	1348	32
rougheye rockfish	206	98	1063	33	0		1269	32
curlfin sole	1147	18	6	68	0		1153	18
California scorpionfish	949	49	9	72	0		958	49
black eelpout	0		672	24	253	34	925	22
threadfin slickhead	0		2	95	893	27	895	28
redbanded rockfish	41	74	847	23	0		888	24
yelloweye rockfish	769	48	38	70	0		807	46
California grenadier	0		526	32	272	46	798	28
deepsea skate	0		0		741	53	741	53
widow rockfish	144	56	421	54	0		565	43
vermilion/sunset rockfish	514	46	0		0		514	46
California halibut	362	40	3	373	0		365	39
smooth grenadier	0		0		355	38	355	37
Pacific hagfish	4	58	2	54	177	56	183	50

Table 12. Estimates of fish biomass (in metric tons) and coefficients of variation (CV), by depth stratum, for the area north of Pt. Conception (lat 48°10′N to lat 34°30′N) from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
Dover sole	54130	9	107776	6	99397	11	261303	5
longspine thornyhead	0		2254	22	180606	9	182860	11
sablefish	60047	45	49829	13	66037	37	175913	5
petrale sole	44764	9	66579	94	0		111343	60
rex sole	32390	10	27789	10	1779	44	61958	
Dungeness crab	58052	25	1738	23	14	65	59804	25
Pacific sanddab	50850	16	19	78	0		50869	17
longnose skate	17412	9	27304	8	4496	17	49212	7
stripetail rockfish	20556	30	26089	25	0		46645	19
shortspine thornyhead	7	71	19672	9	26175	3	45854	8

Table 12 (continued). Estimates of fish biomass and coefficients of variation, by depth stratum, for the area north of Pt. Conception from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
chilipepper rockfish	29246	52	15718	47	0		44964	37
splitnose rockfish	14	50	42744	26	0		42758	26
Pacific hake	20793	26	17151	17	719	31	38663	16
arrowtooth flounder	10008	20	18545	16	106	99	28659	13
English sole	24343	11	2426	30	0		26769	11
grooved tanner crab	189	101	4679	32	18100	14	22968	15
Pacific grenadier	0		11	86	22346	20	22357	21
lingcod	17446	34	4144	37	0		21590	28
greenstriped rockfish	17547	21	2483	32	0		20030	1
shortbelly rockfish	2502	46	14229	78	0		16731	68
giant grenadier	0		10	78	16218	12	16228	14
spotted ratfish	11394	16	4775	15	3	117	16172	12
sharpchin rockfish	1386	63	13388	52	0		14774	48
yellowtail rockfish	9602	43	3801	93	0		13403	42
Pacific ocean perch	54	38	12605	53	0		12659	53
bocaccio	4970	38	6818	65	0		11788	43
Pacific spiny dogfish	8283	45	1662	36	0		9945	37
big skate	8892	4	193	24	0		9085	16
slender sole	6796	16	2101	17	0		8897	13
Canary rockfish	8622	63	134	40	0		8756	62
deepsea sole	0		73	49	8109	9	8182	11
California slickhead	0		0		7596	14	7596	16
brown catshark	78	50	1528	18	5919	11	7525	10
sandpaper skate	784	17	4794	13	130	49	5708	12
darkblotched rockfish	338	25	5023	35	0		5361	34
roughtail skate	0		78	60	5167	14	5245	16
redstripe rockfsh	4361	87	8	62	0		4369	87
Pacific halibut	3077	23	1077	36	0		4154	20
twoline eelpout	0		88	52	3777	22	3865	22
filetail catshark	0		1967	26	1666	27	3633	20
aurora rockfish	0		3323	17	120	43	3443	18
bigfin eelpout	68	32	3056	10	209	80	3333	11
blackgill rockfish	0		2636	44	21	73	2657	44
California skate	2333	17	25	71	0		2358	18
snakehead eelpout	0		27	96	1892	15	1919	16
flathead sole	1420	60	325	46	0		1745	49
rosethorn rockfish	1014	13	592	35	0		1606	23
rougheye rockfish	199	98	909	33	0		1108	31
curlfin sole	1085	18	0		0		1085	19
halfbanded rockfish	1055	70	0		0		1055	70
Pacific flatnose	0		6	69	862	32	868	32

Table 12 (continued). Estimates of fish biomass and coefficients of variation, by depth stratum, for the area north of Pt. Conception from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
yelloweye rockfish	747	49	32	69	0		779	47
redbanded rockfish	34	88	707	24	0		741	23
black eelpout	0		439	19	171	13	610	18
widow rockfish	135	58	361	54	0		496	43
threadfin slickhead	0		1	106	455	33	456	33
California grenadier	0		267	31	123	63	390	28
deepsea skate	0		0		376	60	376	62
California halibut	206	57	0		0		206	57
vermilion/sunset rockfish	98	66	0		0		98	65
Pacific hagfish	3	61	1	61	15	59	19	45
smooth grenadier	0		0		4	62	4	70

Table 13. Estimates of fish biomass (in metric tons) and coefficients of variation (CV), by depth stratum, for the area south of Pt. Conception (lat 34°30′N to lat 32°30′N) from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
longspine thornyhead	0		1040	53	33687	13	34727	18
halfbanded rockfish	14235	46	172	5	0		14407	47
California slickhead	0		0		13702	21	13702	25
Dover sole	109	26	4014	21	9135	21	13258	14
shortspine thornyhead	0		1527	29	6895	17	8422	18
sablefish	51	45	263	25	7593	36	7907	32
Pacific sanddab	5433	24	829	51	0		6262	24
brown catshark	0		131	42	5993	21	6124	23
spotted ratfish	1560	27	3984	37	0		5544	27
grooved tanner crab	0		416	65	4137	25	4553	28
Pacific hake	204	39	3974	32	11	97	4189	31
Pacific grenadier	0		4	93	3811	86	3815	85
splitnose rockfish	3	91	3650	41	0		3653	42
English sole	2516	18	1052	39	0		3568	18
filetail catshark	0		3084	47	99	50	3183	47
longnose skate	83	69	3025	17	0		3108	20
petrale sole	168	40	2760	94	0		2928	44
roughtail skate	0		8	96	1969	25	1977	29
blackgill rockfish	0		1951	55	0		1951	56
rex sole	66	66	1507	27	0		1573	27
stripetail rockfish	459	37	1052	43	0		1511	31
giant grenadier	0		0		1251	43	1251	46

Table 13 (continued). Estimates of fish biomass and coefficients of variation, by depth stratum, for the area south of Pt. Conception from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m)		Mid-Depth (184–549 m)		Deep (550–1280 m)		All strata (55–1280 m)	
Species	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)	Biomass (mt)	CV (%)
slender sole	15	41	1132	40	0		1147	40
California scorpionfish	1087	47	13	68	0		1100	48
bigfin eelpout	1	67	1052	50	0		1053	51
deepsea sole	0		1	104	931	24	932	28
smooth grenadier	0		0		928	36	928	37
twoline eelpout	0		0		873	23	873	28
Pacific spiny dogfish	357	42	506	51	0		863	33
lingcod	540	73	283	59	0		823	54
aurora rockfish	0		708	46	0		708	47
California grenadier	0		308	65	224	52	532	57
threadfin slickhead	0		0		515	45	515	48
deepsea skate	0		0		503	100	503	101
vermilion/sunset rockfish	474	53	0		0		474	55
shortbelly rockfish	430	62	9	85	0		439	63
bocaccio	124	58	293	100	0		417	69
Pacific hagfish	0		1	117	413	62	414	63
chilipepper rockfish	263	48	71	49	0		334	42
California skate	330	48	0		0		330	22
greenstriped rockfish	123	60	128	78	0		251	45
black eelpout	0		213	91	0		213	91
California halibut	171	51	5	102	0		176	51
sandpaper skate	0		167	35	0		167	36
rosethorn rockfish	66	64	81	93	0		147	58
Pacific halibut	0		101	44	0		101	100
Pacific flatnose	0		0		73	68	73	66
curlfin sole	39	45	8	70	0		47	42
big skate	38	73	0		0		38	75
Dungeness crab	21	99	13	76	0		34	68
snakehead eelpout	0		0		15	36	15	49

We show the total number of hauls where we collected weight, number of fish, and lengths for groundfish and selected invertebrate species in Tables 14–16 by depth stratum and area for each species. For the overall area sampled in 2021, we most frequently (>200 tows) collected samples for Dover sole, Dungeness crab, English sole, Pacific sanddab, petrale sole, rex sole, and spotted ratfish in the shallow depth stratum. At mid-depth, the species sampled in the greatest number of tows (147 to 215 tows) included Dover sole, rex sole, Pacific hake, longnose skate, shortspine thornyhead, sablefish, and slender sole (*Lyopsetta exilis*). In the deep depth stratum, the species sampled most commonly (140 to 172 tows) included shortspine thornyhead, longspine thornyhead, grooved tanner crab, sablefish, Dover sole, and California slickhead (Table 14).

In the northern portion of the survey, we also saw a high number of tows (>179) with lingcod and sablefish samples recorded in addition to the species listed for the entire geographic area (Table 15). With the exception of sandpaper skate (*Bathyraja kincaidii*; 128 tows) which replaced slender sole in the mid-depth stratum, the species sampled in the greatest number of tows in the mid-depth and deep strata remained the same north of Pt. Conception relative to the overall geographic area (Table 15).

South of Pt. Conception, the species sampled in more than 25 tows in shallow waters (55–183 m) included English sole, Pacific sanddab, halfbanded rockfish, California skate (*Raja inornata*), stripetail rockfish, plainfin midshipman (*Porichthys notatus*), and chilipepper rockfish. At mid-depth in southern waters, the species sampled in the greatest number of tows (25 to 47) included Dover sole, Pacific hake, slender sole, longnose skate, rex sole, spotted ratfish, splitnose rockfish, and shortspine thornyhead. In the deep depth stratum, we sampled the greatest number of tows (22 to 28) for California slickhead, longspine thornyhead, shortspine thornyhead, grooved tanner crab, and Dover sole (Table 16).

Size Compositions

Figures 45–48 show the estimated population length frequencies separated (male, female) and aggregated (male, female, undetermined) by sex for Dover sole, sablefish, longspine thornyhead, and shortspine thornyhead, presented by depth stratum and with depth strata combined for the entire sampling area. We also show mean length (cm) for males, females, and total catch by depth stratum. The average length (cm) of female Dover sole and sablefish tended to be larger than that of males, with mean size for both males and females increasing with depth stratum from shallow to deep waters (Figures 45 and 46). Longspine thornyhead (Figure 47) and shortspine thornyhead (Figure 48) occurred from mid-depth to deep strata. The mean size for longspine thornyhead differed very little between sexes or by depth, while shortspine thornyhead females tended to be slightly larger than males and increased in average size by depth (Figures 47 and 48).

Table 14. Number of hauls by depth stratum, with catch weight (Wt., in kg), number of fish (No.), and length data (Len., in cm) collected for abundant groundfish and selected invertebrate species for the combined area (U.S.–Canada to U.S.–Mexico borders) of the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m) Total hauls = 290			Mid-Depth (184–549 m) Total hauls = 216			Deep (550–1,280 m) Total hauls = 178		
Species	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**
arrowtooth flounder	110	110	107	97	97	95	1	1	1
aurora rockfish	0	0	0	84	84	83	7	7	7
bank rockfish	0	0	0	7	7	7	0	0	0
big skate	116	116	86	8	8	6	2	2	0
blackgill rockfish	0	0	0	37	37	37	2	2	2
blackspotted rockfish	1	1	1	2	2	2	0	0	0
bocaccio	63	63	62	31	31	31	0	0	0
brown rockfish	9	9	9	0	0	0	0	0	0
butter sole	20	20	18	0	0	0	0	0	0
calico rockfish	12	12	12	0	0	0	0	0	0
California grenadier	0	0		40	39		21	21	
California halibut	9	9		1	1		0	0	
California scorpionfish	21	21	21	3	3	3	0	0	0
California skate	93	93	90	3	3	3	0	0	0
California slickhead	0	0		0	0		146	141	
canary rockfish	46	46	45	8	8	8	0	0	0
chilipepper	91	91	91	36	36	36	0	0	0
copper rockfish	17	17	17	0	0	0	0	0	0
cowcod	13	13	13	7	7	7	0	0	0
curlfin sole	80	80	79	2	2	2	0	0	0
darkblotched rockfish	53	53	53	69	69	69	0	0	0
deepsea sole	0	0	0	8	8	8	140	140	139
Dover sole	224	224	222	215	215	213	148	147	146
Dungeness Crab	209	199		51	49		2	2	
English sole	252	252	250	46	46	46	0	0	0
flathead sole	34	34	34	16	16	15	0	0	0
giant grenadier	0	0	0	2	2	2	110	110	108
greenblotched rockfish	1	1	1	6	6	6	0	0	0
greenspotted rockfish	34	34	34	13	13	13	0	0	0
greenstriped rockfish	117	117	116	50	50	49	0	0	0
grooved tanner crab	0	0		47	46		164	163	
halfbanded rockfish	67	67	67	6	6	6	0	0	0
honeycomb rockfish	3	3	3	0	0	0	0	0	0
kelp greenling	10	10	10	0	0	0	0	0	0
lingcod	193	192	190	35	35	35	0	0	0
longfin sanddab	11	11		0	0		0	0	
longnose skate	174	174	174	189	189	189	46	46	45
longspine thornyhead	0	0	0	46	46	46	171	171	171
Mexican rockfish	2	2	2	3	3	3	0	0	0
Pacific cod	6	6	6	1	1	1	0	0	0

Table 14 (continued). Number of hauls by depth stratum, with catch weight, number of fish, and length data collected for abundant groundfish and selected invertebrate species for the combined area of the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m) Total hauls = 290			Mid-Depth (184–549 m) Total hauls = 216			Deep (550–1,280 m) Total hauls = 178		
Species	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**
Pacific flatnose	0	0	0	1	1	2	35	35	38
Pacific grenadier	0	0	0	2	2	2	100	99	100
Pacific hake	105	105	105	191	191	191	28	28	28
Pacific halibut	28	28		15	15		0	0	
Pacific herring	44	43		1	1		0	0	
Pacific ocean perch	22	22	22	38	38	37	0	0	0
Pacific sanddab	219	219	219	11	11	11	0	0	0
Pacific spiny dogfish	69	69	69	51	51	51	0	0	0
petrale sole	229	229	229	55	55	55	0	0	0
plainfin midshipman	105	100		9	9		0	0	
pygmy rockfish	5	5	5	0	0	0	0	0	0
quillback rockfish	6	6	6	0	0	0	0	0	0
redbanded rockfish	6	6	6	63	63	63	0	0	0
redstripe rockfish	5	5	5	3	3	3	0	0	0
rex sole	218	218	218	193	193	191	15	14	14
rosethorn rockfish	28	28	27	28	28	27	0	0	0
rosy rockfish	1	1	1	0	0	0	0	0	0
rougheye rockfish	8	8	8	20	20	22	0	0	0
roughtail skate	0	0		5	5		91	89	
sablefish	190	189	189	169	168	168	162	162	162
sand sole	19	19	19	0	0	0	0	0	0
sandpaper skate	50	50		137	136		5	5	
sharpchin rockfish	18	18	19	39	38	38	0	0	0
shortbelly rockfish	58	58	58	23	23	23	0	0	0
shortspine thornyhead	6	6	4	173	172	172	173	172	172
silvergray rockfish	4	4	2	3	3	3	0	0	0
slender sole	182	173		147	144		0	0	
Southern rock sole	45	45	44	0	0	0	0	0	0
splitnose rockfish	10	10	10	121	121	120	0	0	0
spotted ratfish	203	202	199	138	138	137	1	1	1
spotted turbot	3	2		0	0		0	0	
squarespot rockfish	10	10	10	0	0	0	0	0	0
starry flounder	11	11	11	0	0	0	0	0	0
starry skate	22	22		2	2		0	0	
stripetail rockfish	94	94	94	72	72	70	0	0	0
vermilion/sunset rockfish	20	20	20	0	0	0	0	0	0
widow rockfish	9	9	7	10	10	10	0	0	0
yelloweye rockfish	18	18	19	3	3	3	0	0	0
yellowtail rockfish	31	31	30	5	5	5	0	0	0

Table 15. Number of hauls by depth stratum, with catch weight (Wt., in kg), number of fish (No.), and length data (Len., in cm) collected for abundant groundfish and selected invertebrate species for the area north of Pt. Conception (lat 48°10′N to lat 34°30′N) from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m) Total hauls = 245			Mid-Depth (184–549 m) Total hauls = 165			Deep (550–1,280 m) Total hauls = 147		
Species	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**
arrowtooth flounder	110	110	107	96	96	95	1	1	1
aurora rockfish	0	0	0	76	76	75	7	7	7
bank rockfish	0	0	0	6	6	6	0	0	0
big skate	114	114	84	8	8	6	2	2	0
blackgill rockfish	0	0	0	24	24	24	2	2	2
blackspotted rockfish	1	1	1	2	2	2	0	0	0
bocaccio	52	52	51	30	30	30	0	0	0
brown rockfish	9	9	9	0	0	0	0	0	0
butter sole	20	20	18	0	0	0	0	0	0
calico rockfish	6	6	6	0	0	0	0	0	0
California grenadier	0	0		29	29		14	14	
California halibut	5	5		0	0		0	0	
California scorpionfish	0	0	0	0	0	0	0	0	0
California skate	64	64	61	3	3	3	0	0	0
California slickhead	0	0		0	0		118	114	
canary rockfish	46	46	45	8	8	8	0	0	0
chilipepper	66	66	66	29	29	29	0	0	0
copper rockfish	7	7	7	0	0	0	0	0	0
cowcod	8	8	8	6	6	6	0	0	0
curlfin sole	67	67	66	0	0	0	0	0	0
darkblotched rockfish	53	53	53	69	69	69	0	0	0
deepsea sole	0	0	0	7	7	7	123	123	122
Dover sole	203	203	201	167	167	166	126	125	124
Dungeness Crab	208	198		49	47		2	2	
English sole	212	212	210	30	30	30	0	0	0
flathead sole	34	34	34	16	16	15	0	0	0
giant grenadier	0	0	0	2	2	2	104	104	102
greenblotched rockfish	0	0	1	1	1	0	0	0	0
greenspotted rockfish	18	18	18	10	10	10	0	0	0
greenstriped rockfish	110	110	109	44	44	44	0	0	0
grooved tanner crab	0	0		39	38		142	142	
halfbanded rockfish	33	33	33	0	0	0	0	0	0
honeycomb rockfish	0	0	0	0	0	0	0	0	0
kelp greenling	10	10	10	0	0	0	0	0	0
lingcod	181	180	178	32	32	32	0	0	0
longfin sanddab	0	0		0	0		0	0	
longnose skate	168	168	168	152	152	152	46	46	45
longspine thornyhead	0	0	0	41	41	41	145	145	145
Mexican rockfish	0	0	0	0	0	0	0	0	0
Pacific cod	6	6	6	1	1	1	0	0	0

Table 15 (continued). Number of hauls by depth stratum, with catch weight, number of fish, and length data collected for abundant groundfish and selected invertebrate species for the area north of Pt.Conception from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m) Total hauls = 245			Mid-Depth (184–549 m) Total hauls = 165			Deep (550–1,280 m) Total hauls = 147		
Species	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**
Pacific flatnose	0	0	0	1	1	1	30	30	30
Pacific grenadier	0	0	0	1	1	1	92	91	92
Pacific hake	93	93	93	144	144	143	27	27	27
Pacific halibut	28	28		14	14		0	0	
Pacific herring	44	43		1	1		0	0	
Pacific ocean perch	22	22	22	38	38	37	0	0	0
Pacific sanddab	180	180	180	3	3	3	0	0	0
Pacific spiny dogfish	60	60	60	39	39	39	0	0	0
petrale sole	221	221	221	50	50	52	0	0	0
plainfin midshipman	79	74		4	4		0	0	
pygmy rockfish	4	4	4	0	0	0	0	0	0
quillback rockfish	6	6	6	0	0	0	0	0	0
redbanded rockfish	6	6	6	63	63	63	0	0	0
redstripe rockfish	5	5	5	3	3	3	0	0	0
rex sole	212	212	212	157	157	155	15	14	14
rosethorn rockfish	22	22	21	25	25	25	0	0	0
rosy rockfish	0	0	0	0	0	0	0	0	0
rougheye rockfish	8	8	8	20	20	22	0	0	0
roughtail skate	0	0		4	4		78	76	
sablefish	179	178	178	152	151	152	145	145	145
sand sole	19	19	19	0	0	0	0	0	0
sandpaper skate	50	50		128	127		5	5	
sharpchin rockfish	18	18	18	38	37	37	0	0	0
shortbelly rockfish	41	41	41	20	20	20	0	0	0
shortspine thornyhead	6	6	4	148	147	147	148	147	147
silvergray rockfish	4	4	2	3	3	3	0	0	0
slender sole	174	166		105	102		0	0	
Southern rock sole	40	40	39	0	0	0	0	0	0
splitnose rockfish	9	9	9	90	90	90	0	0	0
spotted ratfish	179	178	175	105	105	105	1	1	1
spotted turbot	0	0		0	0		0	0	
squarespot rockfish	3	3	3	0	0	0	0	0	0
starry flounder	11	11	11	0	0	0	0	0	0
starry skate	16	16		0	0		0	0	
stripetail rockfish	66	66	66	53	53	53	0	0	0
vermilion/sunset rockfish	7	7	7	0	0	0	0	0	0
widow rockfish	9	9	7	10	10	10	0	0	0
yelloweye rockfish	18	18	19	3	3	3	0	0	0
yellowtail rockfish	31	31	30	5	5	5	0	0	0

Table 16. Number of hauls by depth stratum, with catch weight (Wt., in kg), number of fish (No.), and length data (Len., in cm) collected for abundant groundfish and selected invertebrate species for the area south of Pt. Conception (lat 34°30′N to lat 32°30′N) from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m) Total hauls = 245			Mid-Depth (184–549 m) Total hauls = 165			Deep (550–1,280 m) Total hauls = 147		
Species	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**
arrowtooth flounder	0	0	0	0	0	0	0	0	0
aurora rockfish	0	0	0	8	8	8	0	0	0
bank rockfish	0	0	0	1	1	1	0	0	0
big skate	2	2	2	0	0	0	0	0	0
blackgill rockfish	0	0	0	13	13	13	0	0	0
blackspotted rockfish	0	0	0	0	0	0	0	0	0
bocaccio	11	11	11	1	1	1	0	0	0
brown rockfish	0	0	0	0	0	0	0	0	0
butter sole	0	0	0	0	0	0	0	0	0
calico rockfish	6	6	6	0	0	0	0	0	0
California grenadier	0	0		11	10		7	7	
California halibut	4	4		1	1		0	0	
California scorpionfish	21	21	21	3	3	3	0	0	0
California skate	29	29	29	0	0	0	0	0	0
California slickhead	0	0		0	0		28	27	
canary rockfish	0	0	0	0	0	0	0	0	0
chilipepper	25	25	25	7	7	7	0	0	0
copper rockfish	10	10	10	0	0	0	0	0	0
cowcod	5	5	5	1	1	1	0	0	0
curlfin sole	13	13	13	2	2	2	0	0	0
darkblotched rockfish	0	0	0	0	0	0	0	0	0
deepsea sole	0	0	0	1	1	1	17	17	17
Dover sole	21	21	21	48	48	47	22	22	22
Dungeness crab	1	1		2	2		0	0	
English sole	40	40	40	16	16	16	0	0	0
flathead sole	0	0	0	0	0	0	0	0	0
giant grenadier	0	0	0	0	0	0	6	6	6
greenblotched rockfish	1	1	1	5	5	6	0	0	0
greenspotted rockfish	16	16	16	3	3	3	0	0	0
greenstriped rockfish	7	7	7	6	6	5	0	0	0
grooved tanner crab	0	0		8	8		22	21	
halfbanded rockfish	34	34	34	6	6	6	0	0	0
honeycomb rockfish	3	3	3	0	0	0	0	0	0
kelp greenling	0	0	0	0	0	0	0	0	0
lingcod	12	12	12	3	3	3	0	0	0
longfin sanddab	11	11		0	0		0	0	
longnose skate	6	6	6	37	37	37	0	0	0
longspine thornyhead	0	0	0	5	5	7	26	26	26
Mexican rockfish	2	2	3	3	3	3	0	0	0
Pacific cod	0	0	0	0	0	0	0	0	0

Table 16 (continued). Number of hauls by depth stratum, with catch weight, number of fish, and length data collected for abundant groundfish and selected invertebrate species for the area south of Pt.Conception from the 2021 West Coast Groundfish Bottom Trawl Survey.

	Shallow (55–183 m) Total hauls = 245			Mid-Depth (184–549 m) Total hauls = 165			Deep (550–1,280 m) Total hauls = 147		
Species	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**	**Wt.**	**No.**	**Len.**
Pacific flatnose	0	0	0	0	0	0	5	5	5
Pacific grenadier	0	0	0	1	1	1	8	8	8
Pacific hake	12	12	12	47	47	47	1	1	1
Pacific halibut	0	0		1	1		0	0	
Pacific herring	0	0		0	0		0	0	
Pacific ocean perch	0	0	0	0	0	0	0	0	0
Pacific sanddab	39	39	39	8	8	8	0	0	0
Pacific spiny dogfish	9	9	9	12	12	12	0	0	0
petrale sole	8	8	8	5	5	5	0	0	0
plainfin midshipman	26	26		5	5		0	0	
pygmy rockfish	1	1	1	0	0	0	0	0	0
quillback rockfish	0	0	0	0	0	0	0	0	0
redbanded rockfish	0	0	0	0	0	0	0	0	0
redstripe rockfish	0	0	0	0	0	0	0	0	0
rex sole	6	6	6	36	36	36	0	0	0
rosethorn rockfish	6	6	6	3	3	2	0	0	0
rosy rockfish	1	1	1	0	0	0	0	0	0
rougheye rockfish	0	0	0	0	0	0	0	0	0
roughtail skate	0	0		1	1		13	13	
sablefish	11	11	11	17	17	17	17	17	17
sand sole	0	0	0	0	0	0	0	0	0
sandpaper skate	0	0		9	9		0	0	
sharpchin rockfish	0	0	1	1	1	0	0	0	0
shortbelly rockfish	17	17	17	3	3	3	0	0	0
shortspine thornyhead	0	0	0	25	25	25	25	25	25
silvergray rockfish	0	0	0	0	0	0	0	0	0
slender sole	8	7		42	42		0	0	
Southern rock sole	5	5	5	0	0	0	0	0	0
splitnose rockfish	1	1	1	31	31	30	0	0	0
spotted ratfish	24	24	24	33	33	32	0	0	0
spotted turbot	3	2		0	0		0	0	
squarespot rockfish	7	7	7	0	0	0	0	0	0
starry flounder	0	0	0	2	2	0	0	0	0
sarry skate	6	6		0	0		0	0	
stripetail rockfish	28	28	28	19	19	17	0	0	0
vermilion/sunset rockfish	13	13	13	0	0	0	0	0	0
widow rockfish	0	0	0	0	0	0	0	0	0
yelloweye rockfish	0	0	0	0	0	0	0	0	0
yellowtail rockfish	0	0	0	0	0	0	0	0	0

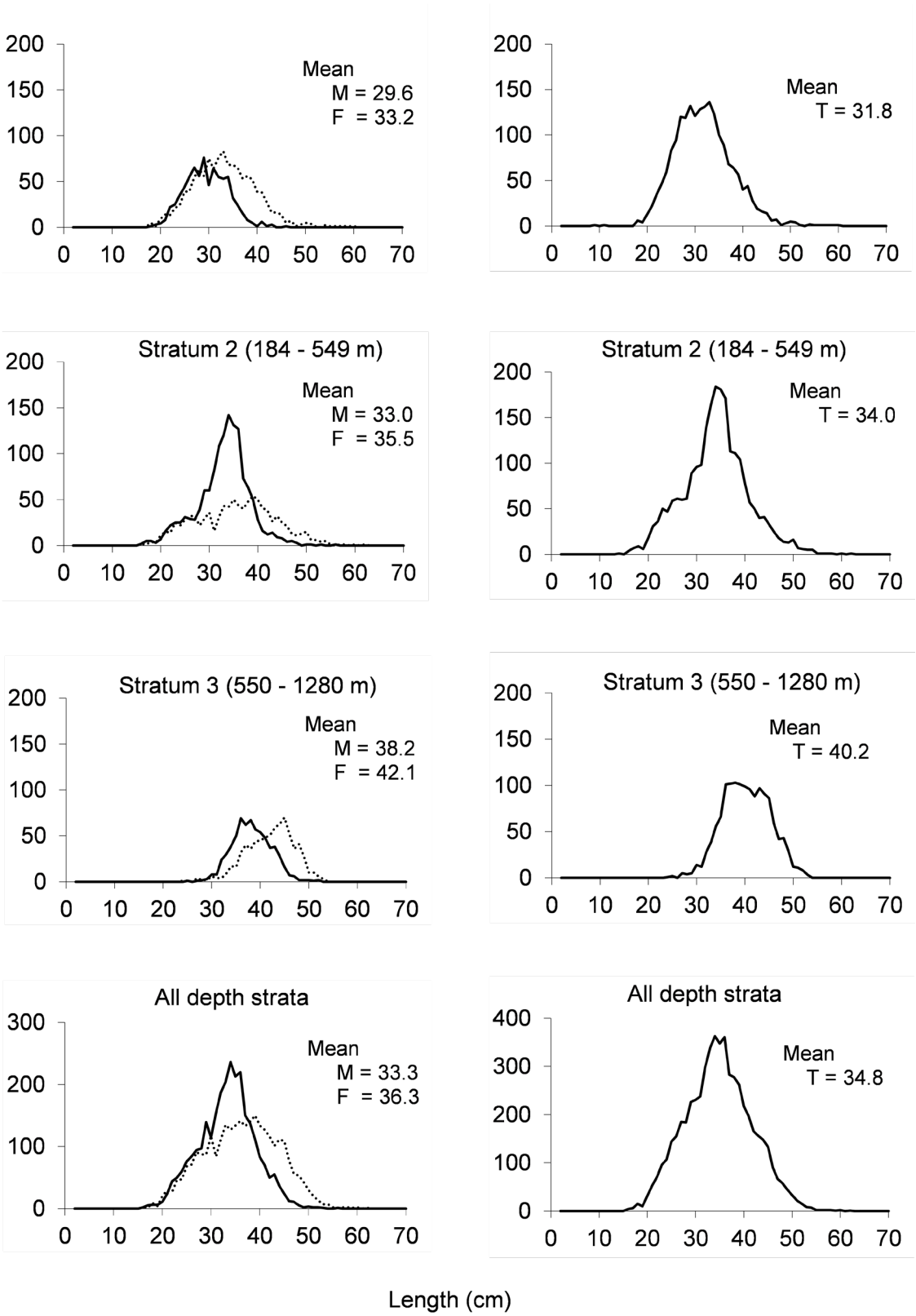


Figure 45. Unweighted length-frequency data and mean lengths (cm) of Dover sole by depth stratum and sex (M = male, F = female, and T = males, females, and unsexed in aggregate) for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

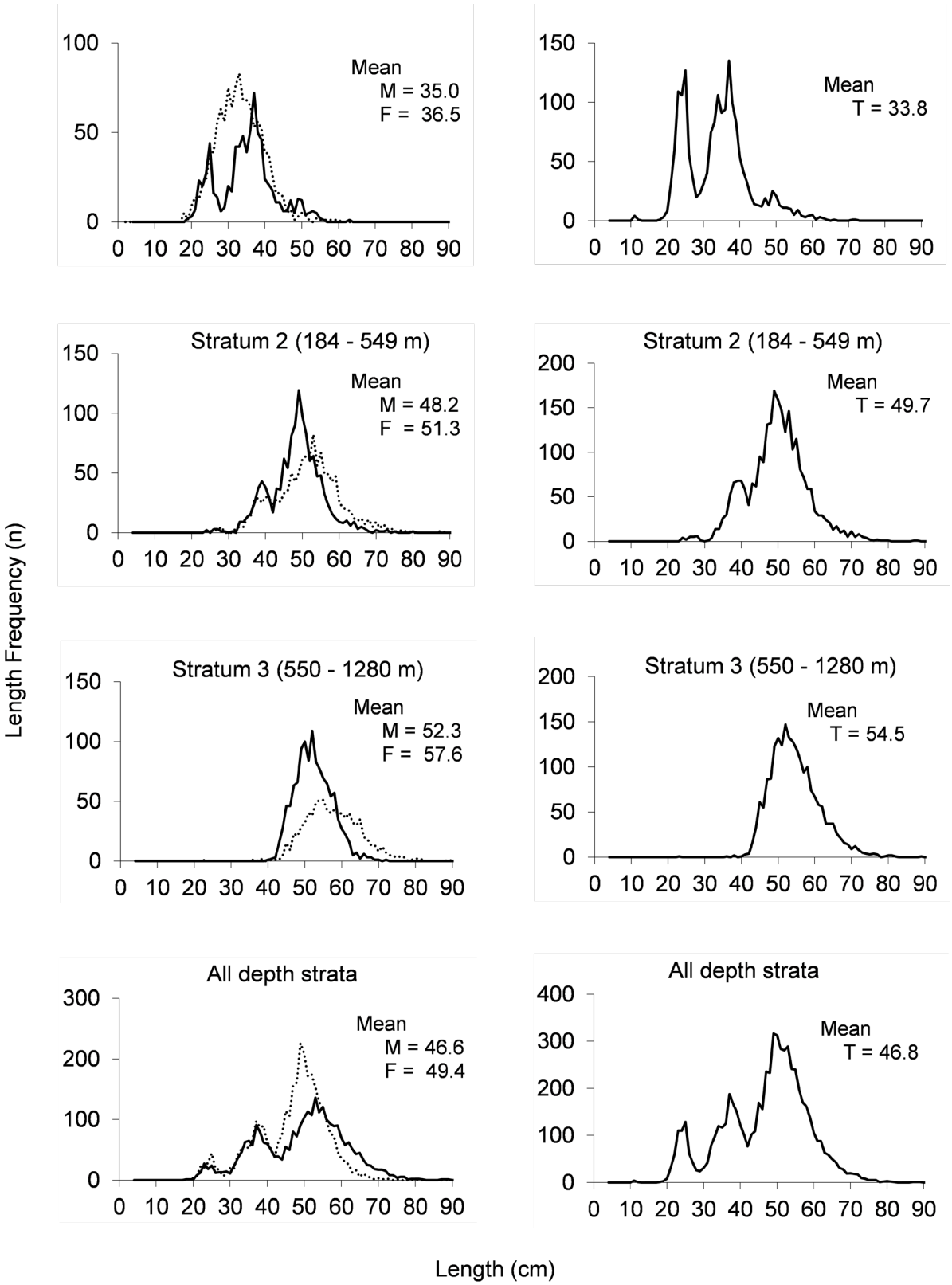


Figure 46. Unweighted length-frequency data and mean lengths (cm) of sablefish by depth stratum and sex (M = male, F = female, and T = males, females, and unsexed in aggregate) for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

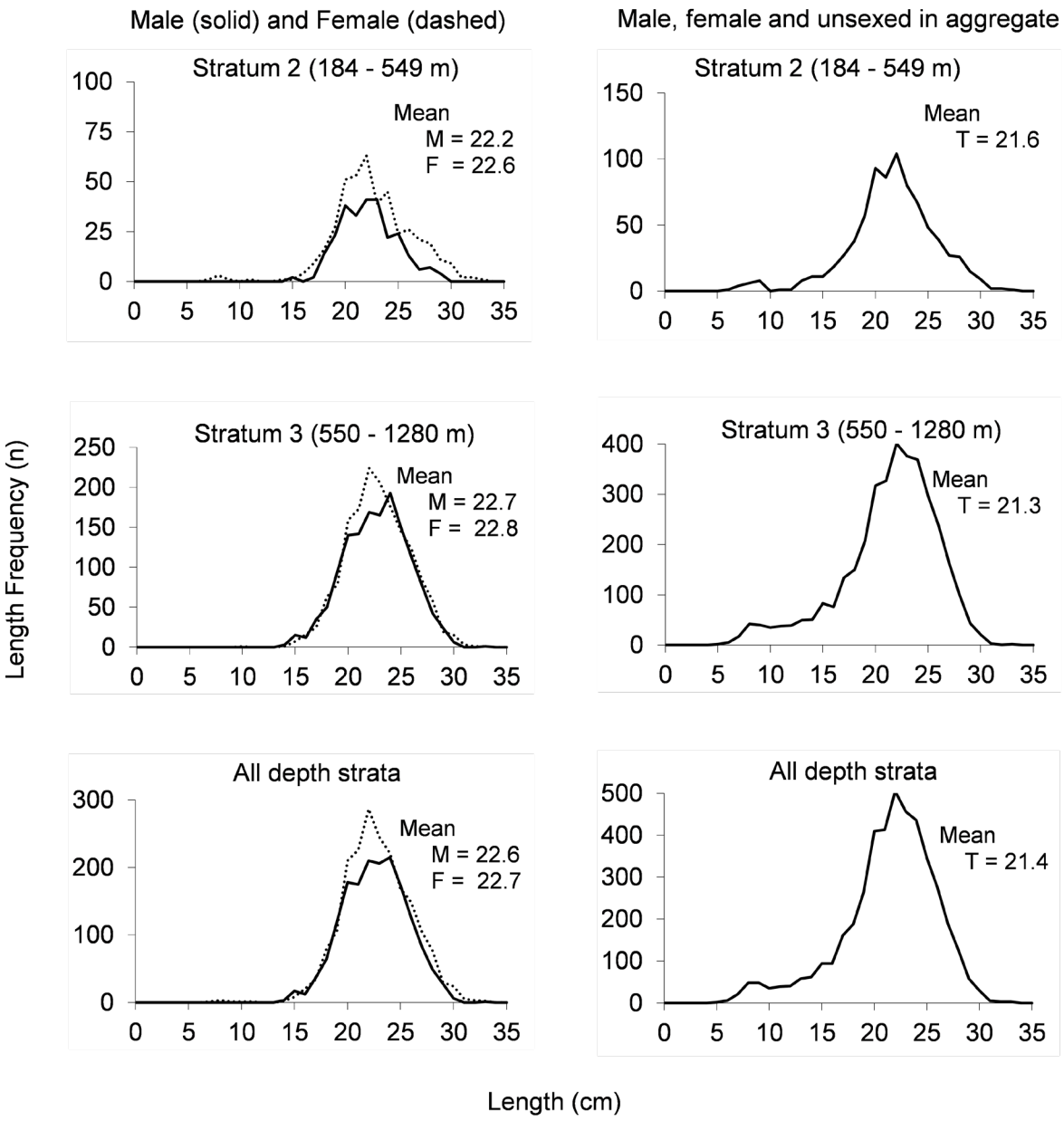


Figure 47. Unweighted length-frequency data and mean lengths (cm) of longspine thornyhead by depth stratum and sex (M = male, F = female, and T = males, females, and unsexed in aggregate) for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

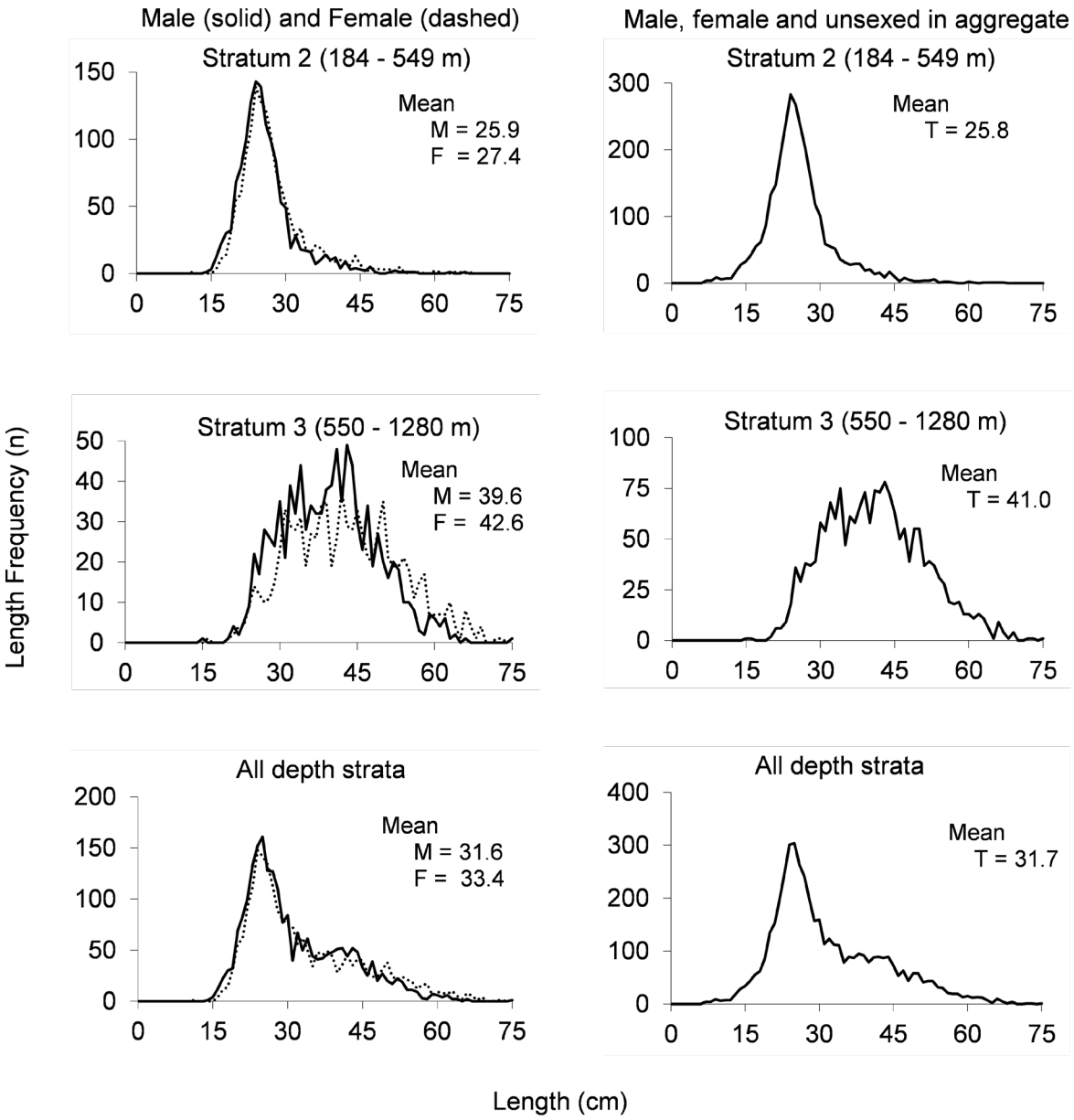


Figure 48. Unweighted length-frequency data and mean lengths (cm) of shortspine thornyhead by depth stratum and sex (M = male, F = female, and T = males, females, and unsexed in aggregate) for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

Figures 49–51 show the length frequency distributions by sex (male, female, and undetermined) for additional important management species in all areas combined for all depths (55–1,280 m). In general, Figures 49–51 include important management species with greater than 500 length measurements taken throughout the survey period: spiny dogfish, California skate, longnose skate, arrowtooth flounder, curlfin sole (*Pleuronichthys decurrens*), English sole, Pacific sanddab, petrale sole, rex sole, Pacific grenadier, lingcod, Pacific hake, aurora rockfish, bocaccio rockfish (*Sebastes paucispinis*), canary rockfish (*S. pinniger*), chilipepper rockfish, darkblotched rockfish (*S. crameri*), greenspotted rockfish (*S. chlorostictus*), greenstriped rockfish, halfbanded rockfish, Pacific ocean perch, rosethorn rockfish (*S. helvomaculatus*), sharpchin rockfish, shortbelly rockfish, splitnose rockfish, stripetail rockfish, and yellowtail rockfish (*S. flavidus*). If we could not determine sex for more than 15% of the individuals measured for a given species (e.g., Pacific grenadier), then a separate category (unsexed) was included in the plot. Note that the length frequencies are the sum of all measured fish and are not adjusted for subsampling, area swept, or stratum size, and that figures are grouped taxonomically. With the exception of spiny dogfish, we observed a greater mean length for females relative to males for all species shown in Figure 49. We saw slightly larger mean sizes for female California skate and longnose skate but, in general, the mean size of female flatfish exceeded males by greater than 4 cm, with female arrowtooth flounder exhibiting on average a mean size ~14 cm greater than males. We also noted that sex ratios differed by species, with considerably more females than males sampled for arrowtooth flounder and English sole.

Figure 50 includes three species with high numbers of small fish with undetermined sex (bold solid line): Pacific grenadier, Pacific hake, and chilipepper rockfish. The mean size of Pacific grenadier males tended to be larger than females, but the observed average size of female Pacific hake and chilipepper rockfish was greater than males. In general, mean size for the remaining female rockfish in Figure 50 (aurora, canary, darkblotched, and greenspotted rockfish) tended to be only slightly greater than males, with the exception of bocaccio, where females averaged 5 cm larger than males. Additionally, lingcod females on average tended to be larger than males by ~10 cm.

For the remaining rockfish species (Figure 51), we saw large numbers of small specimens with unidentified sex for shortbelly, splitnose, and stripetail rockfish. For most of the species shown in the figure, the mean size of females was only slightly larger than males (greenstriped, Pacific ocean perch, sharpchin, shortbelly, and splitnose rockfish). However, we saw the opposite for rosethorn rockfish, with the mean size of males slightly larger than females (Figure 51). Finally, the average size of halfbanded, stripetail, and yellowtail rockfish females was notably larger than that of males.

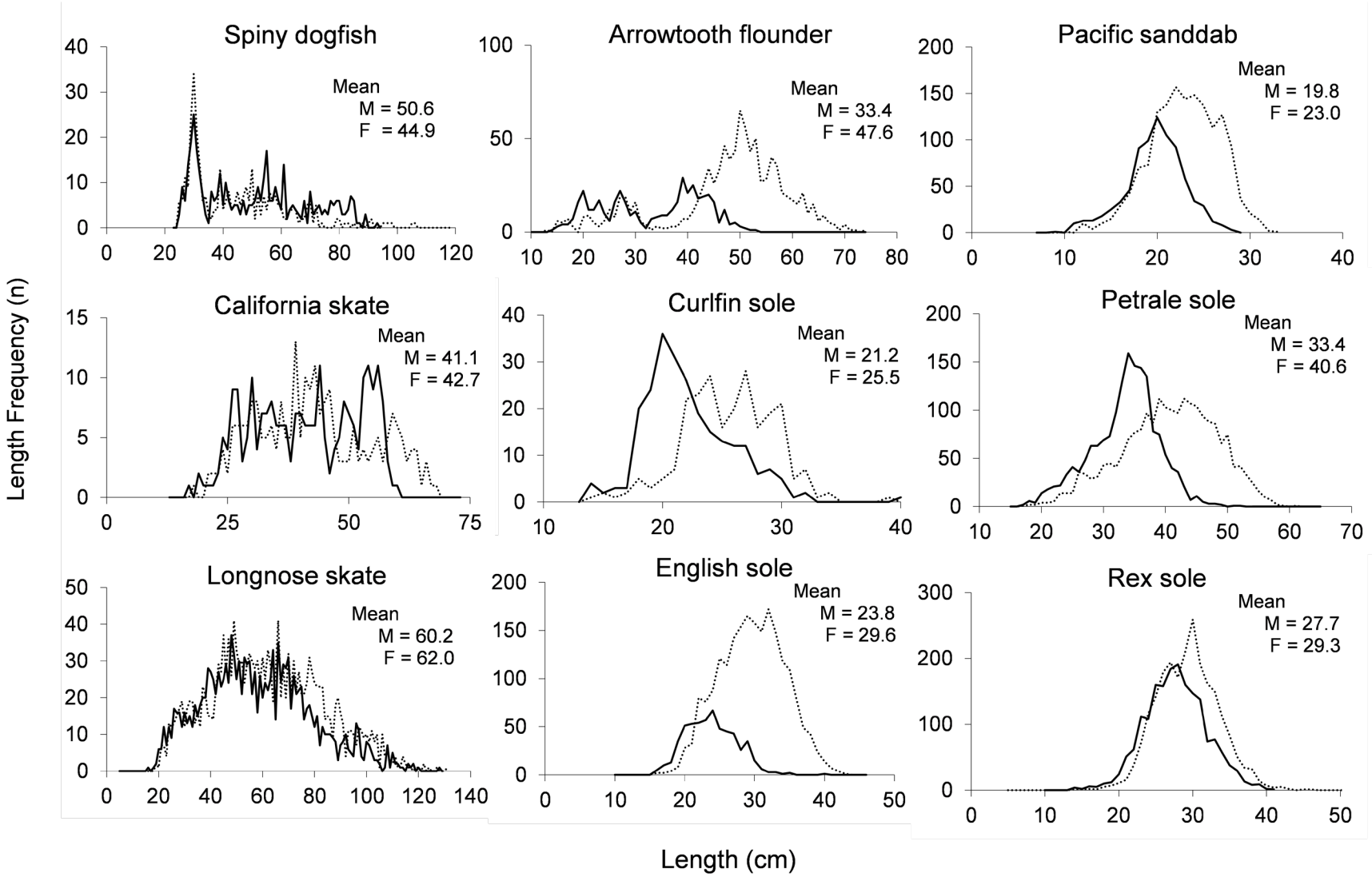


Figure 49. Unweighted length-frequency data and mean lengths (cm) of spiny dogfish, California skate, longnose skate, arrowtooth flounder, curlfin sole, English sole, Pacific sanddab, petrale sole, and rex sole, by sex (M = male, solid line; F = female, dashed line), for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

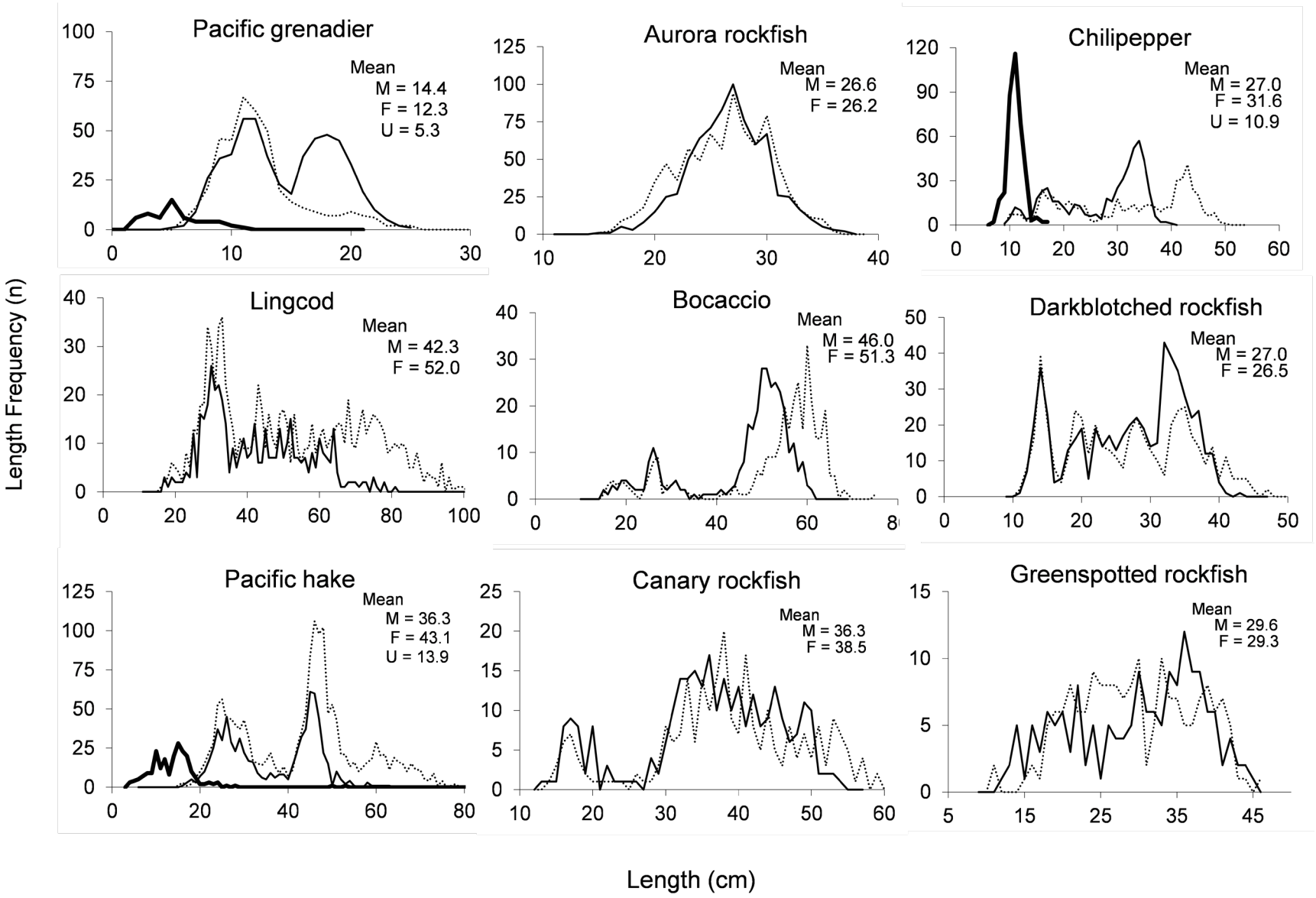


Figure 50. Unweighted length-frequency data and mean lengths (cm) of Pacific grenadier, lingcod, Pacific hake, aurora rockfish, bocaccio rockfish, canary rockfish, chilipepper rockfish, darkblotched rockfish, and greenspotted rockfish, by sex (U = undetermined, bold solid line; M = male, solid line; F = female, dashed line), for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

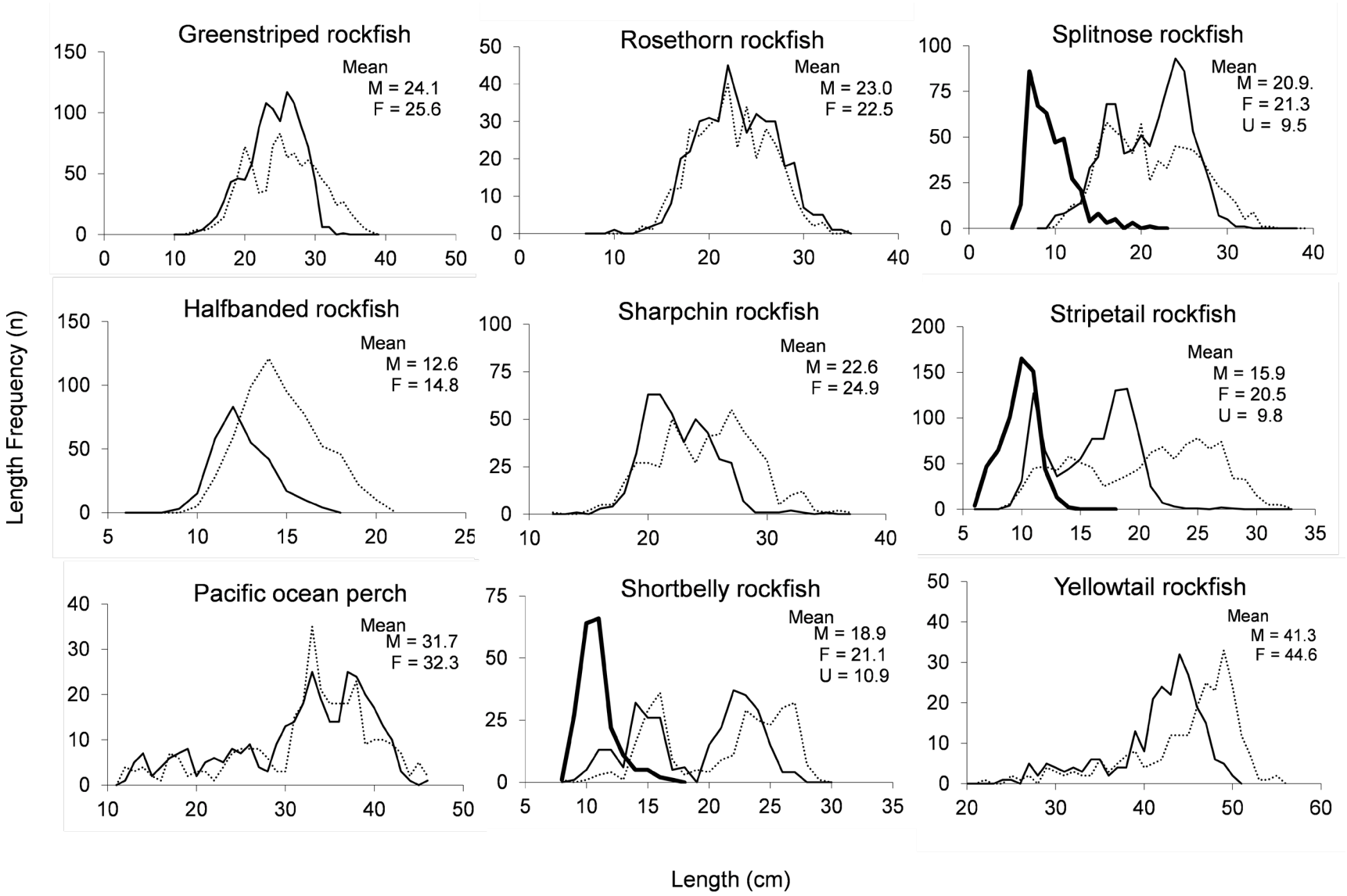


Figure 51. Unweighted length-frequency data and mean lengths (cm) of greenstriped rockfish, halfbanded rockfish, Pacific ocean perch, rosethorn rockfish, sharpchin rockfish, shortbelly rockfish, splitnose rockfish, stripetail rockfish, and yellowtail rockfish, by sex (U = undetermined, bold solid line; M = male, solid line; F = female, dashed line), for the geographic area sampled during the 2021 West Coast Groundfish Bottom Trawl Survey.

Weight–Length Relationships

We collected individual measurements of weight (g) and length (cm) for multiple groundfish species during the 2021 West Coast Groundfish Bottom Trawl Survey. We fit these data to the following weight–length relationship using nonlinear least squares:

$$W = a \times L^b \tag{4}$$

where W is fish weight in grams, L is fish length in cm, and a and b are constants. We excluded species with few measurements from the analysis, and present results for 60 species (Table 17). As noted, we measured fork length (or total length) for most species; however, we recorded anal length for giant grenadier, and wingspan for big skate and longnose skate. We report results of these analyses, including number sampled and the coefficient of determination (r^2), in Table 17.

Length–Age Relationships

We also collected otoliths, dorsal fin rays, or dorsal spines from specimens of 65 groundfish species (Table 2) to determine ages. To date, we have only determined ages for petrale sole and canary rockfish from the 2021 collections. We described size at age using the von Bertalanffy growth model (von Bertalanffy 1938),

$$L_t = L_\infty (1 - e^{-k(t - t_0)}) \tag{5}$$

where L_t is fork length (cm) at age t in years, L_∞ is the theoretical maximum fork length (cm), k is growth rate (per year), and t_0 is the theoretical age (years) when the fish was length zero.

We fit size versus age data for males and females separately (Table 18), and utilize these data in age-structured assessment models to account for possible sex-specific growth rates. For petrale sole, we sexed all aged fish and fit a growth model for females (n = 473), males (n = 325), and all aged specimens (n = 798) (Table 18, Figure 52). For canary rockfish, we were unable to determine sex for 48 aged specimens. To examine the impact of including these ages in fitting the von Bertalanffy growth model, we present results for males (n = 217) and females (n = 203) without data from those with undetermined sex, but included them in the overall fit for all aged specimens (n = 468; Figure 53). All fits were highly significant, with $P < 0.0001$). Additional size-at-age relationships for management species will be reported in stock assessment documents published by the Pacific Fishery Management Council, when available.

Table 17. The weight–length relationships from the 2021 West Coast Groundfish Bottom Trawl Survey, using a least squares fit for the following equation: fish weight (g) = a × length (cm)^b.

Species	Number sampled	Weight–length coefficients		r^2
		a	*b*	
arrowtooth flounder	633	0.0056	3.1448	0.99
aurora rockfish	784	0.0118	3.0996	0.97
bank rockfish	24	0.0062	3.2558	0.99
big skate	139	0.0096	2.9373	0.99
blackgill rockfish	423	0.0139	3.0476	0.98
blackspotted rockfish	7	0.0078	3.1766	0.99
bocaccio	555	0.0122	2.9853	0.99
brown rockfish	26	0.0136	3.0435	0.99
calico rockfish	49	0.0151	2.9993	0.74
California scorpionfish	212	0.0211	2.9510	0.95
canary rockfish	469	0.0231	2.9076	0.99
chilipepper	770	0.0139	3.1246	0.99
copper rockfish	92	0.0083	3.2175	0.99
cowcod	33	0.0186	2.9585	0.98
curlfin sole	245	0.0008	3.1971	0.96
darkblotched rockfish	622	0.0115	3.1246	0.99
deepsea sole	4	0.0003	3.9992	0.99
Dover sole	1123	0.0045	3.2224	0.98
English sole	579	0.0067	3.0951	0.96
flathead sole	199	0.0079	3.0435	0.98
giant grenadier	411	0.2258	2.8514	0.92
greenblotched rockfish	32	0.0070	3.2704	0.99
greenspotted rockfish	332	0.0108	3.1280	0.98
greenstriped rockfish	629	0.0067	3.2121	0.97
halfbanded rockfish	530	0.0322	2.6738	0.82
honeycomb rockfish	7	0.0125	3.0840	0.97
kelp greenling	32	0.0061	3.1989	0.97
lingcod	702	0.0026	3.2966	0.99
longnose skate	404	0.0042	3.0788	0.99
longspine thornyhead	453	0.0175	2.8826	0.94
Mexican rockfish	23	0.0403	2.6880	0.96
Pacific cod	24	0.0090	3.0319	0.99
Pacific flatnose	154	0.0014	3.4192	0.96
Pacific hake	601	0.0078	2.9577	0.98
Pacific ocean perch	819	0.0082	3.1636	0.99
Pacific sanddab	461	0.0056	3.2088	0.95
petrale sole	1244	0.0026	3.4096	0.98
pygmy rockfish	37	0.0122	2.9908	0.88
quillback rockfish	12	0.0142	3.0796	0.98
redbanded rockfish	226	0.0095	3.1647	0.99
redstripe rockfish	197	0.0117	3.0367	0.93
rex sole	828	0.0051	3.0745	0.93
rosethorn rockfish	442	0.0104	3.1014	0.95

Table 17 (continued). The weight–length relationships from the 2021 West Coast Groundfish Bottom Trawl Survey.

Species	Number sampled	Weight–length coefficients		
		a	*b*	r^2
rougheye rockfish	142	0.0114	3.0862	0.99
sablefish	2193	0.0044	3.2057	0.99
sand sole	134	0.0059	3.1432	0.98
spiny dogfish	312	0.0033	3.0696	0.99
sharpchin rockfish	572	0.0131	3.0276	0.94
shortbelly rockfish	452	0.0147	2.9163	0.94
shortspine thornyhead	690	0.0061	3.2053	0.99
silvergray rockfish	5	0.0172	2.9296	0.98
southern rock sole	224	0.0059	3.2029	0.97
splitnose rockfish	555	0.0407	2.7103	0.95
squarespot rockfish	11	0.0064	3.2704	0.96
starry flounder	16	0.0130	2.9993	0.98
stripetail rockfish	718	0.0338	2.7226	0.96
vermilion/sunset rockfish	203	0.0086	3.1991	0.97
widow rockfish	66	0.0041	3.3525	0.99
yelloweye rockfish	68	0.0056	3.3128	0.99
yellowtail rockfish	383	0.0126	3.0584	0.98

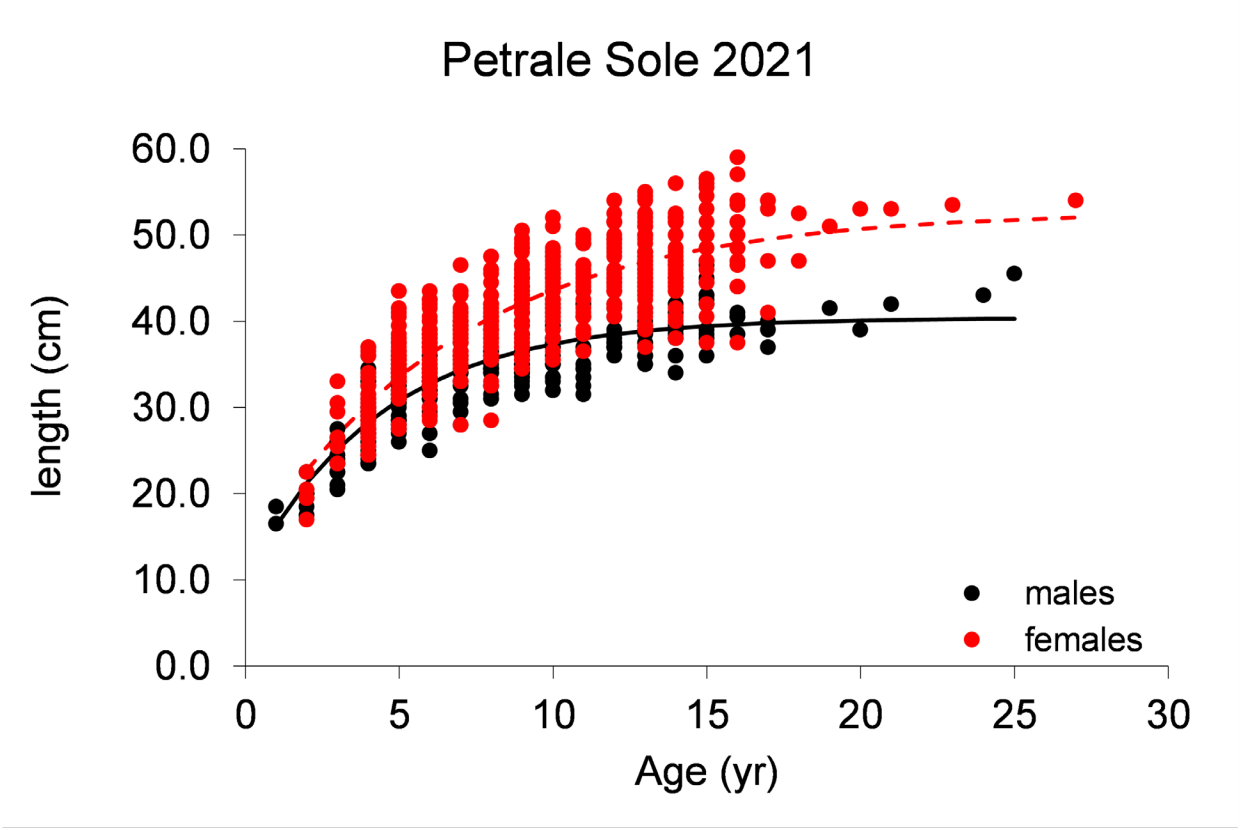
Table 18. Parameters of the von Bertalanffy growth model: L_t (fork length, cm) at age t (years), L_∞ (theoretical maximum fork length, cm), k (growth rate per year), and t_0 (theoretical age, in years) for petrale sole and canary rockfish, by sex (F = female and M = male) and overall (All = female, male, and undetermined).

a) Petrale sole

sex	L_∞ (±SE)	k (±SE)	t_0 (±SE)	n
F	52.75 (1.24)	0.149 (0.016)	–1.790 (0.499)	473
M	40.39 (0.58)	0.231 (0.021)	–1.239 (0.362)	325
All	48.80 (0.91)	0.162 (0.014)	–1.667 (0.388)	798

b) Canary rockfish

sex	L_∞ (±SE)	k (±SE)	t_0 (±SE)	n
F	55.68 (0.84)	0.142 (0.007)	–0.611 (0.177)	203
M	49.76 (0.48)	0.169 (0.006)	–0.510 (0.122)	217
All	52.53 (0.45)	0.152 (0.004)	–0.683 (0.074)	468



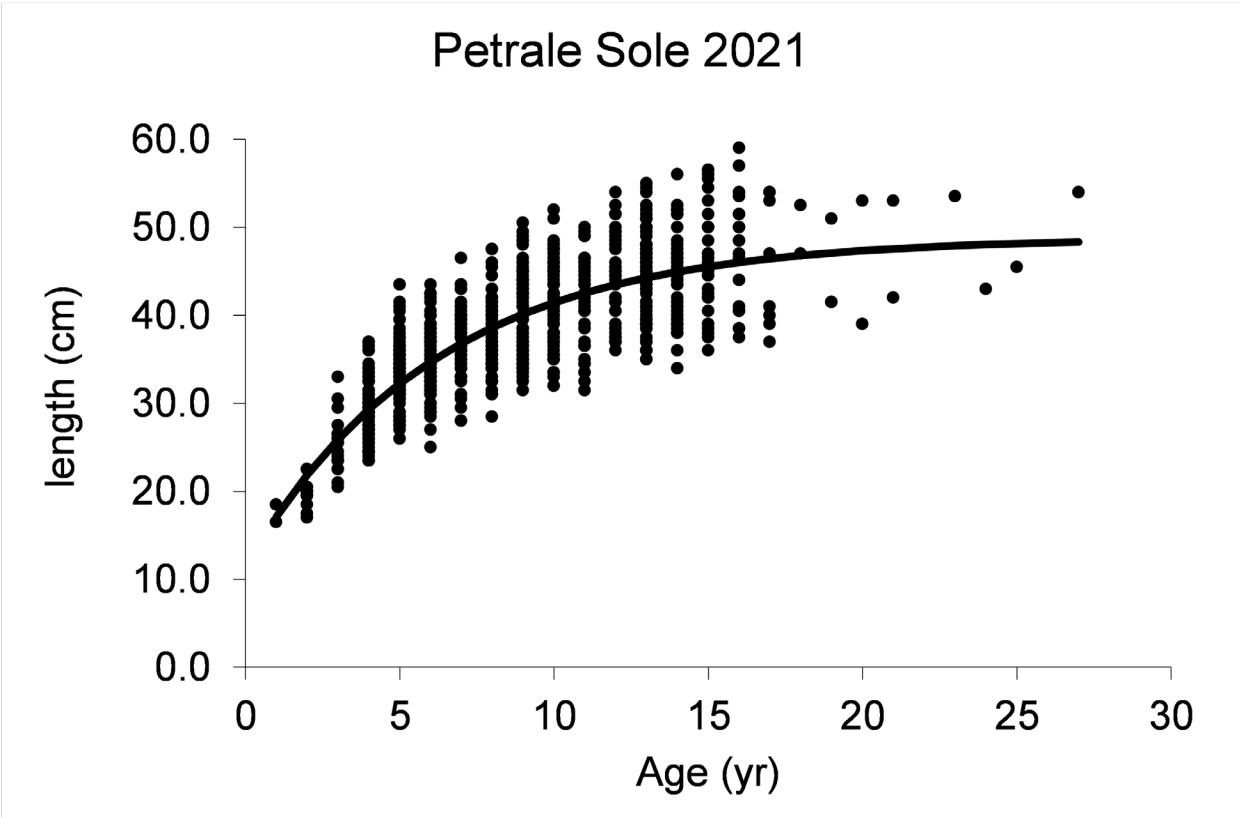


Figure 52. Length-at-age plots for (top) female (red circles) and male (black circles) petrale sole, and (bottom) all petrale sole (male and female combined), from the 2021 West Coast Groundfish Bottom Trawl Survey. We show parameter estimates, L_{∞} (cm), k (per yr), and t_0 (yr) for fitted von Bertalanffy curves in Table 18.

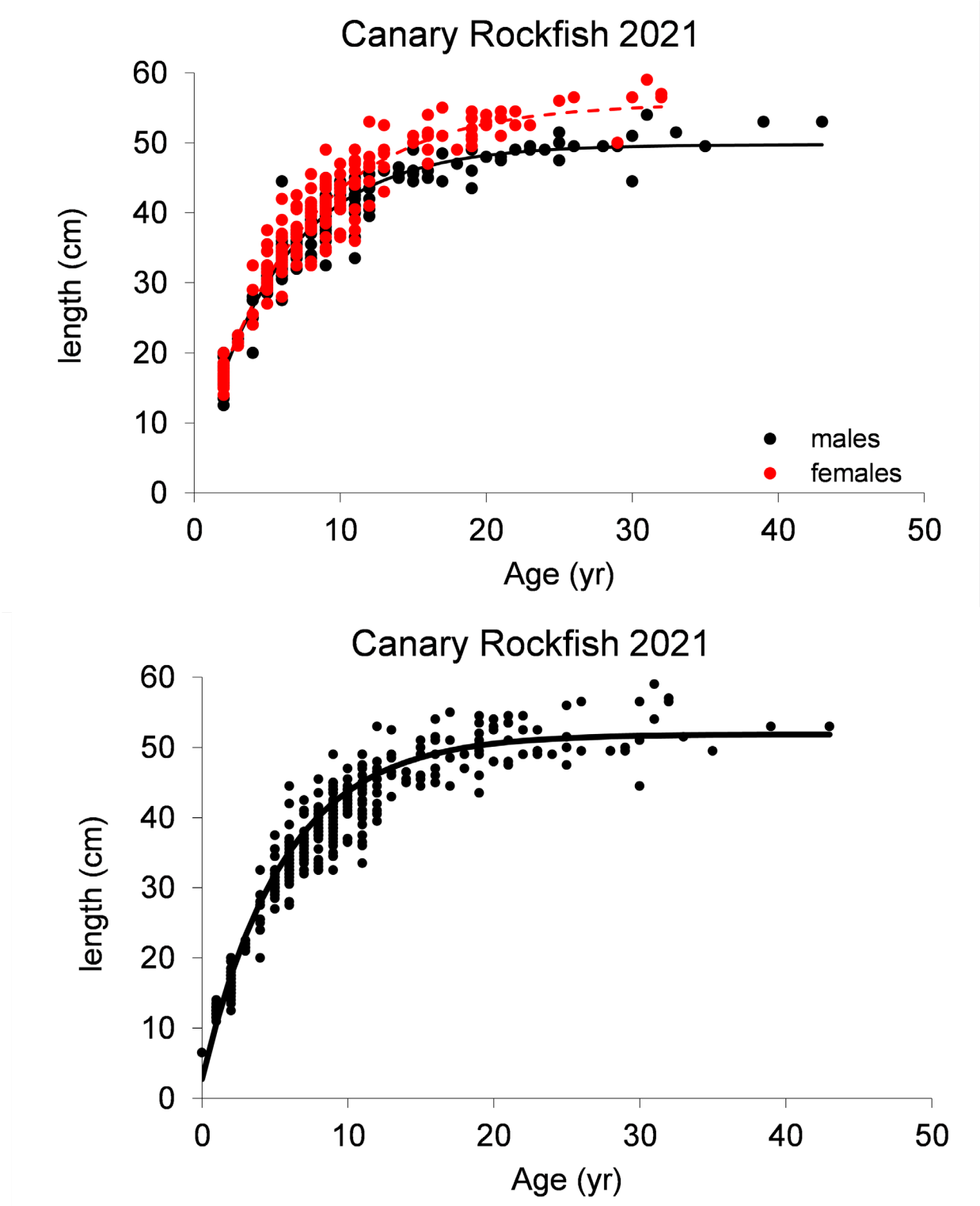


Figure 53. Length-at-age plots for (top) female (red circles) and male (black circles) canary rockfish, and (bottom) all canary rockfish (male, female, and undetermined), from the 2021 West Coast Groundfish Bottom Trawl Survey. We show parameter estimates, L_{∞} (cm), k (per yr), and t_0 (yr) for fitted von Bertalanffy curves in Table 18.

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