OCNMS recruitment analysis: Black and yellowtail rockfish complex

Nick Tolimieri & Ole Shelton

2025-02-06

These are derived data products relevant to estimating recruitment (young-of-year abundance) of the black rockfish (*Sebastes melanops*) and yellowtail rockfish (*S. flavidus*) complex (BYT); the data source is the NWFSC dive survey in Olympic Coast National Marine Sanctuary (OCNMS) conducted between 2015 and 2024. We estimate recruitment for the BYT domplex because it is difficult to distinguish small recruits for these species. Description of survey methods and aims are detailed in (Tolimieri et al. 2023). We also estimate an abundance index for large (>10 cm total length) black rockfishes and provide a size class analysis. We do not include large yellowtail rockfish because they are rarely seen on our dive surveys in this area.

Data description

Divers on SCUBA conducted in situ surveys to count fish at each site along benthic belt transects (30 m by 2 m) following procedures modified from Malone et al. (2022). Transects were conducted within or directly adjacent to canopy kelp beds (consisting of giant *Macrocystis pyrifera* or bull *Nereocystis luetkeana* kelps). In 2015 surveyed at 10 sites and conducted four (4) transects per site at 5 m depth (Fig. 1, (Shelton et al. 2018)). From 2016 on, we surveyed at five (5) sites (Fig. 1), sampling at two (2) locations within each site separated by >100 m, and 2 depths within each location (5 and 10 m) Our goal was to complete six (6) replicate transects at each year-site-depth combination (Tolimieri et al. 2023).

During each fish transect, we counted and estimated the size (total length to nearest cm) of all fishes >5 cm total length; the exception was rockfishes *Sebastes* spp., for which we estimated sizes of all individuals. Rockfishes $\leq$ 10 cm were considered young-of-year. Divers also estimated horizontal visibility on each transect by determining the distance at which the lead diver could distinguish their buddy's extended fingers. Transects with visibility less than 2 m were excluded from analyses.

As noted above, it is difficult to visually distinguish many rockfish species when they are small. Therefore, on our surveys, we categorized juvenile rockfishes into five (5) groups established in the literature (Johansson et al. 2018; Markel and Shurin 2020):

(1) Yellowtail and black (YTB) included both yellowtail (*S. flavidus*) and black (*S. melanops*) rockfishes

(2) The copper/quillback/brown (CQB) group included copper (*S. caurinus*), quillback (*S. maliger*), and brown (*S. auriculatus*) rockfishes

(3) Canary (*S. pinniger*)

(4) Blue rockfish (*S. mystinus*)

(5) Unidentified individuals were categorized as juvenile rockfishes

The estimated recruitment trend for (1) the black rockfish and yellowtail rockfish complex (BYT complex), is presented here.

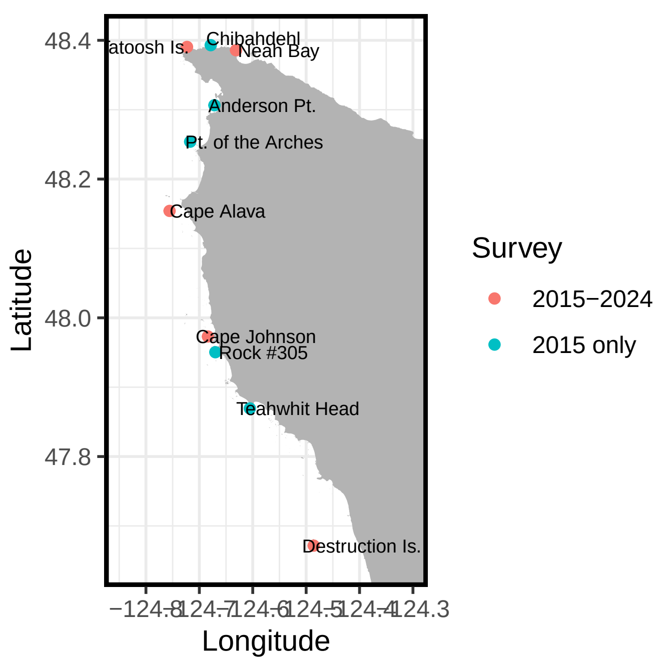

Figure 1: Dive survey locations along the coast of Washington state.

Transects were omitted from analyses if the horizontal visibility was <2 m. The following tables (Table 2) show how the number fish transects with visibility >2 m were distributed across depth, site, and years (Table 1), as well as across sites and year (Table 2). 2015 includes only surveys conducted at 5-m depth; other years have data approximately evenly split between 5-m and 10-m depths.

Table 1: Number of transects conducted by year, site and depth zone. Only transects that had at least 2m visibility are included

Year	Zone	Destruction Island	Cape Johnson	Cape Alava	Tatoosh Island	Neah Bay	Total
2016	5	0	4	6	4	4	18
2016	10	3	6	6	4	6	25
2017	5	3	5	4	3	4	19
2017	10	0	4	6	4	4	18
2018	5	0	4	4	8	4	20
2018	10	0	3	8	7	8	26
2019	5	4	4	8	8	7	31
2019	10	8	7	8	6	8	37
2021	5	4	8	7	8	8	35
2021	10	3	8	7	6	8	32
2022	5	0	0	4	8	8	20
2022	10	0	0	7	6	5	18
2023	5	6	8	8	8	10	40
2023	10	4	9	8	8	7	36
2024	5	0	0	4	4	4	12
2024	10	3	0	3	9	9	24

Table 2: Number of transects conducted by year and site. Only transects that had at least 2-m visibility are included

Site	2016	2017	2018	2019	2021	2022	2023	2024
Destruction Island	3	3	0	12	7	0	10	3
Cape Johnson	10	9	7	11	16	0	17	0
Cape Alava	12	10	12	16	14	11	16	7
Tatoosh Island	8	7	15	14	14	14	16	13
Neah Bay	10	8	12	15	16	13	17	13
TOTAL	43	37	46	68	67	38	76	36

Abundance trends

Recruitment: BYT young-of-year abundance trends

To calculate the average density of BYT complex in each year, we first calculate the mean density and standard error per site in each year. This approach means we are treating each transect as a i.i.d. sample of YOY density within each site and thus we ignore differences in abundance by depth zone.

From these site-year level means, we calculated a year-specific mean density by simulation. Specifically, for each year we independently drew a mean density for each site using a t-distribution with μ (the estimated site mean), σ (the estimated site-specific standard error) and degrees of freedom, τ. So for the i^{th} realization, for site s in year y we have a predicted density, X_{isy}

$$X_{isy} \sim T(\mu_{sy}, \sigma_{sy}, \tau_{sy}) \tag{1}$$

(2)

and then the predicted density for a single realization in a given year is the mean among sites observed. We repeat the simulation 100,000 times to provide an estimated mean density and uncertainty for a given year (Fig. 2).

Nearly all small rockfish fall into the 4 to 7 cm length range and all are considered to have recruited from the plankton during the calender year of the survey. Therefore, we view the density of <10cm rockfish to be an indicator of recruitment for the black/yellowtail rockfish complex (Fig. 2).

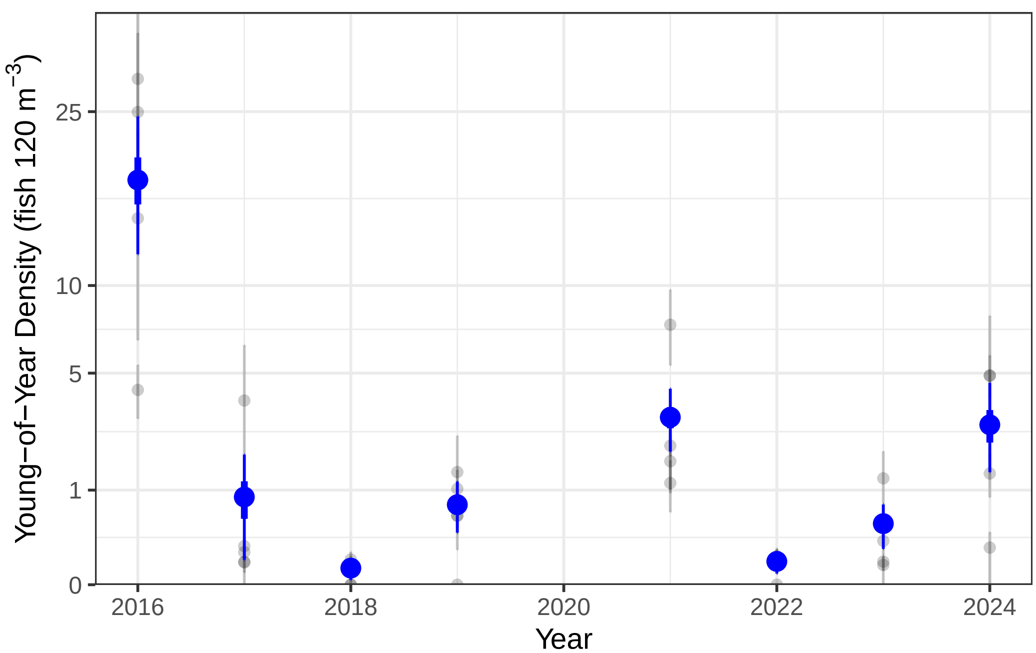

Figure 2: Time-series of estimated young-of-year rockfish (black-yellowtail complex) density on the Washington coast. Black points show means and standard errors for individual sites. Blue points show coastwide density estimates, interquartile range and 95% intervals for each year. Note y-axis is square root.

Large (>10 cm total length) black rockfish

We used the same approach as above to calculate the average density of large black rockfish in each year (Fig. 3). Yellowtail rockfish are not common in our dive surveys and are not considered below.

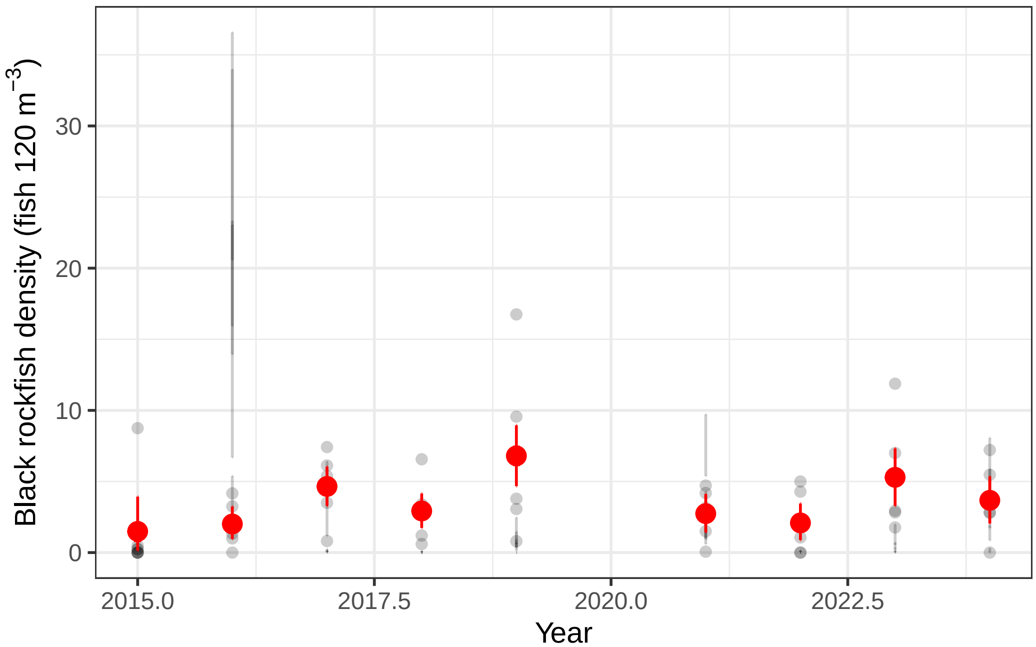

Figure 3: Time-series of estimated black rockfish density on the Washington coast. Black points show means and standard errors for individual sites. Red points show coast-wide density estimates, interquartile range and 95% intervals for each year

Information on size data for black rockfish 2015-2024

In addition to abundance data, we visually estimate size (total length) for all individuals observed during the surveys. Young-of-year show remarkably limited variation in size and so we exclude them from the analysis. The data here are for black rockfish; yellowtail are not presented because the adults are uncommon at our sites.

Plots of size distribution grouped into 5 cm bins (Figs. 4 & 5).

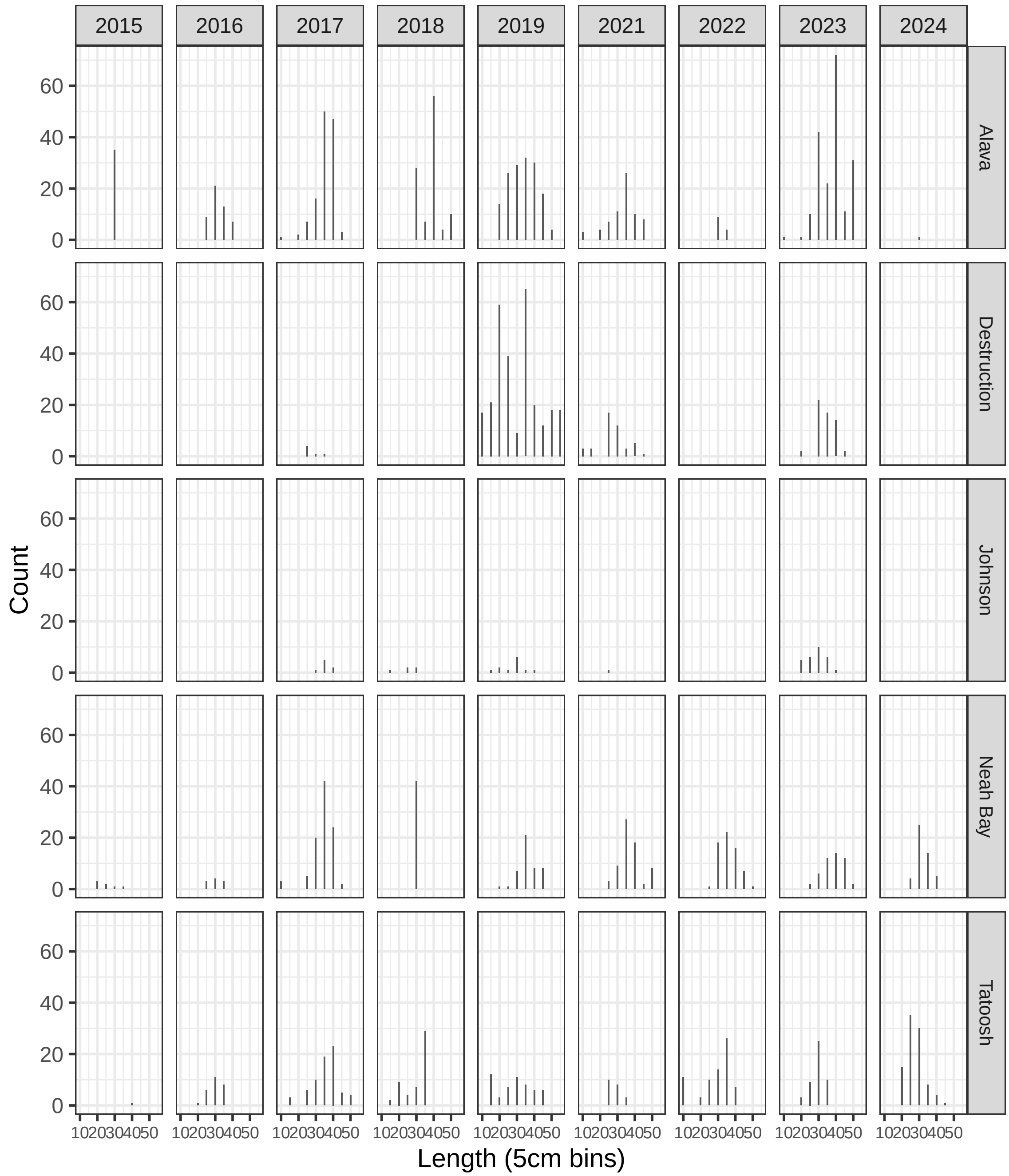

Figure 4: YOY size distribution by 5-cm size bins.

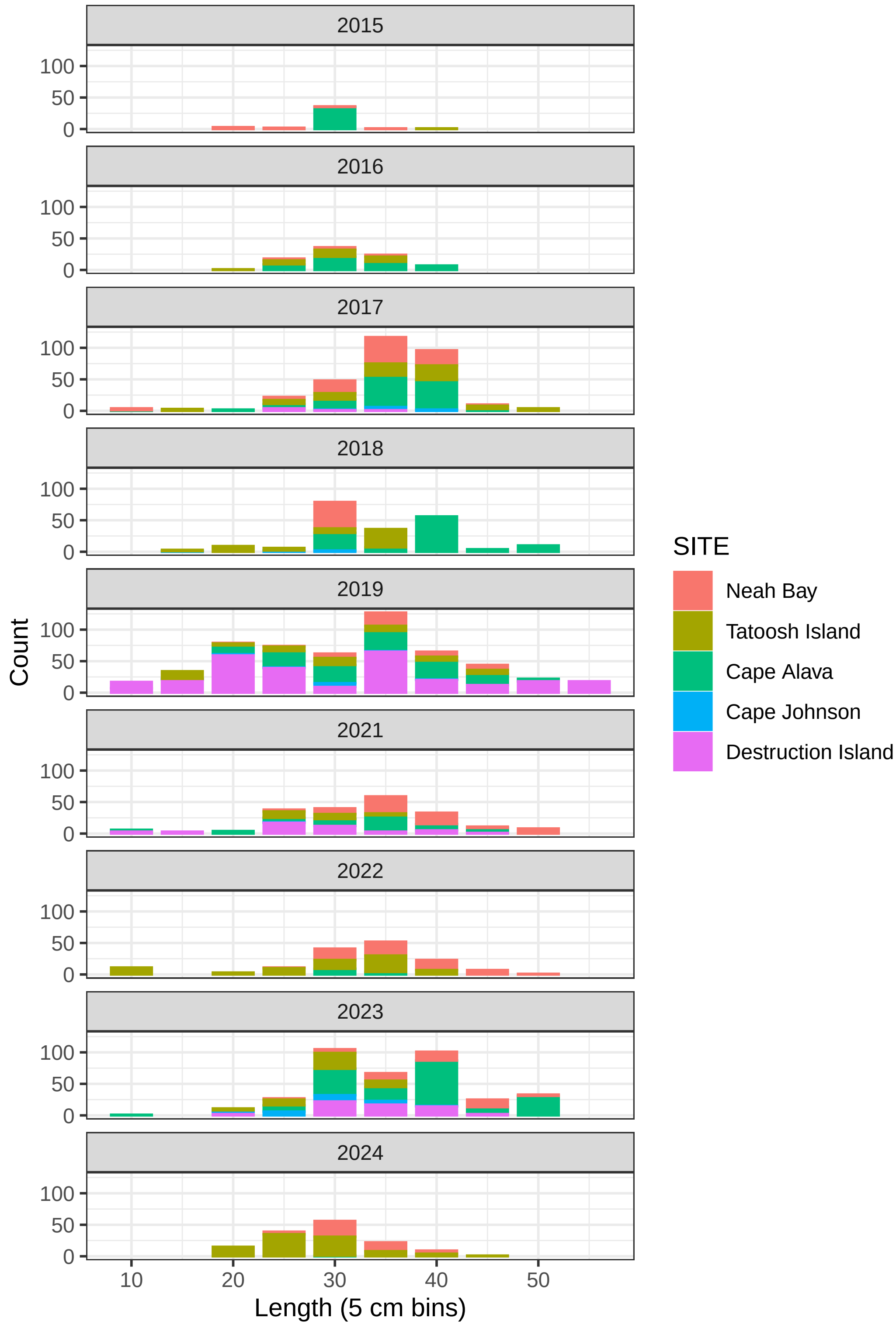

Figure 5: YOY size distribution by 5-cm size bins plotted by site.

While nominally sizes are recorded in 1-cm increments, in practice sizes in 5cm increments are recorded (Fig. 6).

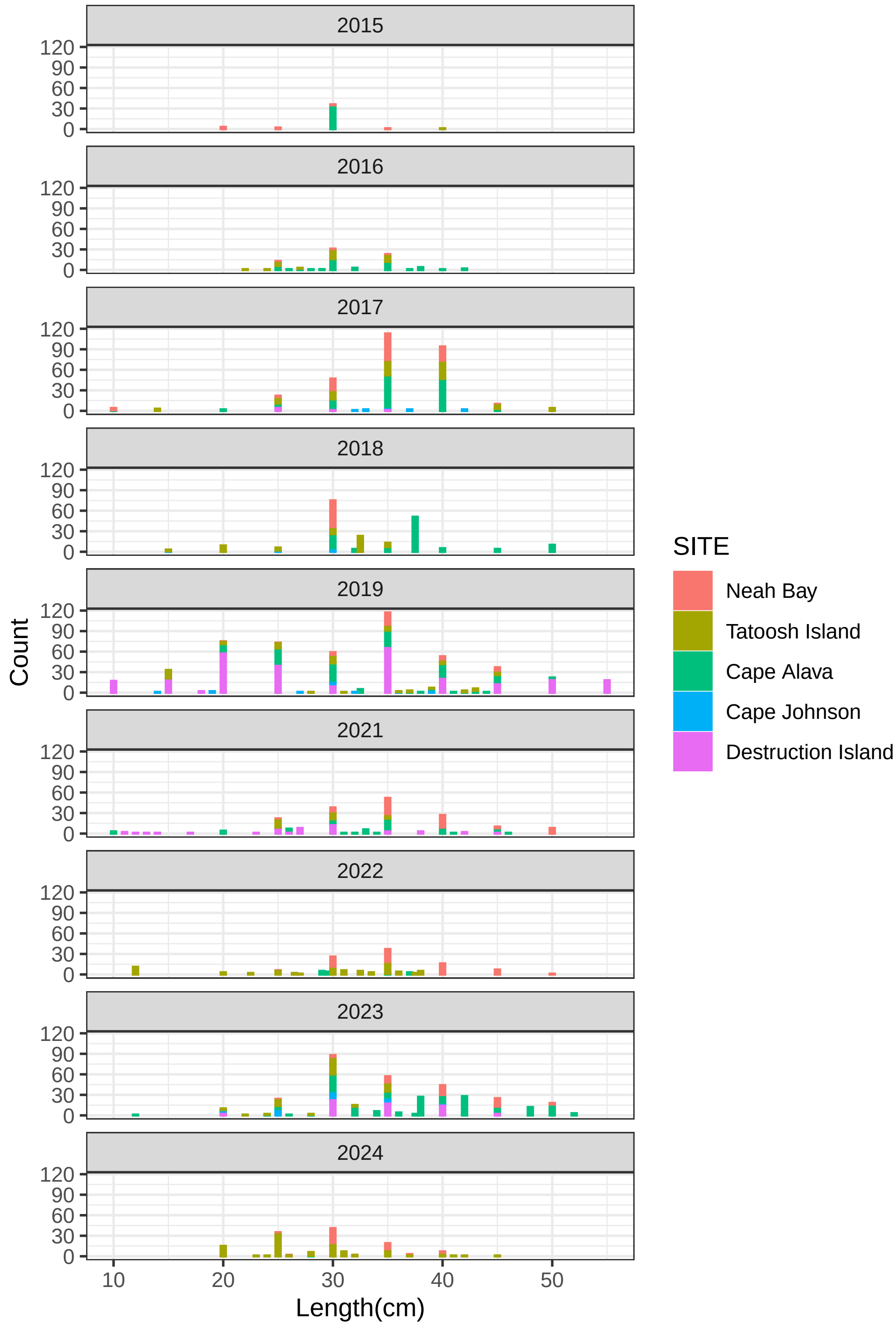

Figure 6: Plots of size distribution, but without 5cm bins.

References

Johansson ML, Litz MN, Brodeur RD, et al (2018) Seasonal distribution of late larval and juvenile rockfish (*Sebastes* spp.) and associated environmental conditions off Oregon and Washington: new insights based on genetics. Fishery Bulletin 266–291

Malone DP, Davis K, Lonhart SI, et al (2022) Large-scale, multidecade monitoring data from kelp forest ecosystems in California and Oregon (USA)

Markel RW, Shurin JB (2020) Contrasting effects of coastal upwelling on growth and recruitment of nearshore Pacific rockfishes (genus *Sebastes*). Canadian Journal of Fisheries and Aquatic Sciences 77:950–962

Shelton AO, Harvey CJ, Samhouri JF, et al (2018) From the predictable to the unexpected: kelp forest and benthic invertebrate community dynamics following decades of sea otter expansion. Oecologia 188:1105–1119

Tolimieri N, Shelton AO, Samhouri JF, et al (2023) Changes in kelp forest communities off Washington, USA, during and after the 2014-2016 marine heatwave and sea star wasting syndrome. Marine Ecology Progress Series 703:47–66