



Rocky Intertidal Monitoring

2017–2018 Results from Redwood National and State Parks

Natural Resource Report NPS/KLMN/NRR—2022/2425



ON THE COVER

Researchers sampling the intertidal community at Enderts Beach, Redwood National and State Parks.

Photograph by: David Lohse

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Contents

	Page
Figures.....	v
Tables.....	vii
Executive Summary	viii
Acknowledgments.....	ix
Introduction.....	1
Study Area	4
Methods.....	6
Community Structure Surveys	6
Sample Design.....	6
Field Log	6
Photoplots.....	6
Sea Stars	8
Surfgrass and Sea Palm Abundance	8
Mussel Measurement.....	8
Sea Surface Temperature.....	9
Coastal Biodiversity Surveys	9
Sample Design.....	9
Point Contact Surveys	10
Quadrat Sampling.....	10
Swath Transects.....	11
Topography Surveys.....	11
Data Collection and Entry	11
Data Analysis	12
Results.....	13
Community Structure Surveys	13
Field Log	13

Contents (continued)

	Page
Photoplots	15
Sea Star Plots	28
Mussel Measurements	30
Surfgrass and Sea Palm Transects	32
Sea Surface Temperature.....	32
Coastal Biodiversity Surveys	33
Point Contact Surveys and Quadrat Sampling	33
Swath Transects.....	41
All Taxa Recorded.....	41
Conclusion	42
Literature Cited	43
Appendix: Species List	44

Figures

	Page
Figure 1. Map of northern California showing the locations of the study sites sampled in the spring and fall of each year within Redwood National and State Parks.	4
Figure 2. Photographs depicting the 5 target species sampled in permanent photoplots in Redwood National and State Parks.	7
Figure 3. Example diagram of biodiversity grid set up (left) and photograph of grid set up (right). Baselines on the figure refer to monumented reference lines.	9
Figure 4. Example schematic diagram of mobile invertebrate quadrat sampling (blue squares) along biodiversity transect lines.	11
Figure 5. Mean percent cover of the most common taxa or substrate in the barnacle (<i>Balanus/Chthamalus</i>) photoplots during 2017 surveys.	16
Figure 6. Mean percent cover of the most common taxa or substrate in the barnacle (<i>Balanus/Chthamalus</i>) photoplots during 2018 surveys.	17
Figure 7. Mean percent cover of the most common taxa or substrate in turfweed (<i>Endocladia muricata</i>) photoplots during 2017 surveys.	19
Figure 8. Mean percent cover of the most common taxa or substrate in turfweed (<i>Endocladia muricata</i>) photoplots during 2018 surveys.	20
Figure 9. Mean percent cover of the most common taxa or substrate in the rockweed (<i>Fucus gardneri</i>) photoplots during 2017 surveys.	22
Figure 10. Mean percent cover of the most common taxa or substrate in the rockweed (<i>Fucus gardneri</i>) photoplots during 2018 surveys.	23
Figure 11. Mean percent cover of the most common taxa or substrate in dwarf rockweed (<i>Pelvetiopsis limitata</i>) photoplots during 2017 surveys.	24
Figure 12. Mean percent cover of the most common taxa in dwarf rockweed (<i>Pelvetiopsis limitata</i>) photoplots during 2018 surveys.	25
Figure 13. Mean percent cover of the most common taxa or substrate in mussel (<i>Mytilus californianus</i>) photoplots during 2017 surveys.	26
Figure 14. Mean percent cover of the most common taxa or substrate in mussel (<i>Mytilus californianus</i>) photoplots during 2018 surveys.	27
Figure 15. Size distributions of ochre sea stars (<i>Pisaster ochraceous</i>) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 and 2018.	29

Figures (continued)

	Page
Figure 16. Size distributions of mussels (<i>Mytilus californianus</i>) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 and 2018.....	31
Figure 17. Sea surface temperatures from 3 Redwood National and State Parks sites in 2017–2018.....	33
Figure 18. Percent cover of the most common taxa and substrate recorded during biodiversity surveys at Enderts Beach in 2018.	34
Figure 19. Percent cover of the most common taxa and substrate recorded during biodiversity surveys at Damnation Creek in 2017.	35
Figure 20. Percent cover of the most common taxa and substrate recorded during biodiversity surveys at False Klamath Cove in 2017 and 2018.....	36
Figure 21. Density of the most common mobile taxa recorded during biodiversity surveys at Enderts Beach in 2018.	38
Figure 22. Density of the most common mobile taxa recorded during biodiversity surveys at Damnation Creek in 2017.	39
Figure 23. Density of the most common mobile taxa recorded during biodiversity surveys at False Klamath Cove in 2017 and 2018.	40

Tables

	Page
Table 1. Summary of species monitored in photoplots at Redwood National and State Park sites including number of replicate plots.	7
Table 2. Sampling locations and dates for rocky intertidal monitoring at Redwood National and State Parks, 2017–2018.	12
Table 3. Field conditions for sampling trips in 2017 and 2018 at 3 intertidal sites within Redwood National and State Parks.	13
Table 4. Common shorebirds observed at Redwood National and State Parks monitoring sites during intertidal sampling trips in 2017–2018 (maximum seen at any 1 time).	14
Table 5. Number of total individuals (n) sampled and mean size for ochre sea stars (<i>Pisaster ochraceous</i>) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 (SU17) and 2018 (SU18).	30
Table 6. Mean bed depth, individual length, and ratio of depth to length for mussels (<i>Mytilus californianus</i>) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 (SU17) and 2018 (SU18).	32

Executive Summary

This report presents the results of the monitoring surveys done in 2017 and 2018 of the rocky intertidal community at 3 sites within the Redwood National and State Parks (RNSP) in Del Norte County, California. These sites are part of MARINe (Multi-Agency Rocky Intertidal Network), a regional intertidal monitoring network sponsored by the Bureau of Ocean Energy Management (BOEM), with additional funding and support from local and state governments, universities, and private organizations (see www.marine.ucsc.edu). Funding for annual monitoring in RNSP is provided by the National Park Service (NPS) Klamath Network (KLMN) through a cooperative agreement with the University of California at Santa Cruz (UCSC). Field sampling is accomplished through a collaborative effort between UCSC and RNSP staff. The 2017 and 2018 field crews each consisted of 4 UCSC biologists and 3 RNSP staff members.

This monitoring program, adapted from MARINe protocols, was designed to identify and follow temporal trends in populations of the common and/or ecologically important organisms in the rocky intertidal community at 3 index sites within the RNSP. To accomplish this, sites are sampled once a year, and data are collected from permanent plots established to monitor changes in sessile invertebrates, algae, and the ochre sea star (*Pisaster ochraceus*), and from permanent transects to monitor surfgrass (*Phyllospadix* spp.) and sea palm (*Postelsia palmaeformis*). These data are utilized to determine annual status of the community, and archived for future use to explore broader spatial and temporal trends.

All of the monitored populations varied to some degree over the course of 2017–2018.

The KLMN rocky intertidal monitoring program (“RNSP rocky intertidal monitoring program” in previous reports), which started in RNSP in 2004, continues to progress successfully. The procedures for data collection, data management, data analysis, and reporting are regularly assessed and have undergone some revisions based on the evolution of the monitoring program (Ammann and Raimondi 2008; protocol revision in progress [Eric Dinger, National Park Service ecologist, pers. comm., Feb 24, 2022]). As such, this year’s report contains some departures from past years’ reports. New to this report is the inclusion of broader scale biodiversity data collected through Coastal Biodiversity Survey protocol. These biodiversity data are sampled at 2 of the 3 sites every sampling period. This report begins a shift away from previous full summary annual reports that contained in-depth analyses towards a simpler data summary. It also reports on optional MARINe protocol data we collected that are not part of the KLMN rocky intertidal protocol (e.g., mussel sizes and sea palm measurements). Some of these optional data measurements may be discontinued in future years. Subsequent reports will follow this format, with some simplification. More comprehensive trend analyses of the data are available in the program’s 5-year trend reports, the first of which included data through 2013 (Ammann et al. 2017).

Acknowledgments

We thank the 2017–2018 field crew for their hard work and dedication to the project: Maya George, Laura Anderson, Nathan Fletcher, and Melissa Douglas. We also appreciate the field assistance from Redwood National and State Parks staff including David Anderson, Terry Hines, Kyle Max, Heather Brown, and numerous seasonal staff and volunteers. Allison Snyder, Sonya Daw, and Alice Chung-MacCoubrey from the Klamath Network have provided editorial, technical, and data assistance. Dr. Pete Raimondi (UCSC) is the Principal Investigator for the cooperative agreement and field work at Redwood National and State Parks.

Introduction

Among the many concerns of resource managers is the ability to detect and mitigate the effects of anthropogenic events, like oil spills and climate change, which can alter the structure of natural communities. An important tool needed to accomplish this is long-term monitoring programs that establish baseline data and follow changes over time (Davis 2005). Such programs provide important information needed to distinguish natural changes in community structure from those caused by unnatural/anthropogenic events. As such, a consortium of monitoring programs has been established for rocky intertidal habitats, including protocols used in Redwood National and State Parks (RNSP) as part of the Klamath Inventory and Monitoring Network (KLMN) vital signs monitoring programs.

The Bureau of Ocean Energy Management (BOEM), part of the U.S. Department of Interior, and the Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO) have been working in concert with a number of academic and government organizations to monitor intertidal zones along the western coast of North America, from Alaska to California. Community Structure Surveys of the rocky intertidal zone have been conducted by PISCO and members of Multi-Agency Rocky Intertidal Network (MARINE), a monitoring consortium including over 20 coastwide agencies. Several other coastal national parks, including Cabrillo National Monument, Golden Gate National Recreation Area, Point Reyes National Seashore, and Channel Islands National Park, have intertidal monitoring programs to 1) establish baseline datasets of their marine resources, and 2) follow changes in these resources (Davis and Halvorson 1996; Davis 2005). Because such monitoring allows changes to be tracked within and between communities over yearly time scales, it provides critical information needed to make informed management decisions. Further, understanding these patterns is necessary for detecting changes resulting from disturbances such as oil spills or global climate change.

The Community Structure Surveys were initiated in the early 1990s to determine abundance and distributional patterns of intertidal species along the southern California coast (Ambrose et al. 1992). Since then, sites have been added in central and northern California, Oregon, Washington, and Alaska. The Klamath Network has adapted the protocols used in these surveys (Engle 2005) to monitor the intertidal communities within RNSP (Ammann and Raimondi 2008). This facilitates comparisons between the RNSP sites and those elsewhere along the coast.

The specific monitoring objectives of the KLMN rocky intertidal monitoring program (“RNSP rocky intertidal monitoring program” in previous reports), conducted at RNSP, include the following:

- Monitor the temporal dynamics of target invertebrate, algal, and surfgrass species at accessible, representative, and historically sampled rocky intertidal sites at Redwood National and State Parks that can feasibly be monitored with the Klamath Inventory and Monitoring Network’s intertidal monitoring budget (\$30k/y) with the goal to 1) evaluate potential impacts of visitor use or other park-specific activities, and 2) provide monitoring information to help assess level of impacts and changes outside normal limits of variation due to oil spills, nonpoint source pollution, or other anthropogenic stressors that may come from outside the parks.

- Determine status through time of morphology, disease/condition, and other key parameters describing population status (e.g., size, structure) of the selected intertidal organisms.
- Integrate with and contribute to a monitoring network spanning a broad geographic region in order to evaluate trends at multiple scales, from parkwide to regionwide.
- Detect and document invasions, changes in species ranges, the spread of diseases, and the rates and scales of processes affecting the structure and function of rocky intertidal populations and communities to better understand normal limits of variation.

The specific measurement and analysis objectives of the program follow:

- Provide a photographic record of sessile invertebrates and algae using fixed plots (photoplots) as reference.
- Determine the abundance (percent cover) of organisms within select fixed plots (interchangeably called photoplots or photoquadrats).
- Within fixed plots, determine the abundance of sea stars, snails, chitons, limpets, and crabs (mobile invertebrates), which may serve as an indicator of overall or specific ecosystem health.
- Determine surfgrass abundance by measuring cover along fixed point-intercept transects.
- Identify changes that are inconsistent with the established baseline conditions, whether they are park-specific or broader in scale, and whether there are potential management actions needed to mitigate them.
- Prepare annual summary reports and 5-year, peer reviewed trend analysis reports showing data relevance following National Park Service reporting guidelines. Reports will display any major (>50%) changes in the abundance of target taxa between sampling intervals as a highlight for potential management actions.
- Under optional MARINe protocols that we will implement variously from year to year, additional measurement objectives include:
 - Measure sea palms using similar methods to surfgrass abundance. This is an optional MARINe parameter and was implemented at RNSP in 2014.
 - Measure mussel sizes and bed/patch thickness using an optional MARINe protocol implemented in 2011.
- Under protocol revisions currently in preparation, the additional measurement objectives are to quantify species distribution and abundance across sites using biodiversity surveys conducted by a team of taxonomic experts, and are implemented in this study period.

The KLMN rocky intertidal monitoring program uses a park-based design with judgment selected sites that integrates with a long-term, spatially extensive program. The national parks are promoting the importance of marine resources by establishing long-term monitoring programs supported by the public and the scientific community. This effort will translate into a greater appreciation of these

resources and an awareness of the importance of maintaining them for future generations. See www.eeb.ucsc.edu/pacificrockyintertidal for more information.

This annual report documents the results of data collected in 2017–2018 for the KLMN rocky intertidal monitoring program at RNSP (Ammann and Raimondi 2008). It also documents data collected as part of MARINe optional measurements (methods used in short-term studies by the larger monitoring consortium), plus community biodiversity data collected as investigations into protocol additions and revisions.

Study Area

Three rocky intertidal sites are monitored within RNSP: Enderts Beach, Damnation Creek, and False Klamath Cove (Figure 1). These index sites are approximately 5 km apart and span the nearly 20 km of rocky intertidal habitat present in RNSP. The sites are all located in an Area of Special Biological Significance (Redwood National Park ASBS).

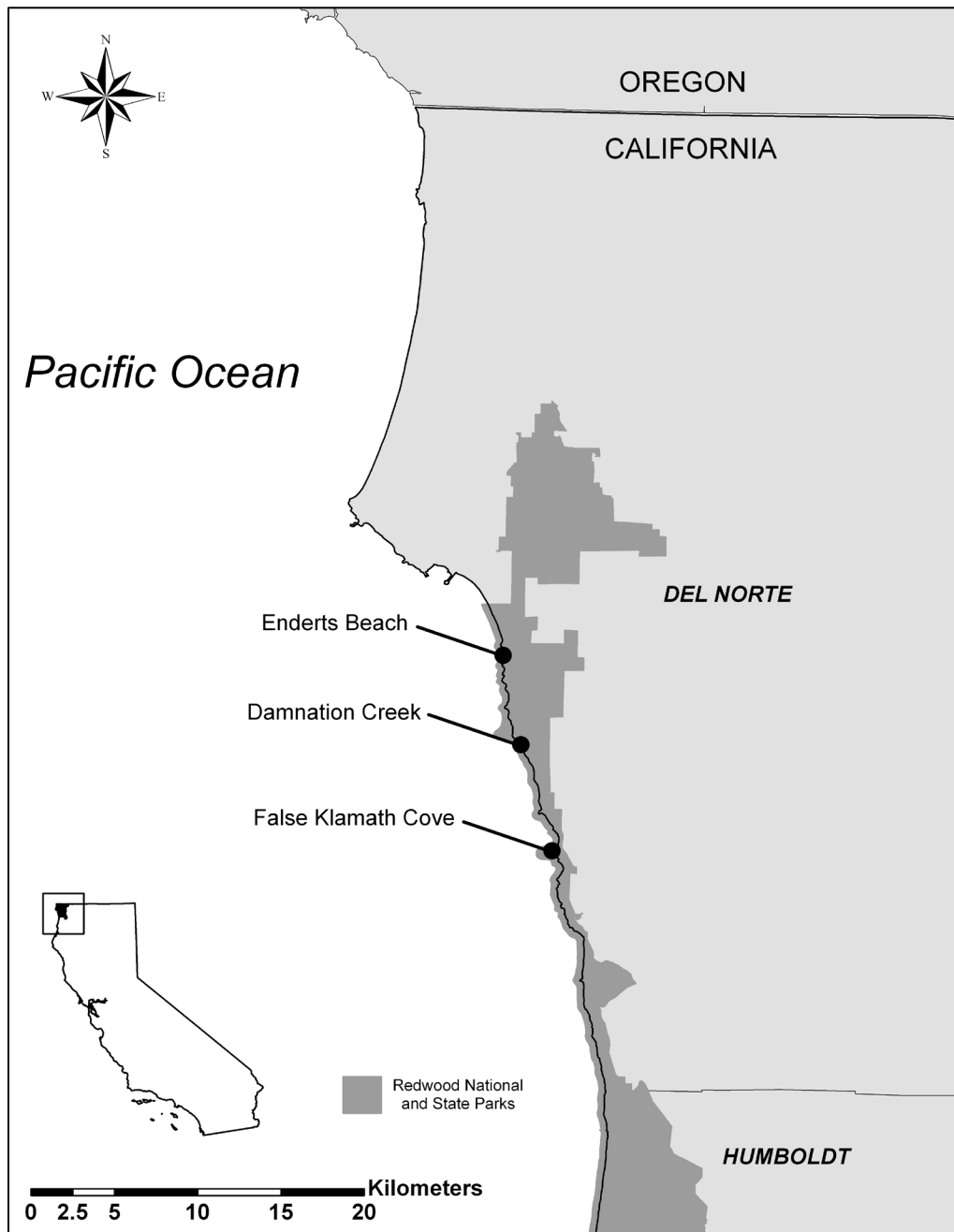


Figure 1. Map of northern California showing the locations of the study sites sampled in the spring and fall of each year within Redwood National and State Parks.

Enderts Beach, located at the southern end of Crescent Beach, is at the northern edge of RNSP. The site consists of a large, gently sloping bench (approximately 100 m wide) and a series of 3 smaller benches separated by surge channels, a few scattered boulders, and cobble beds. Rocky intertidal monitoring occurs on the 3 smaller benches. Public visitation is relatively low due to obstructed access through a cave. Enderts Beach is dominated by consolidated bedrock (greywacke mudstone/sandstone with calcite intrusions), and the area surrounding the site comprises a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west.

Damnation Creek is 5 km south of Enderts Beach and 6.5 km north of False Klamath Cove. It is an extensive rocky bench cut by channels, with a few large sedentary boulders at its seaward edge. To access this site a 45-minute steep hike is required, and then Damnation Creek must be crossed. This site receives very low visitation by hikers. Damnation Creek is dominated by a mixture of consolidated bedrock, boulders, and cobble beach. The area surrounding the site comprises a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest. Although the site is near the mouth of Damnation Creek, most of the monitoring plots are established far enough away from the creek's outflow to avoid direct freshwater input. The exception to this is a series of mussel plots established within the path of the creek's outflow.

False Klamath Cove is located just south of Wilson Creek, about 8 km north of the Klamath River. This site has variable substrata ranging from coarse sand to large boulders. There is potential for temporal variation in sand scour and boulder movement. The intertidal study site is peninsula-like with the ocean to the north and south and a sea stack (approximately 75 m tall and 100 m wide) at the west end. The primary coastal orientation of this site is west. The peninsula stretches approximately 250 m long with a width of approximately 100 m. The site consists of a gently sloping field of boulders and small benches dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site comprises a mixture of consolidated bedrock, boulder fields, and sandy beach. The vast majority of the sampling takes place on variously sized boulders.

Methods

Community Structure Surveys

Sample Design

The methods used for monitoring algal and invertebrate species in RNSP during the 2017–2018 monitoring years, and since monitoring began in 2004, are based on protocols developed by MARINe (marine.ucsc.edu). Protocols are explained in detail in Ammann and Raimondi (2008). In brief, the abundance of ecologically important organisms is measured in discrete, fixed plots that have been established in targeted assemblages. Using fixed plots allows the dynamics of species to be monitored with reasonable sampling effort and provides greater statistical power to detect changes over time, but limits the statistical inference. Smaller (50×75 cm) plots are used to monitor sessile (or relatively nonmotile) algae and invertebrates. Larger, irregular plots are used to sample more mobile species. Transects (10 m) are used to sample surfgrass and sea palm. Data collection and reporting for 2017–2018 also include parameters measured as part of short-term MARINe monitoring (<https://marine.ucsc.edu/methods/index.html>) but that are not required by the KLMN protocol.

Field Log

Field logs were kept to provide a record of general observations made during the surveys at the monitoring sites. Recorded observations included weather conditions, participants, changes to or deviations from the protocols, and any unique or unusual occurrences. Physical and weather-related conditions were collected initially upon reaching the site, as were counts of birds, marine mammals, and humans. These data included: tidal information, temperature, wind, levels of rain, sand scour, plant wrack, dead animals, and trash.

Photoplots

At each site, photoplots (50×75 cm) were used to record changes in abundance (measured as percent cover) of conspicuous, abundant, and ecologically important species, including mussels (*Mytilus californianus*), barnacles (*Chthamalus dalli*/*Balanus glandula*), and 3 species of algae: turfweed (*Endocladia muricata*), dwarf rockweed (*Pelvetiopsis limitata*), and rockweed (*Fucus gardneri*) (Figure 2).

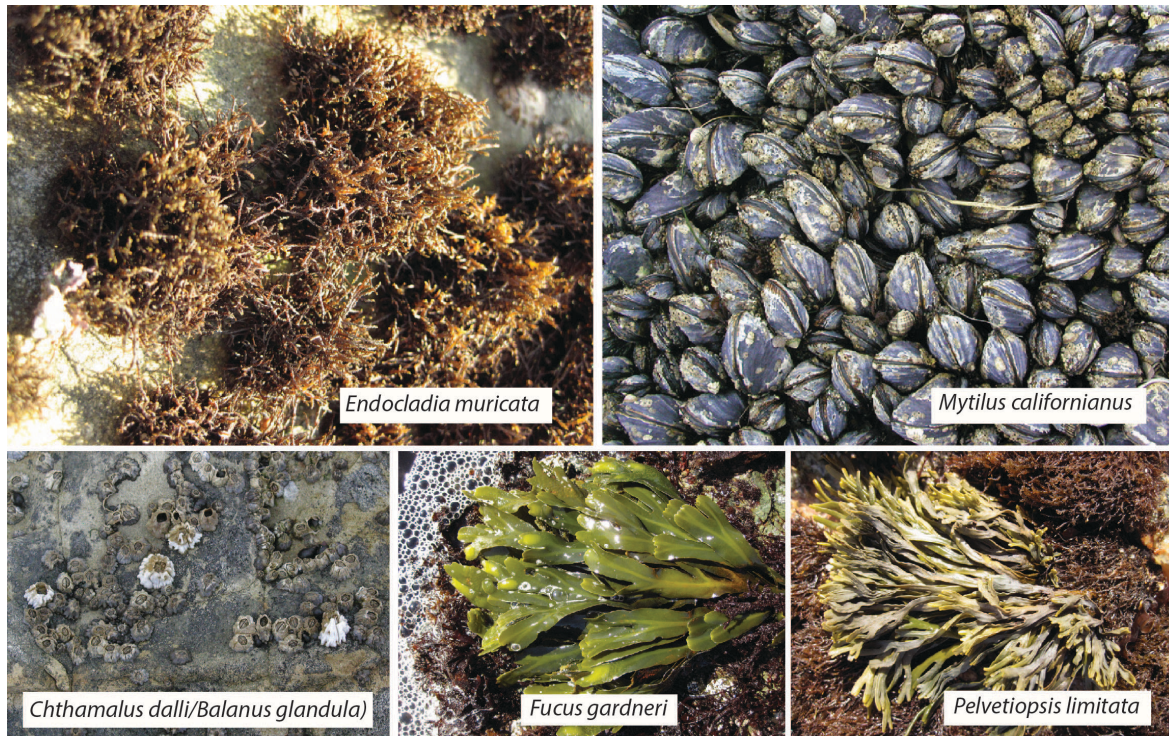


Figure 2. Photographs depicting the 5 target species sampled in permanent photoplots in Redwood National and State Parks.

Five photoplots were established for each species (Table 1), and the location of each plot was chosen to maximize the abundance of the targeted species. Because the rockweed (*Fucus*) was not abundant at Enderts Beach, and dwarf rockweed (*Pelvetiopsis*) was not abundant at Damnation Creek, no plots were set up to monitor these species at those sites. At Damnation Creek, 5 additional mussel plots were established in the outflow of Damnation Creek, where salinity is often much lower than in the other mussel plots (Cox and McGary 2006). At low tide the salinity of the water surrounding the mussel plots near Damnation Creek has been recorded to be as low as 22 ppt (parts per thousand) compared to the average ocean salinity between 32 and 35 ppt.

Table 1. Summary of species monitored in photoplots at Redwood National and State Park sites including number of replicate plots.

Site	Mussels	Barnacles	Rockweeds/Sessile algae species		
	<i>Mytilus</i> spp.	<i>Chthamalus</i> / <i>Balanus</i>	<i>Pelvetiopsis</i> <i>limitata</i>	<i>Endocladia</i> <i>muricata</i>	<i>Fucus</i> <i>gardneri</i>
Enderts Beach	5 plots	5 plots	5 plots	5 plots	–
Damnation Creek	10 plots*	5 plots	–	5 plots	5 plots
False Klamath Cove	5 plots	5 plots	5 plots	5 plots	5 plots

*Five mussel plots are located away from creek outflow and 5 plots are located near the outflow of Damnation Creek.

The photoplots were marked by 3 permanent bolts and were photographed using a digital camera mounted on a PVC photo-framer. The abundances (percent cover) of all sessile species in the photoplots were determined using a rectangular grid of 100 uniformly spaced points. This grid was placed over the plot and the taxon under each point was identified. In 2014 a new layering Standard Operating Procedure (SOP) was implemented, based on MARINe protocol, that allowed more than 1 taxon to be recorded per point whenever multiple layers were present. Apple iPads were used to record these data in the field.

Sea Stars

Irregularly-shaped, large (greater than 1×10 m) permanent plots were used to monitor the size and abundance of the ochre sea star. Three plots were monitored at Damnation Creek and False Klamath Cove, and 2 plots were sampled at Enderts Beach. These plots varied in size and were established in areas where sea stars were abundant (preferably >20 individuals per plot) and were thus not intended to quantify the overall density of sea stars at the site. Each ochre sea star encountered was counted and measured. Other rarer sea stars, such as the bat star (*Patiria miniata*), giant sea star (*Pisaster giganteus*), sunflower star (*Pycnopodia helianthoides*), six-armed star (*Leptasterias hexactis*), and leather sea star (*Dermasterias imbricate*), were also counted when encountered. *Kathrina tunacata*, the leather or Katy chiton, was also monitored in these plots. Since the onset of Sea Star Wasting Syndrome (SSWS) in 2013, monitoring groups, including the KLMN rocky intertidal team, have been recording the disease category of each sea star noted. More information and detailed sampling protocols for tracking SSWS can be found at seastarwasting.org.

Surfgrass and Sea Palm Abundance

To measure the abundance (percent cover) of surfgrass (*Phyllospadix scouleri/torreyi*), 2 permanent line transects were established at Damnation Creek. Note that surfgrass is not abundant at the other sites. Each transect was 10 m long and was sampled by noting the species under each 10 cm mark. Thickness of the surfgrass bed was measured every meter along the transects.

Starting in 2014 at False Klamath Cove, 2 permanent line transects, each 6 meters long, were established to measure the abundance (counts) of sea palm (*Postelsia palmaeformis*). Note that sea palms are not present at the other sites. Each transect line was divided into 1 m segments, and numbers of *Postelsia* were recorded in 1×1 m segments along both sides of the line. However, due to certain wave conditions and specific habitat requirements it may not be possible to sample the transects during every field survey. For example, *Postelsia* is found only in very wave exposed habitats, and therefore may not have been counted during every survey trip. This measurement is an optional MARINe parameter and may be discontinued if time limitations make it necessary to prioritize other species.

Mussel Measurement

Starting in 2011, mussel (*Mytilus californianus*) sizes and bed/patch thickness were measured within each mussel photoplot. Ten length measurements (more if the mussel bed is multilayered) and 5 mussel bed/patch depth measurements were recorded in each plot. When combined with measures of mussel spatial cover and density (number of individuals per m^2), these measurements can provide

estimates of site-wide mussel biomass. This procedure is an optional MARINe parameter and may be discontinued if time limitations make it necessary to prioritize metrics.

Sea Surface Temperature

Sea surface temperature was measured at each site using small TidbiT temperature data loggers (Onset Computer Corporation). These units were attached to the rock below the mussel zone, and set to record temperatures every 15 minutes. The units were changed out during each site visit, downloaded, and then reset for use again. Sea surface temperature was calculated only from those times of the day when the probe was underwater.

Coastal Biodiversity Surveys

Sample Design

Layered upon the above described Community Structure Surveys are the additional goals of documenting species richness and changes in the distribution of species within and among sites over time. Coastal Biodiversity Surveys, designed to capture information about the rocky intertidal community as a whole (rather than targeted species), are used to address these goals. These surveys are much more intensive and require a high-level of expertise and consistency in the identification of marine organisms.

We trialed Coastal Biodiversity Surveys for the first time in 2017. We followed the proposed schedule of conducting them at 2 of the 3 RNSP sites each year with a rotating schedule that allows for each site to be sampled twice every 3 years. These surveys are conducted along a series of parallel transect lines permanently established from the high to low intertidal zone at each site (see Figure 3). For this report, the trialed methods have been adapted from a published protocol (<https://marine.ucsc.edu/biodiversityprotocol.pdf>) available from the MARINe website (<https://marine.ucsc.edu/methods/biodiversity-methods.html>). We present a simplified summary of the methods.

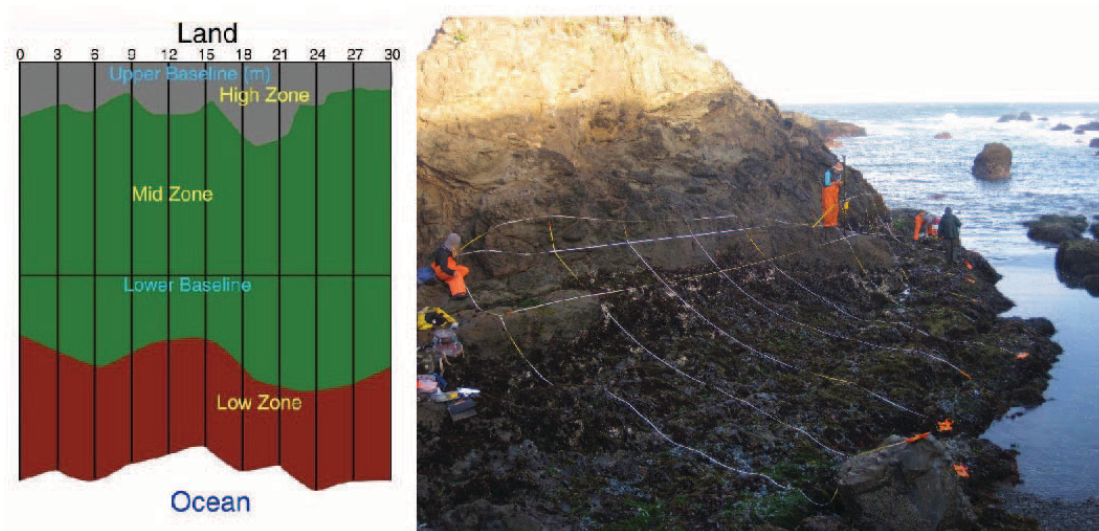


Figure 3. Example diagram of biodiversity grid set up (left) and photograph of grid set up (right). Baselines on the figure refer to monumented reference lines.

Point Contact Surveys

Point contact surveys are used to estimate the abundance and diversity of sessile intertidal taxa (algae and invertebrates). Each transect is sampled using the point intercept method to record the taxa found directly underneath approximately 100 points on each transect. Point contact data are recorded in the field directly with handheld tablet computers (i.e., Apple iPad mini) into a specially designed application created by DiveNav, Inc.

As part of the forthcoming protocol revisions, 2 variations of this method were used at RNSP sites: 1) first point only, and 2) full point. The first point method only records the identity of the top most taxa visible under each point. In contrast, the full point method identifies all taxa under each point. Thus, if there are multiple taxa under a point, such as when there is layering or epibionts on hosts, more than 1 taxa is recorded per point. In addition, if fewer than 3 taxa are recorded under a point, then data are collected on the identity of the next 1 or 2 taxa closest to that point. Both variations of point contact surveys were trialed at False Klamath Cove (full point in 2017, first point in 2018). The purpose of testing the first point method was to see if results would reduce sampling time, which could be used for cost cutting measures in the future. Comparisons of data from the 2 methods are part of protocol revisions currently in progress and are not included here. Sampling trips include days with optimal low tides as well as days with less optimal tides (thus fewer workable hours), so rotating the point contact methods at sites each year is a way to optimize our sampling efforts.

Quadrat Sampling

Quadrat sampling is used to estimate the density of mobile invertebrates. Quadrat sampling consists of recording the abundance of all mobile invertebrate species within 0.5×0.5 m quadrats randomly placed within each of the 3 biological intertidal zones (high, mid, and low) along each transect (see Figure 4). Three quadrats are sampled along each transect, for a total of 33 quadrats per site. Similar to point contact surveys above, at False Klamath Cove, we utilized full-point methods in 2017 and first point methods in 2018.

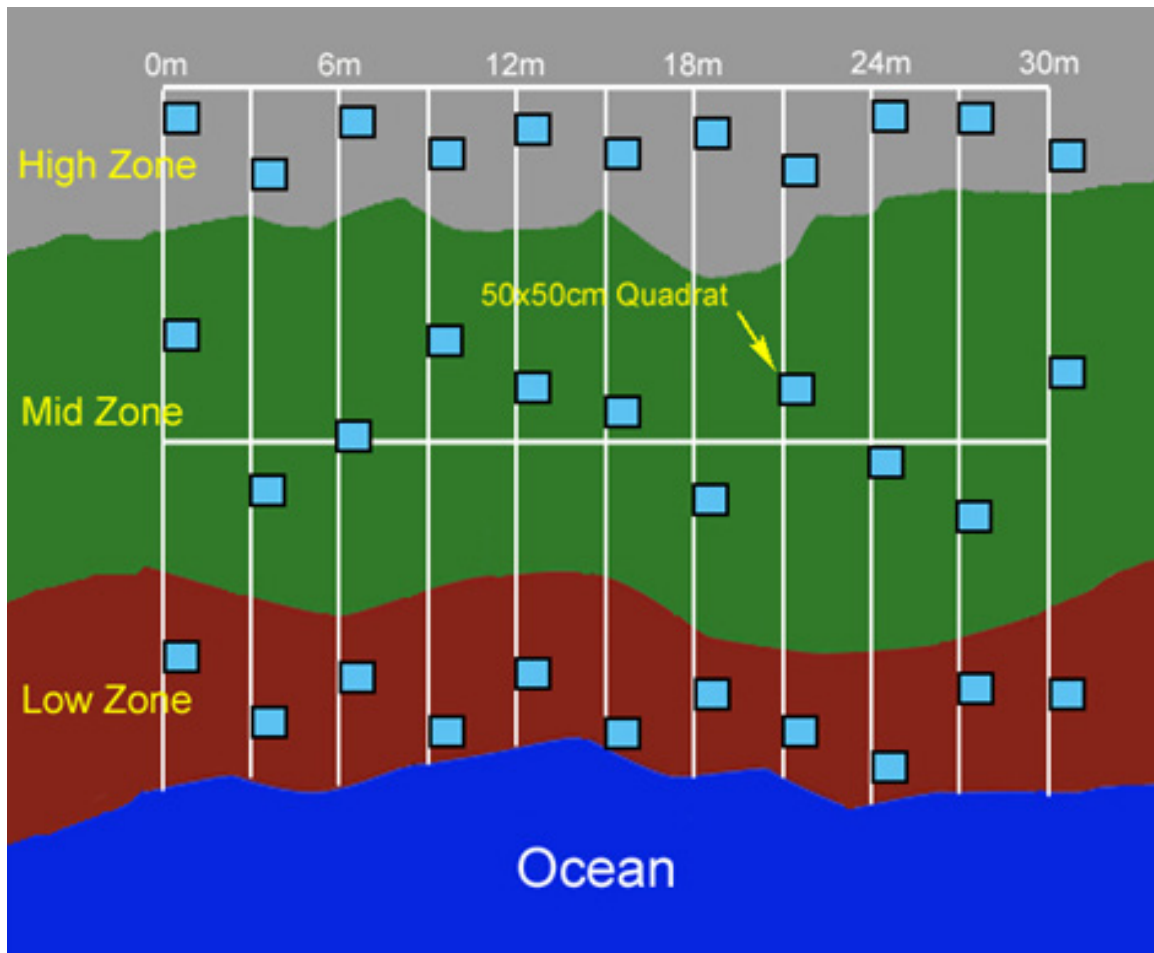


Figure 4. Example schematic diagram of mobile invertebrate quadrat sampling (blue squares) along biodiversity transect lines.

Swath Transects

Swath transects are used to estimate the density of sea stars, abalone, and other large mobile invertebrates. Swath sampling consists of recording the number of large invertebrates in a 2 m wide band centered over each transect. The location (to the nearest 0.5 m along the transect), number, and species names are recorded.

Topography Surveys

Topography surveys are used to create a 3D topographical representation of each survey area. Using a rotating laser level and a stadia rod, heights are measured along each transect at locations where there are major changes in elevation. These data are then converted to heights relative to mean sea level (MSL) by also measuring the height of a reference bolt whose elevation has been measured using a Trimble differential GPS unit. This survey is only performed once per site.

Data Collection and Entry

The intertidal sites at RNSP were sampled annually in the spring/summer when tides were sufficiently low to permit sampling. The surveys occur in May or June. All data for this report were collected between May 26 and 27, 2017 and between May 28 and June 2, 2018 (Table 2). Each site

required 1 full low tide sequence to conduct the long-term monitoring survey and 1 to 2 days for each biodiversity survey. Note that Enderts Beach site was not sampled in 2017 due to a rock slide and road closure. Surveys required a team of 4 to 6 experienced intertidal field biologists with 2 to 4 extra field biologists and/or volunteers assisting. The summer 2017 crew consisted of 4 UC Santa Cruz (UCSC) biologists (David Lohse, Melissa Redfield, Karah Ammann, and Laura Anderson) with 3 RNSP crewmembers (David Anderson and alternating Heather Brown, Kelley Breen and Terry Hines). The summer 2018 crew consisted of 4 UCSC biologists (Karah Ammann, Maya George, Laura Anderson and Nathan Fletcher) with 3 RNSP crewmembers (David Anderson and alternating Terry Hines, Kyle Max, Kelley Breen, Heather Brown, Carolyn Aguayo, Gary Sousa and Teresa King). Additional volunteers from Humboldt State University (HSU) included Georgia Bennett and Beta Hernandez.

Table 2. Sampling locations and dates for rocky intertidal monitoring at Redwood National and State Parks, 2017–2018. Enderts Beach was not sampled (NS) in 2017 due to road closures.

Site	Site Code	Latitude ¹	Longitude ¹	Summer 2017	Summer 2018
False Klamath Cove	FKC	41.59476	124.10643	27–28 May	30–31 May
Damnation Creek	DMN	41.65249	124.12784	26 May	2 June
Enderts Beach	END	41.69000	124.14257	NS	28–29 May

¹ Site coordinates are in decimal degrees, NAD83 datum (source Bureau of Land Management).

After completing each survey, researchers reviewed the data forms for missing or incorrectly recorded data. Once complete, the data from field logs, photoplots, sea star plots, and surfgrass transects were entered into the MARINe Data Management System (MDMS), a system that provides uniform data information storage and retrieval for all MARINe institutions. Detailed information about QA/QC procedures for data collection, verification, and validation can be found in the protocol narrative and SOP #14 Data Management (Ammann and Raimondi 2008).

Data Analysis

Basic summary statistics were used to examine variations in abundance for the key species found in the photoplots (e.g., barnacles [*Chthamulus*, *Balanus*, etc.], mussels [*Mytilis* spp.], and rockweed species [e.g., *Pelvetiopsis limitata*]) and in the line transects (e.g., surfgrass [*Phyllospadix* spp.]). Mean percent cover values are presented for each site (based on pooled values for all plots in each zone) in summer sampling periods. This report covers 2 years of data; any analysis of trends should be based on a longer time series (>5 years). Trend graphs are available at <https://marine.ucsc.edu/sites/index.html>.

Results

Raw data used to create this report are available upon request through MARINe or the National Park Service. Please contact the authors with requests.

Community Structure Surveys

Field Log

Species List and Conditions

The general observations of conditions for each survey are presented in Table 3.

Table 3. Field conditions for sampling trips in 2017 and 2018 at 3 intertidal sites within Redwood National and State Parks. Tide level is relative to Mean Low Low Water. NS = not sampled due to trail closures.

Site ¹ ID	Season ² Code	Start Time	End Time	Low Tide Level (ft)	Low Tide Time	Swell Surge ³	Wind ³	Rain ³	Recent Rain ³	Sediment Level ³	Scour ³	Rock Movement ³	Plant Wrack ³	Drift wood ³	Shell Debris ³	Dead Animals ³	Trash ³
END	SU17	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
END	SU18	0500	0900	-0.9	0630	M	L	0	0	L	L	L	L	L	L	0	0
DMN	SU17	0545	1045	-2.1	0650	L	L	0	0	L	L	L	L	M	L	L	L
DMN	SU18	0630	1015	-0.5	0930	L	L	0	0	L	L	L	L	L	L	0	L
FKC	SU17	0515	1130	-2.2	0740	L	L	0	0	L	L	M	L	L	L	0	0
FKC	SU18	0430	0900	-0.7	0554	L	L	0	M	M	L	M	L	L	L	0	0

¹Site ID = END = Enderts Beach; DMN = Damnation Creek; FKC = False Klamath Cove.

²Season Code = SU17 = summer 2017 (May 26–27, 2017); SU18 = summer 2018 (May 28–June 2, 2018).

³Condition levels: 0 = zero; L = relatively few or low levels; M = Medium or moderate levels.

Shorebirds and Mammals Species Lists

The only marine mammal seen at the sites during the 2017 and 2018 sampling surveys was an occasional harbor seal swimming offshore. Summaries of the common shorebirds observed during the RNSP surveys are presented in Table 4. These data represent the greatest number of each species observed at any 1 time on or near the sampled reef. They are not intended as census data, but rather as field observations. A list of additional bird species that were noted nearby or flying over the sampling sites at 1 or more occasions during 2017–2018 follows.

Table 4. Common shorebirds observed at Redwood National and State Parks monitoring sites during intertidal sampling trips in 2017–2018 (maximum seen at any 1 time).

Site ID ¹	Season ²	Cormorant (<i>Phalacrocorax</i> spp.)	Gull (<i>Larus</i> spp.)	Oystercatcher (<i>Haematopus</i> <i>bachmani</i>)	Small Shorebirds (various species)
END	SU17	0	0	0	0
END	SU18	1	4	0	0
DMN	SU17	0	2	2	0
DMN	SU18	2	0	1	0
FKC	SU17	10	0	3	0
FKC	SU18	1	3	3	0
Totals	n/a	14	9	9	0

¹ END = Enderts Beach; DMN = Damnation Creek; FKC = False Klamath Cove.

² SU17 = summer 2017 (May 26–27, 2017); SU18 = summer 2018 (May 28–June 2, 2018).

Additional non-shorebird species (common name [scientific name]) observed at Redwood National and State Parks intertidal sites during 2017–2018 sampling follow:

- Bald Eagle (*Haliaeetus leucocephalus*)
- Black-headed Grosbeak (*Pheucticus melanocephalus*)
- Brandt's Cormorant (*Phalacrocorax penicillatus*)
- Brown Pelican (*Pelecanus occidentalis*)
- Common Murre (*Uria aalge*)
- Common Raven (*Corvus corax*)
- Double-crested Cormorant (*Phalacrocorax auritus*)
- Loons (*Gavia* spp.)
- Marbled Murrelet (*Brachyramphus marmoratus*)
- Peregrine Falcon (*Falco peregrinus*)
- Pelagic Cormorant (*Phalacrocorax pelagicus*)
- Pigeon Guillemot (*Cepphus columba*)

- Swallows (*Tachycineta* spp.)
- Swainson's Thrush (*Catharus ustulatus*)
- Song Sparrow (*Melospiza melodia*)
- Turkey Vulture (*Cathartes aura*)
- Western Gull (*Larus occidentalis*)
- Wrentit (*Chamaea fasciata*)
- Wilson's Warbler (*Wilsonia pusilla*)

Photoplots

Abundance (percent cover) of species found in the 5 types of photoplots are presented in Figures 5–14 and will be discussed in detail below. The figures include the top 5 most abundant taxa within the photoplots. Note that the following summaries are from only 2 years of observation and, as such, are not intended to represent an analysis of any long-term changes. Graphs with the data can be created with the interactive map and graphing tool at <https://marine.ucsc.edu/explore-the-data/index.html> and can be recreated in various configurations.

Barnacle (*Chthamalus dalli* and *Balanus glandula*) Photoplots

While barnacles represented the dominant species in all of these plots during both 2017 and 2018 (Figures 5 and 6), only at Damnation Creek did barnacle cover exceed >50%. Cover of barnacles at both False Klamath Cove and Enderts Beach was below 40%.

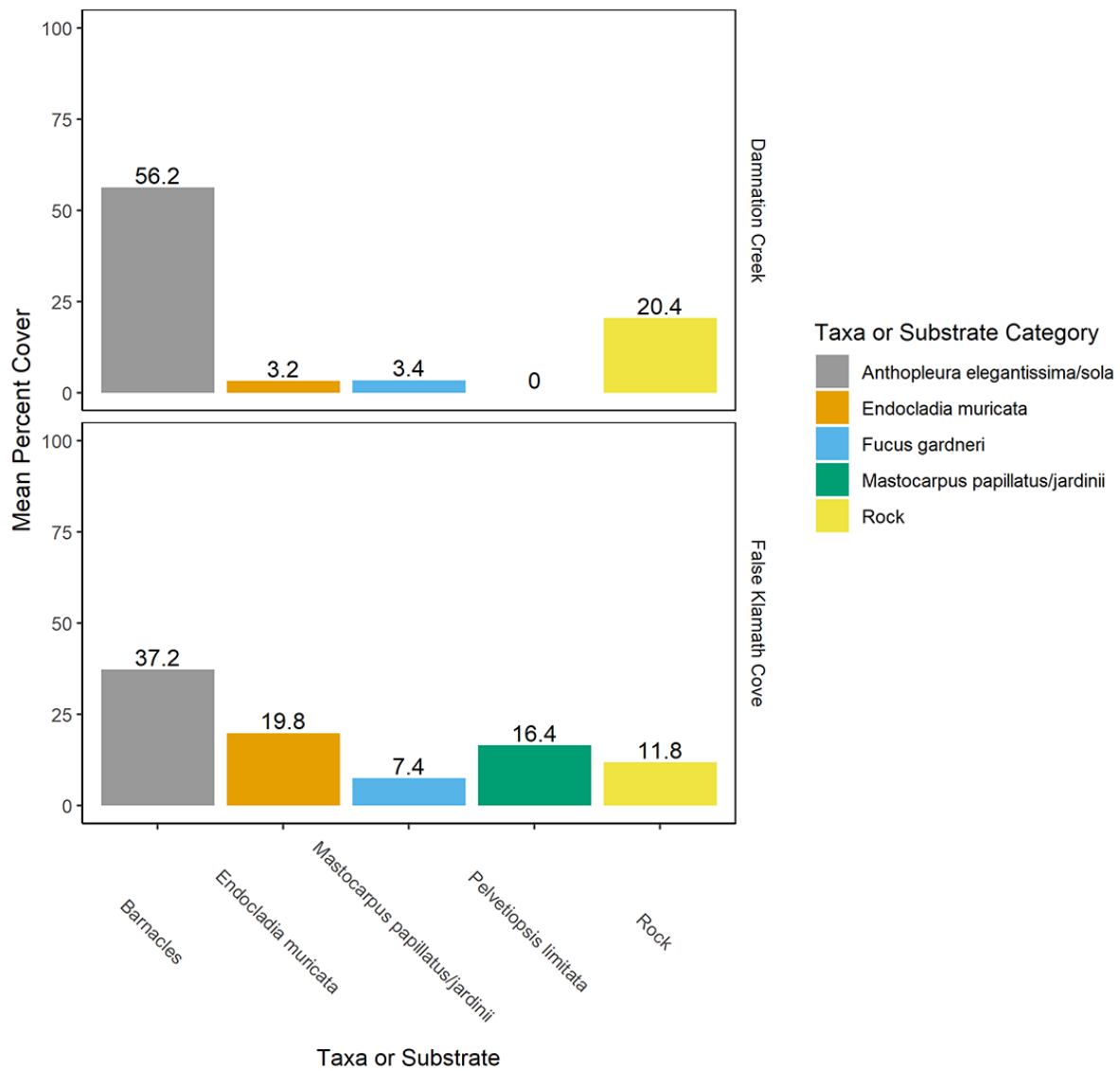


Figure 5. Mean percent cover of the most common taxa or substrate in the barnacle (*Balanus/Chthamalus*) photoplots during 2017 surveys. Enderts Beach was not sampled in 2017 due to blocked access.

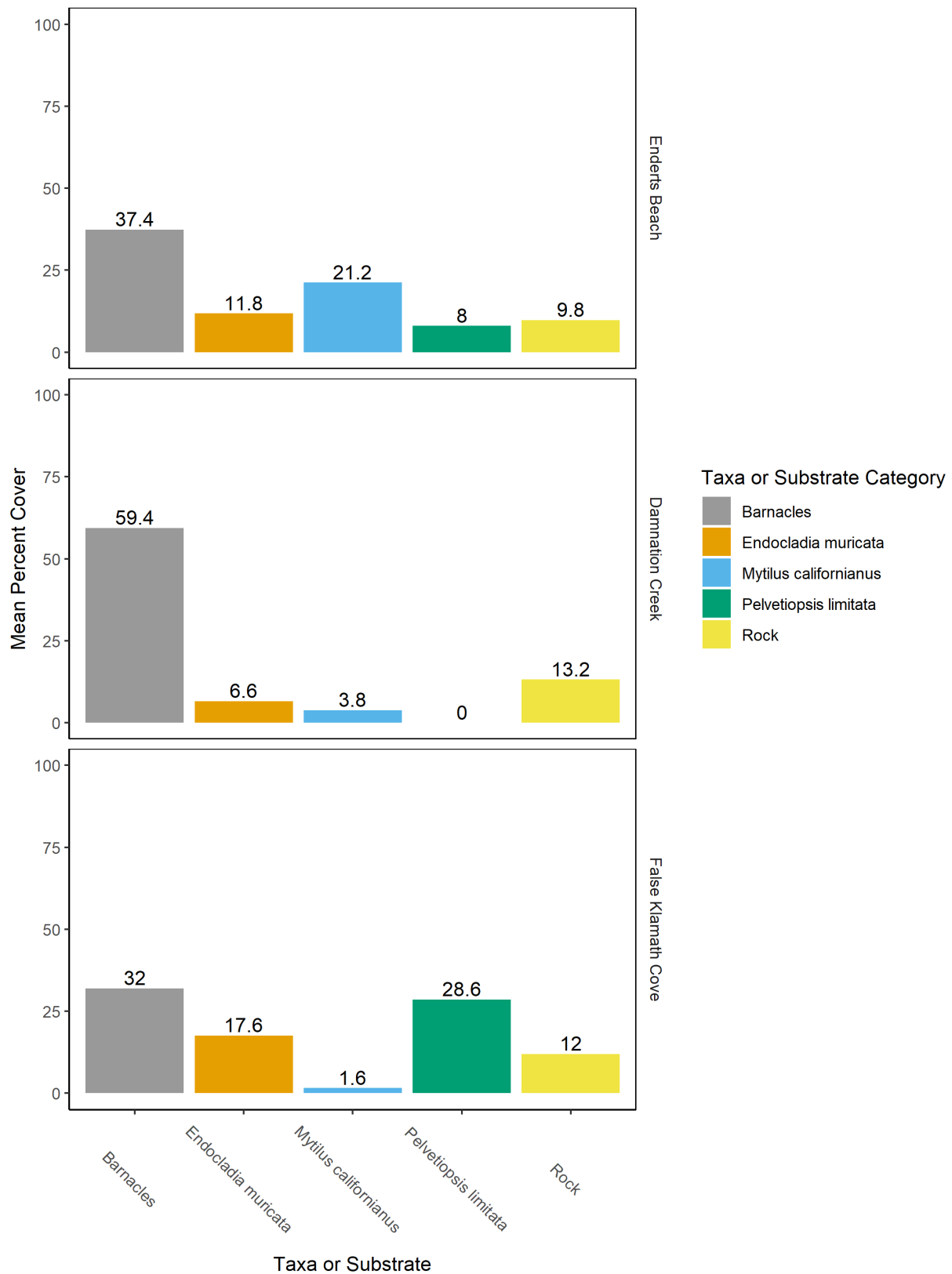


Figure 6. Mean percent cover of the most common taxa or substrate in the barnacle (*Balanus/Chthamalus*) photoplots during 2018 surveys.

Turfweed (*Endocladia muricata*) Photoplots

At all sites during both 2017 and 2018 surveys, turfweed (*Endocladia muricata*) represented the most dominant cover in these plots (Figures 7 and 8). At Damnation Creek the cover of *Endocladia* in the plots increased more than 10% from 2017 to 2018, while cover at False Klamath Cove remained nearly constant between surveys.

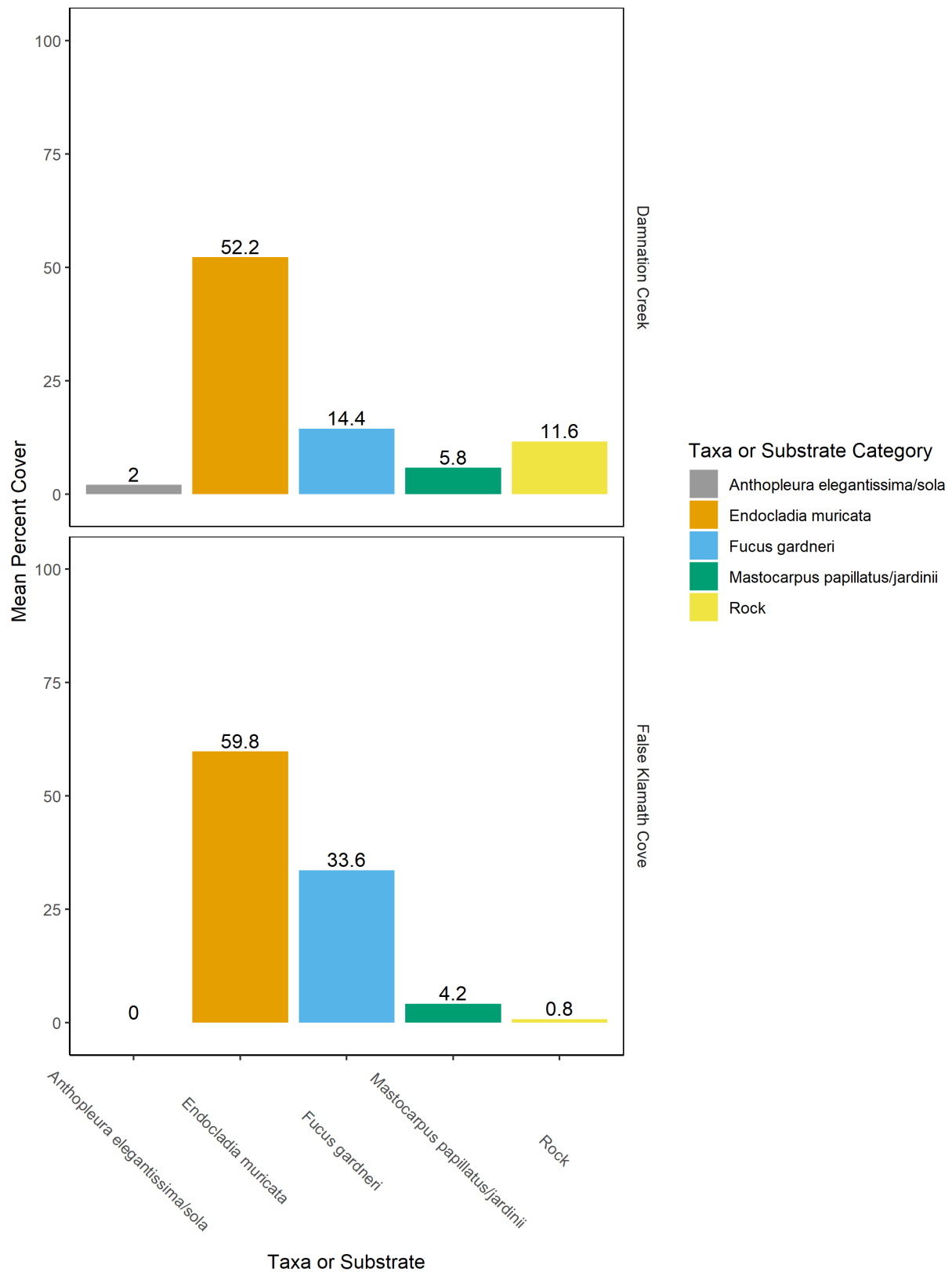


Figure 7. Mean percent cover of the most common taxa or substrate in turfweed (*Endocladia muricata*) photoplots during 2017 surveys. Enderts Beach was not sampled in 2017 due to blocked access.

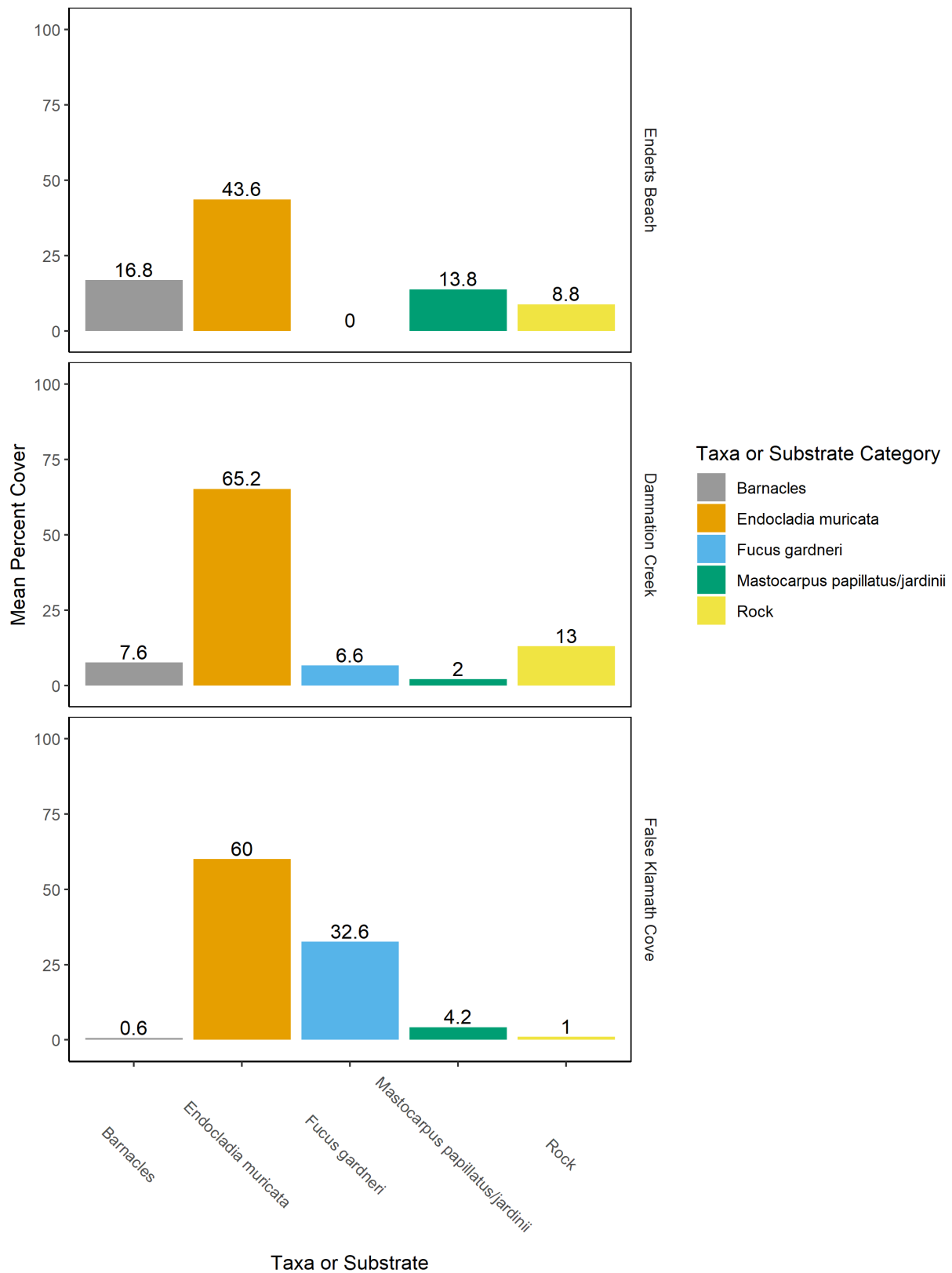


Figure 8. Mean percent cover of the most common taxa or substrate in turfweed (*Endocladia muricata*) photoplots during 2018 surveys.

Rockweed (*Fucus gardneri*) and Dwarf Rockweed (*Pelvetiopsis limitata*) Photoplots

In both sets of rockweed plots the dominant species was also the targeted species. Specifically, cover of *Fucus gardneri* was >75% in plots at False Klamath Cove and nearly 90% at plots at Damnation Creek during both 2017 and 2018 surveys (Figures 9 and 10). *Pelvetiopsis limitata* was between 60 and 70% within the plots at False Klamath Cove during 2017 and 2018 (Figures 11 and 12), with similar (~60%) cover at Enderts Beach in 2017 (Figure 12).

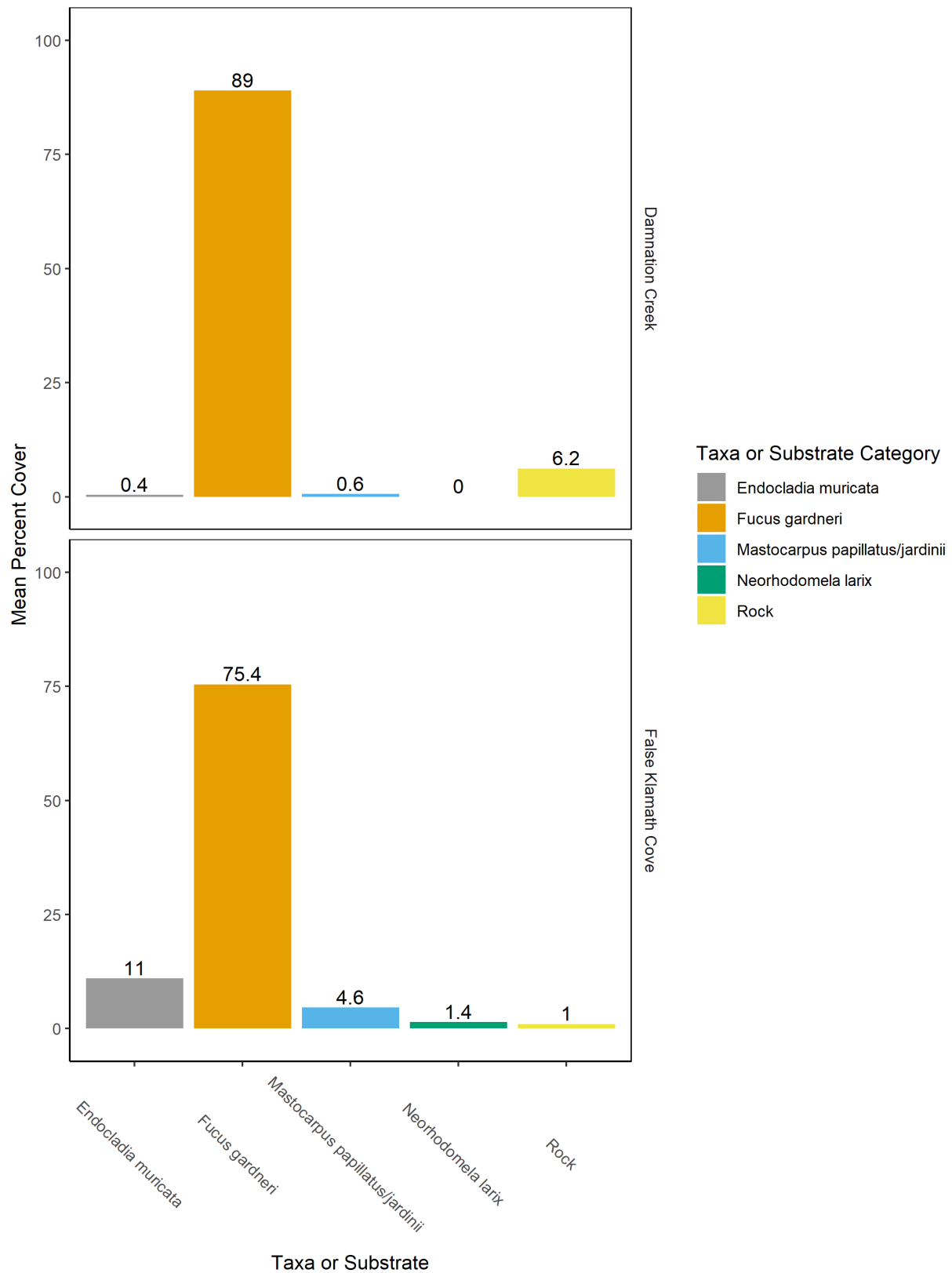


Figure 9. Mean percent cover of the most common taxa or substrate in the rockweed (*Fucus gardneri*) photoplots during 2017 surveys. Enderts Beach was not sampled in 2017 due to blocked access.

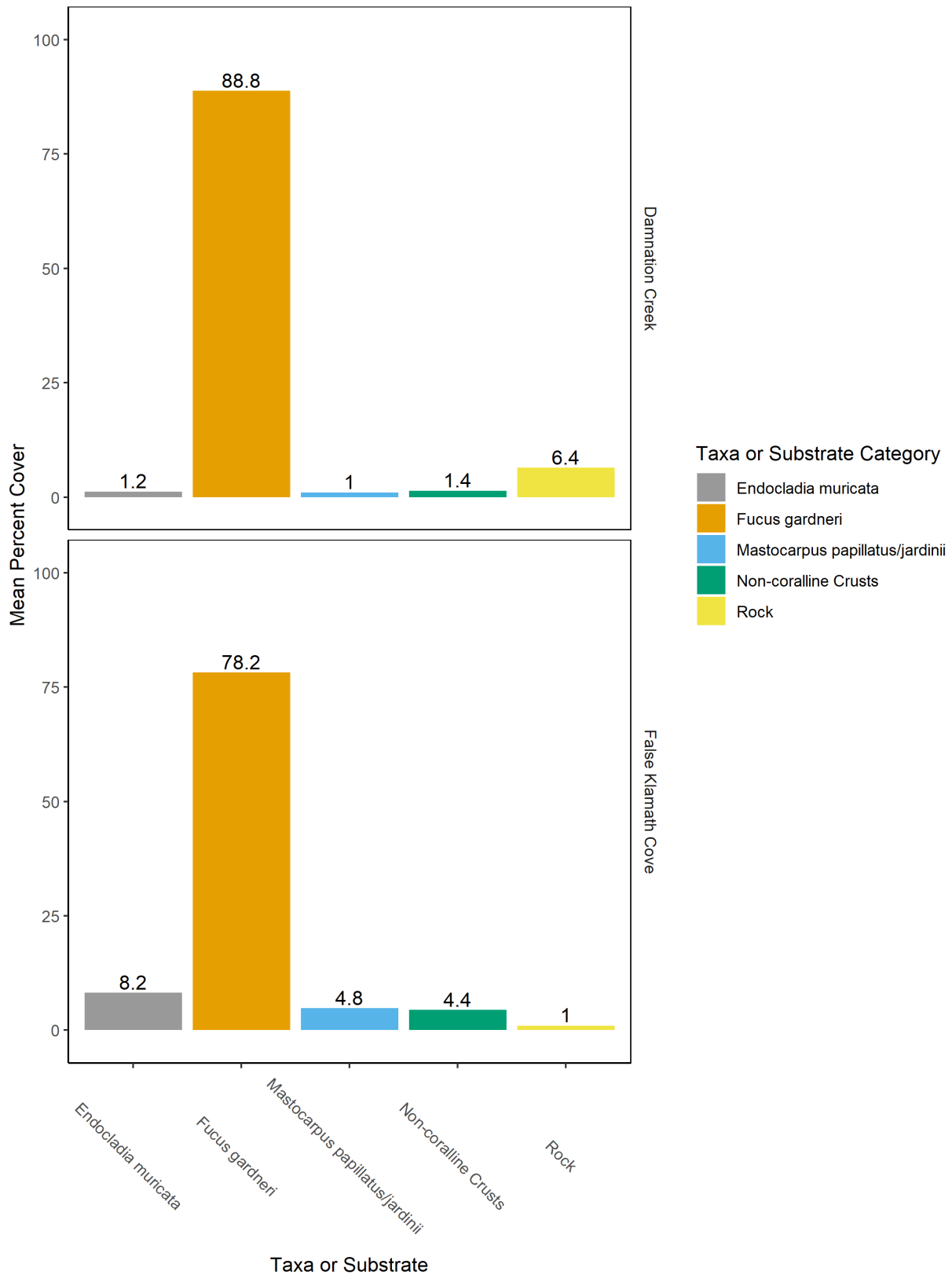


Figure 10. Mean percent cover of the most common taxa or substrate in the rockweed (*Fucus gardneri*) photoplots during 2018 surveys.

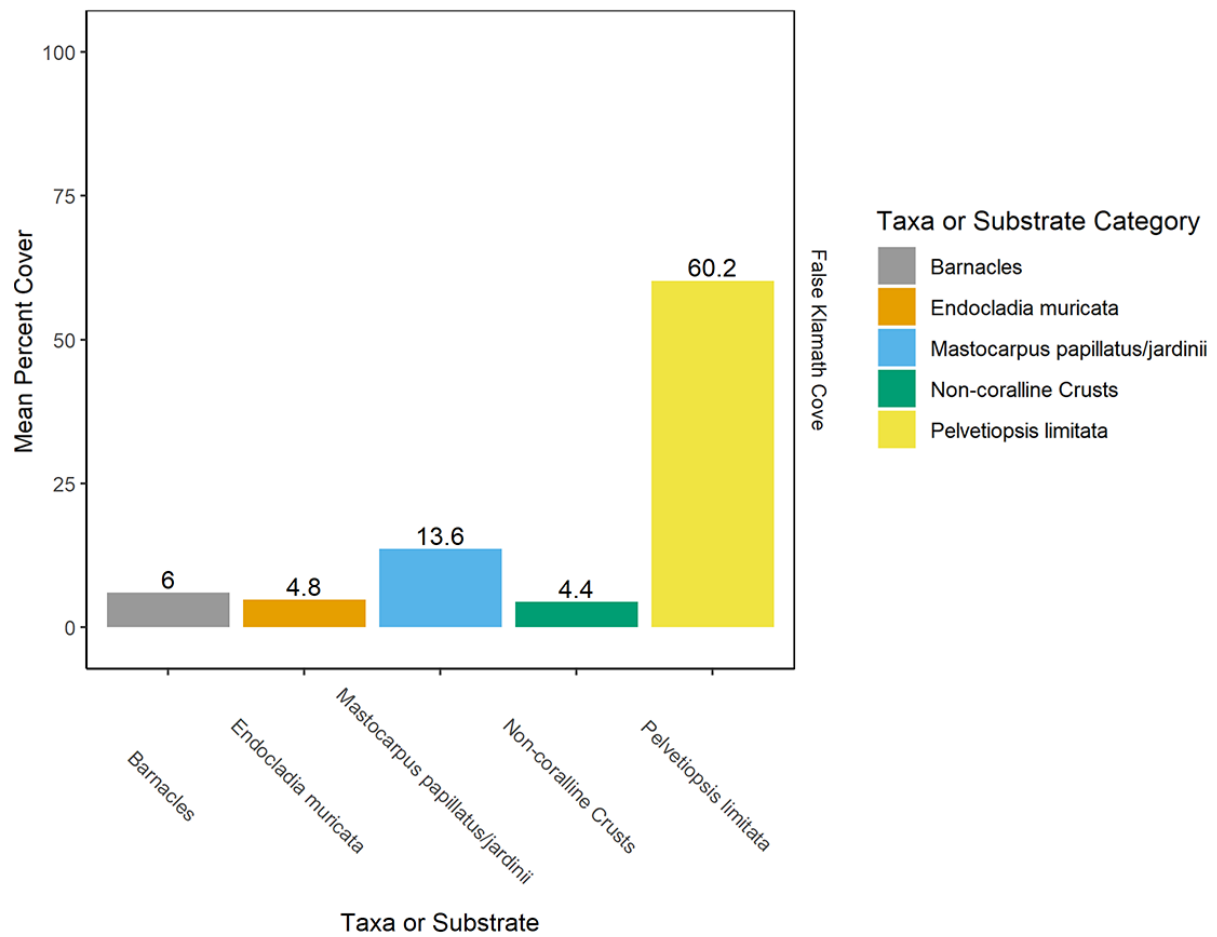


Figure 11. Mean percent cover of the most common taxa or substrate in dwarf rockweed (*Pelvetiopsis limitata*) photoplots during 2017 surveys. Enderts Beach was not sampled in 2017 due to blocked access.

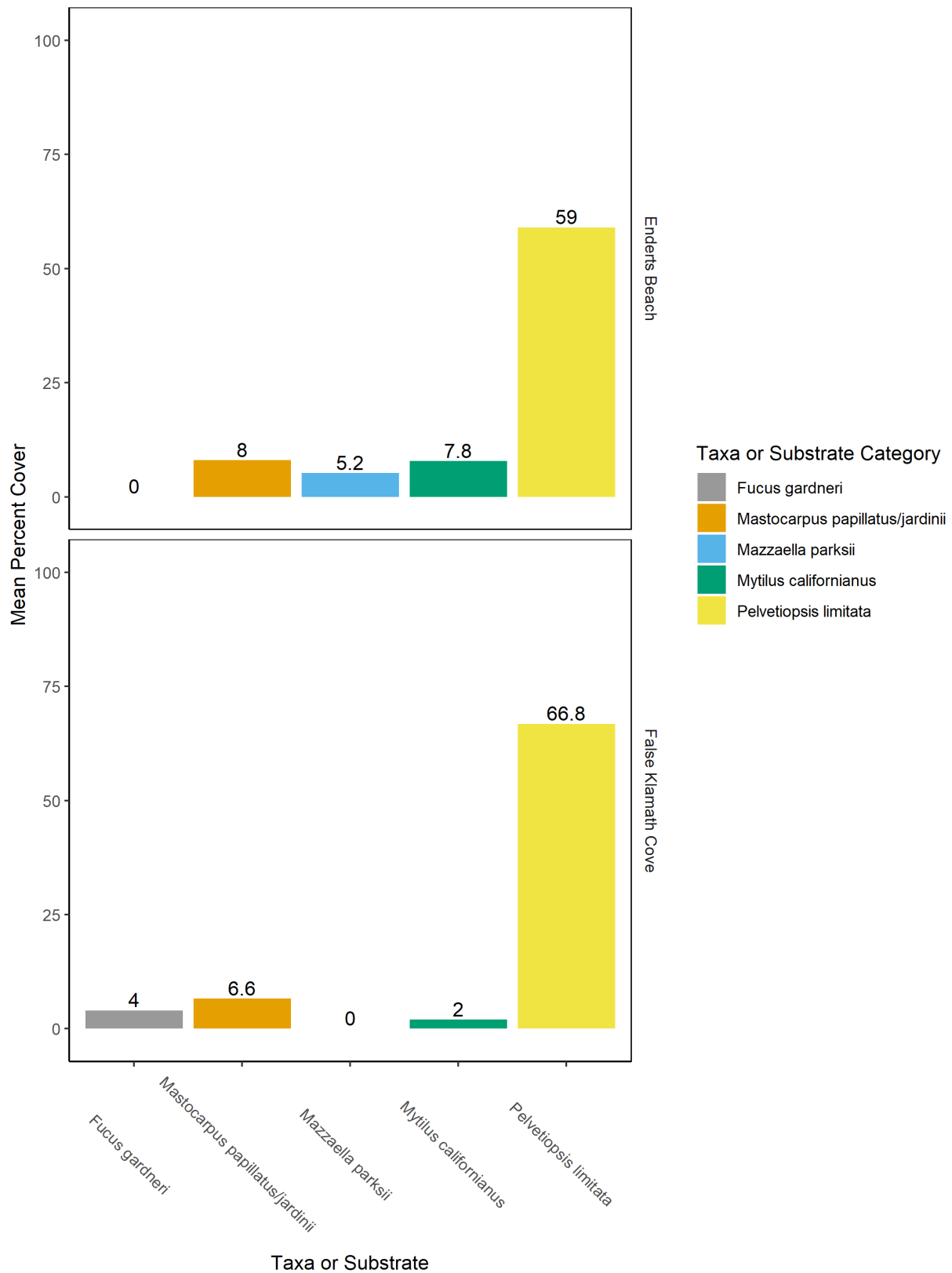


Figure 12. Mean percent cover of the most common taxa in dwarf rockweed (*Pelvetiopsis limitata*) photoplots during 2018 surveys.

Mussel (*Mytilus californianus*) Photoplots

Overall, mussel (*Mytilus californianus*) cover in plots at Damnation Creek was high (>90%) during 2017 (Figure 13) and 2018 (Figure 14). Mussel cover at False Klamath Cove was moderately high (75–85%), with an increase of 10% from 2017 to 2018 surveys (Figures 13 and 14). Enderts Beach mussel cover was the lowest at 70% in 2018 (Figure 14).

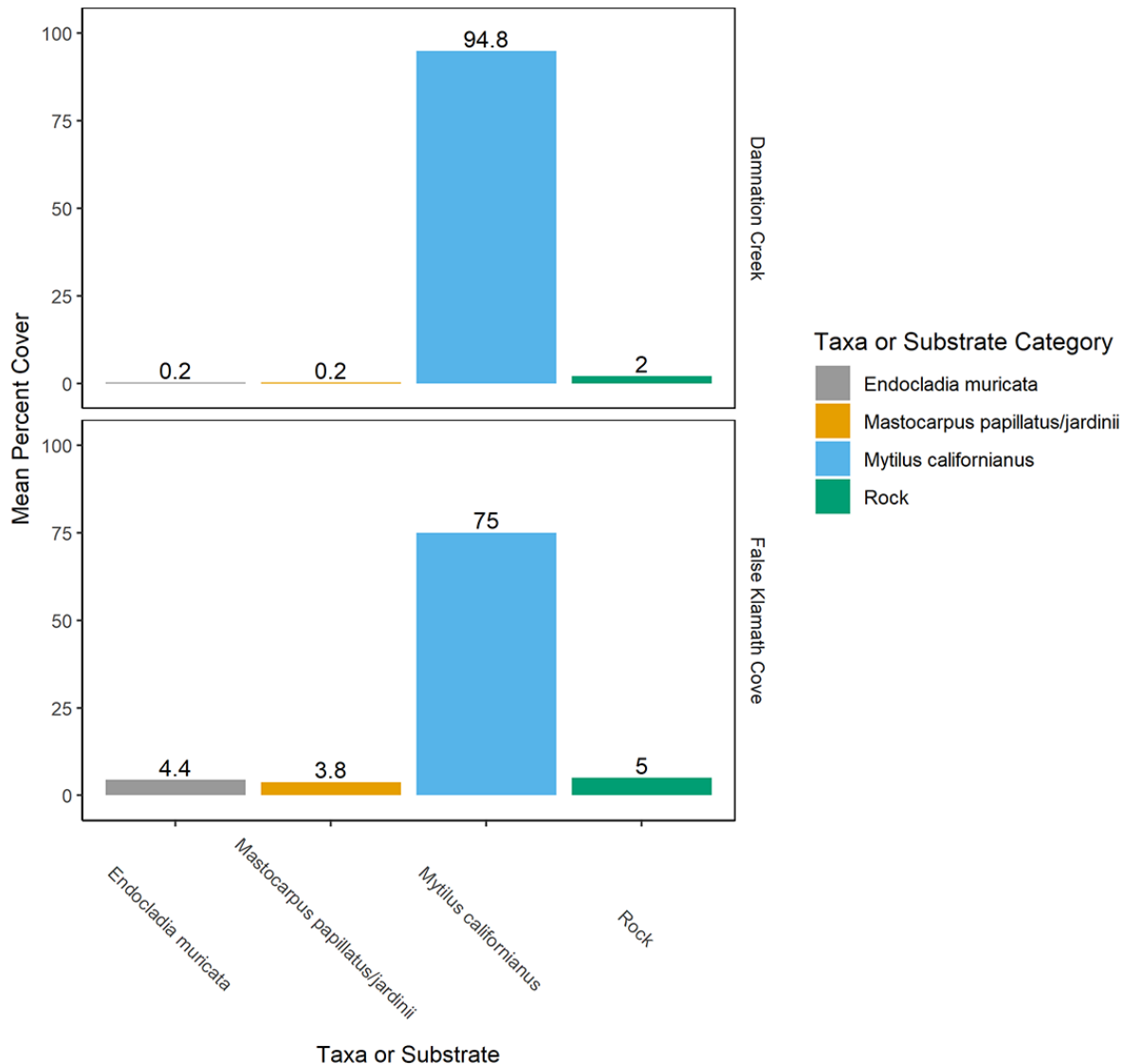


Figure 13. Mean percent cover of the most common taxa or substrate in mussel (*Mytilus californianus*) photoplots during 2017 surveys. Enderts Beach was not sampled in 2017 due to blocked access.

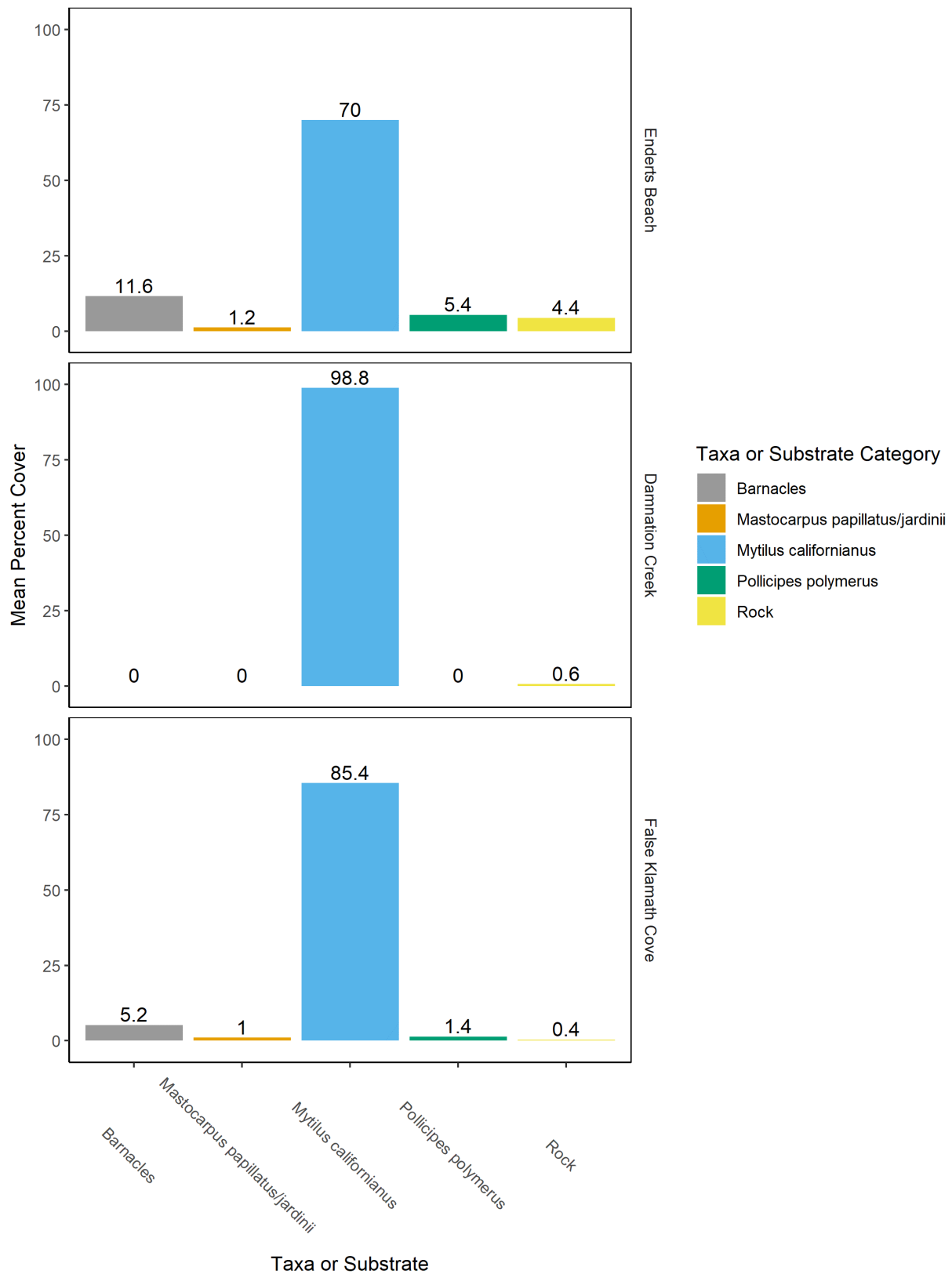


Figure 14. Mean percent cover of the most common taxa or substrate in mussel (*Mytilus californianus*) photoplots during 2018 surveys.

Sea Star Plots

Because the size of the sea star plots varied among the sites, sea star abundances should not be compared across sites. At both Enderts Beach and False Klamath Cove, the majority of the ochre sea stars (*Pisaster ochraceous*) were ≤ 40 mm (Figure 15). This was due to a large increase in the number of small (< 20 mm) individuals within the past few years, which suggests a recent recruitment event had occurred. Damnation Creek had far fewer sea stars than the other sites, with a greater proportion of larger individuals.

The size structure of the ochre sea star populations differed among the 3 sites (Figure 15). The range of sizes was greatest at Enderts Beach in 2018, and the size structure of *Pisaster* was similar at Enderts Beach and False Klamath Cove. Mean size was similar between survey periods for each site but differed between sites (Table 5). Hundreds of individuals < 20 mm were observed in plots at False Klamath Cove and Enderts Beach. In contrast, at Damnation Creek, *P. ochraceus* numbers decreased in all plots. Fewer than 5 individuals measuring ≤ 20 mm were observed in the Damnation Creek plots in 2017 and only a single small individual (50 mm) was observed in 2018.

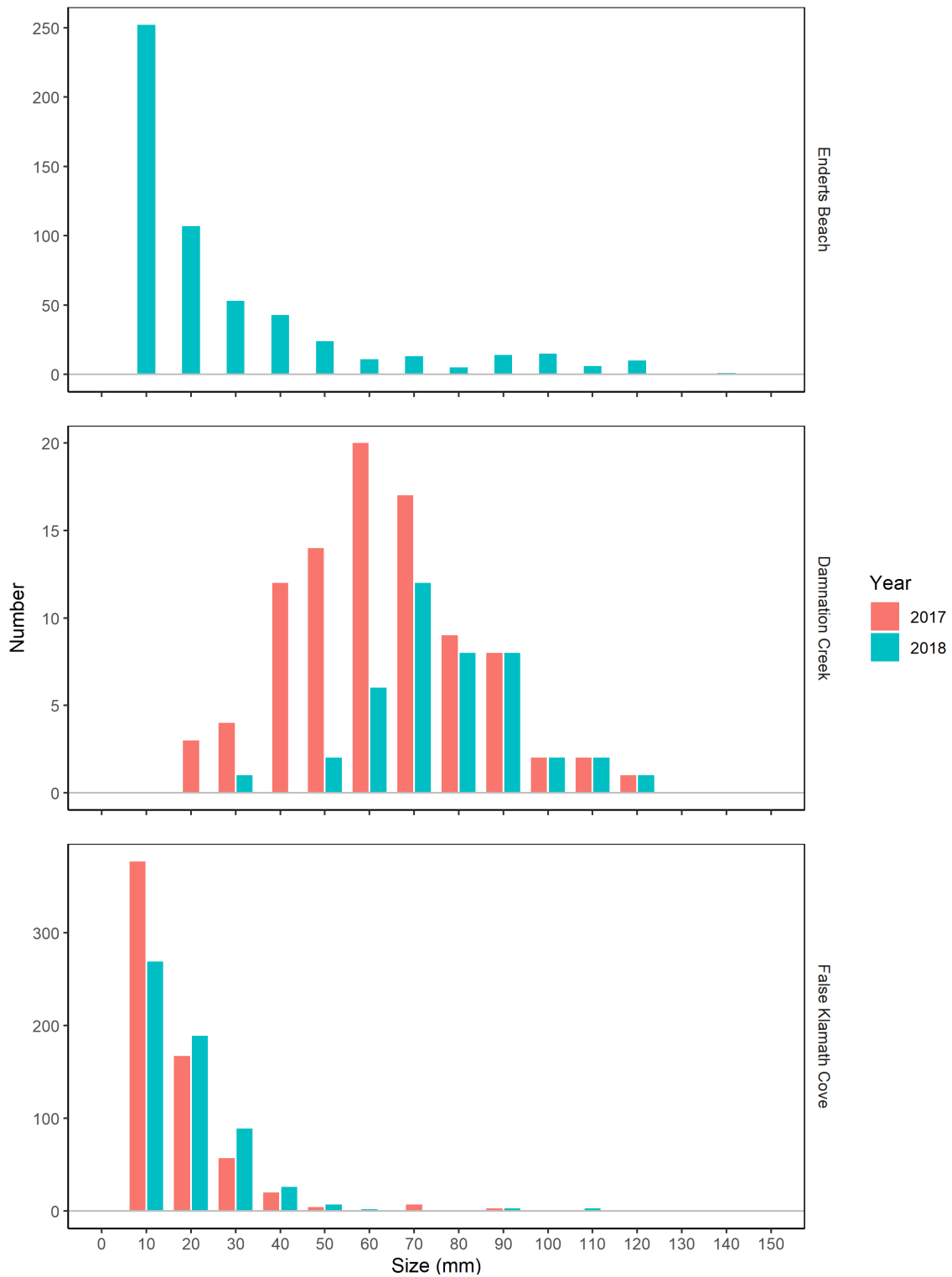


Figure 15. Size distributions of ochre sea stars (*Pisaster ochraceous*) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 and 2018. Note different scale on y-axis. Note that Enderts Beach was not sampled in 2017 due to blocked access.

Table 5. Number of total individuals (n) sampled and mean size for ochre sea stars (*Pisaster ochraceous*) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 (SU17) and 2018 (SU18). NS = not sampled.

Site	Season	n	Mean Size (mm)
Enderts Beach	SU17	NS	NS
Enderts Beach	SU18	554	28.7
Damnation Creek	SU17	92	62.3
Damnation Creek	SU18	42	76.9
False Klamath Cove	SU17	636	16.8
False Klamath Cove	SU18	589	19.3

Mussel Measurements

Size distributions of the mussels (*Mytilus californianus*) within the plots at Enderts Beach, Damnation Creek, and False Klamath Cove for 2017 and 2018 summer surveys are shown in Figure 16. For mussels at Damnation Creek, the size distributions varied between survey years. In 2017, size structure skewed more towards the smallest size class compared to 2018. The distributions are also different at False Klamath Cove, again with a skew toward smaller individuals in 2017. The Enderts Beach mussels during the 2017 summer survey were smaller, with a majority of the individuals measuring 20 mm or less (note Enderts Beach was not sampled in 2018). Mean size of mussels (average length of individuals) as well as the mussel bed depths were greatest for both years at Damnation Creek and smallest at Enderts Beach (Table 6). The mussel beds were approximately 2 times deeper at Damnation Creek in 2017 and 2018 than the other sites (Table 6). The depth to length ratios of the mussel beds were greater than 1 at all sites in both years, which indicates that they were multilayered (i.e., the visible surface layer hides additional layers of mussels below them). The depth to length ratio at Enderts Beach, however, was nearly 1 indicating a single layer of mussels at this site.

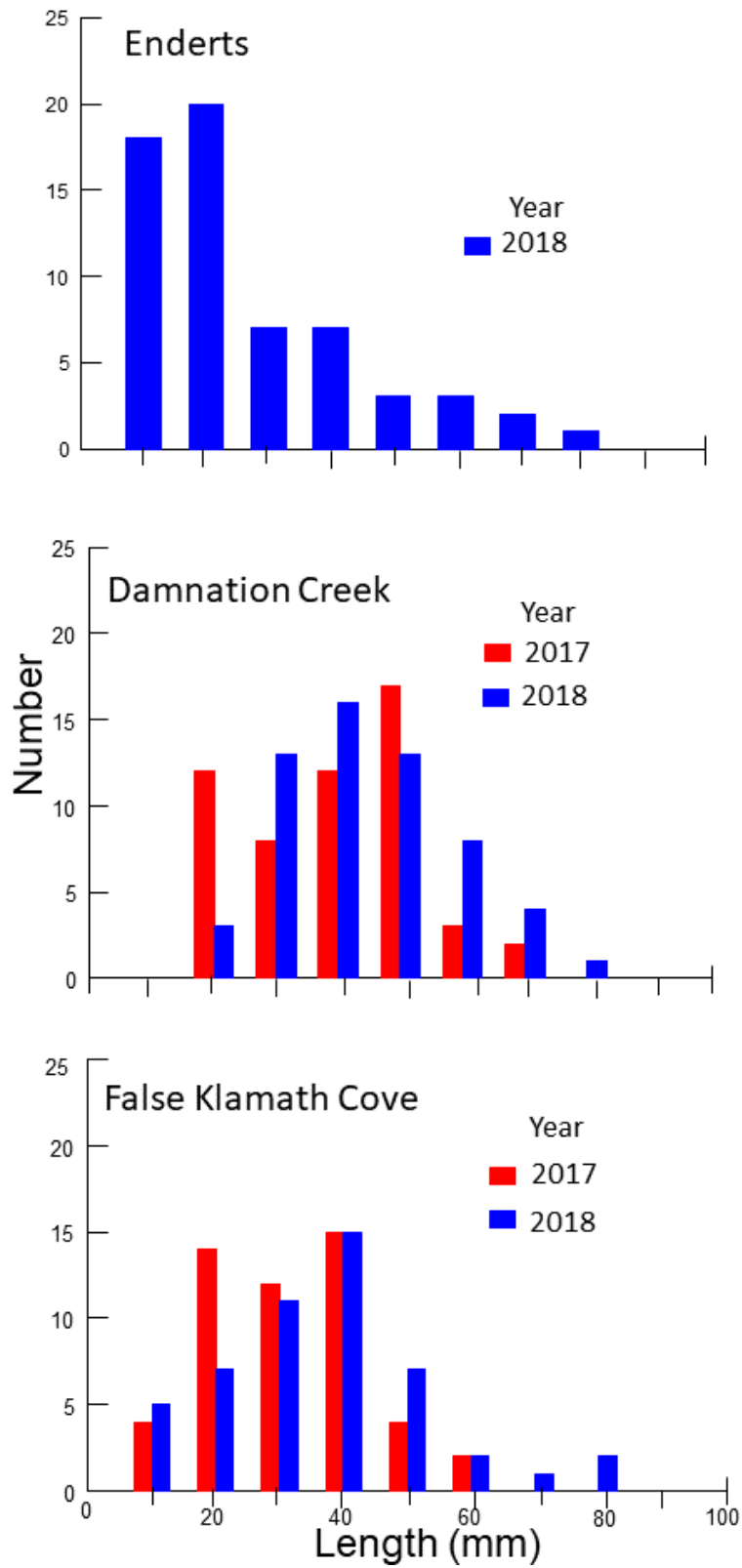


Figure 16. Size distributions of mussels (*Mytilus californianus*) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 and 2018.

Table 6. Mean bed depth, individual length, and ratio of depth to length for mussels (*Mytilus californianus*) at 3 sites within the Redwood National and State Parks during the summer sampling period in 2017 (SU17) and 2018 (SU18). NS = not sampled.

Site	Season	n	Mean Bed Depth (mm)	Mean Individual Length (mm)	Depth/Length
Enderts Beach	SU17	NS	NS	NS	NS
Enderts Beach	SU18	25	40.8	26.6	1.53
Damnation Creek	SU17	25	103.2	39.4	2.62
Damnation Creek	SU18	25	83.6	44.5	1.88
False Klamath Cove	SU17	25	49.6	31.4	1.58
False Klamath Cove	SU18	25	58.4	36.4	1.60

Surfgrass and Sea Palm Transects

During the 2017 summer survey, surfgrass (*Phyllospadix scouleri/torreyi*) abundance at Damnation Creek was 84% in transect 1 and 72% in transect 2. In 2018, transect 1 had 83% surfgrass cover and transect 2 had 89% cover. During the 2017 and 2018 summer survey, sea palm (*Postelsia palmaeformis*) counts at False Klamath Cove were 0 individuals for transect 1 and 797 and 877 individuals, respectively, for transect 2.

Sea Surface Temperature

During 2017–2018, sea surface temperature ranged from lows of 9.2° C to highs of 17.4° C (Figure 17). There was little temperature variation among the 3 sites. Note the temperature probe at False Klamath Cove was lost between the 2017 and 2018 sampling date so data for that period is missing. It was replaced during the 2018 sampling event. Temperature probe failure for Enderts Beach in March 2018 also resulted in missing data until the logger was replaced upon the May 2018 visit.

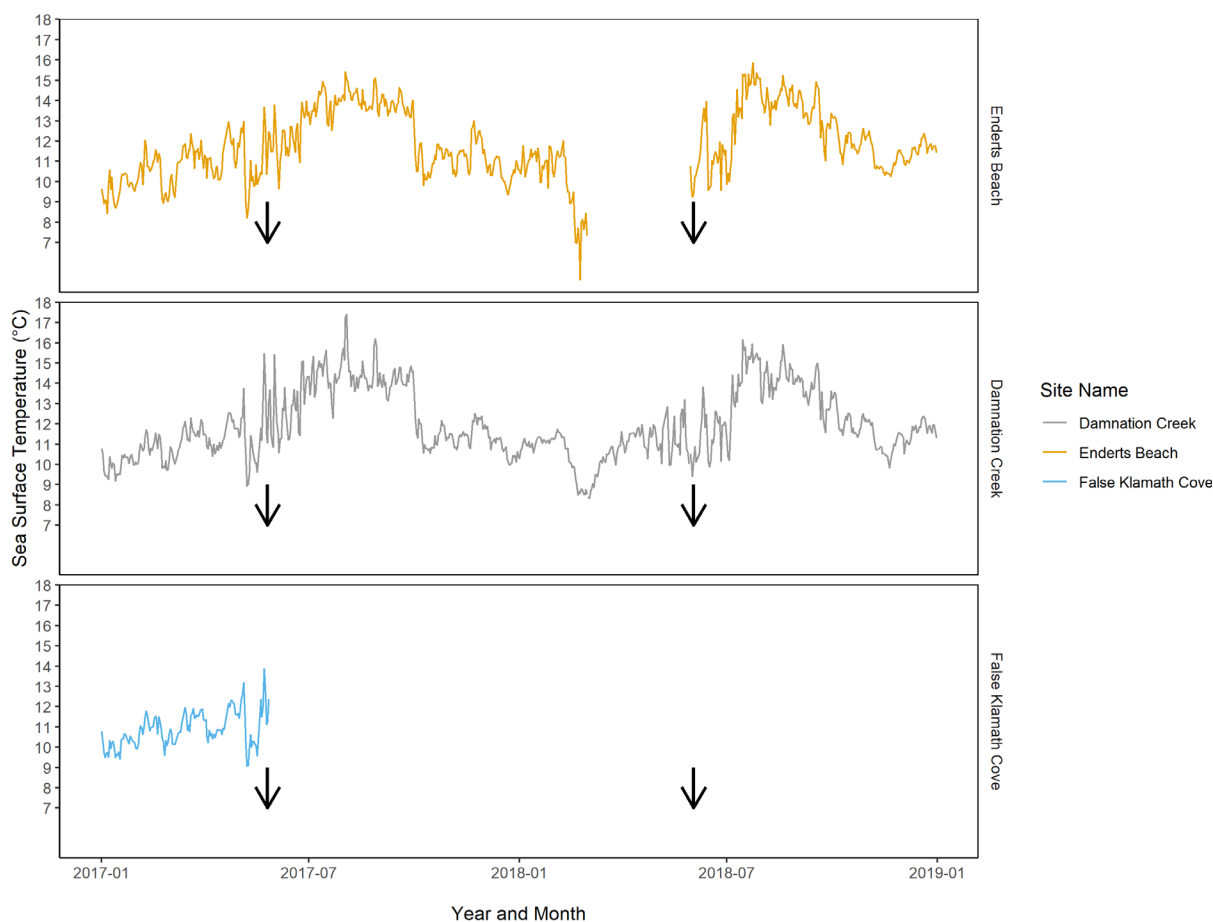


Figure 17. Sea surface temperatures from 3 Redwood National and State Parks sites in 2017–2018. Arrows denote the 2 periods when the community structure surveys were performed. Continuous temperature data collected with Onset TidbiT brand temperature loggers. Gaps indicate missing data; either the logger’s batteries failed or the logger was missing upon the site visit.

Coastal Biodiversity Surveys

In 2017, biodiversity surveys were conducted at Damnation Creek and False Klamath Cove using the full point protocol. In 2018, they were conducted at Enderts Beach and False Klamath Cove using the full point and first point protocols, respectively (see Methods section for details).

Point Contact Surveys and Quadrat Sampling

The percent cover for each of the most common species (>1%) and substrate type observed during the point contact surveys is shown in Figures 18–20.

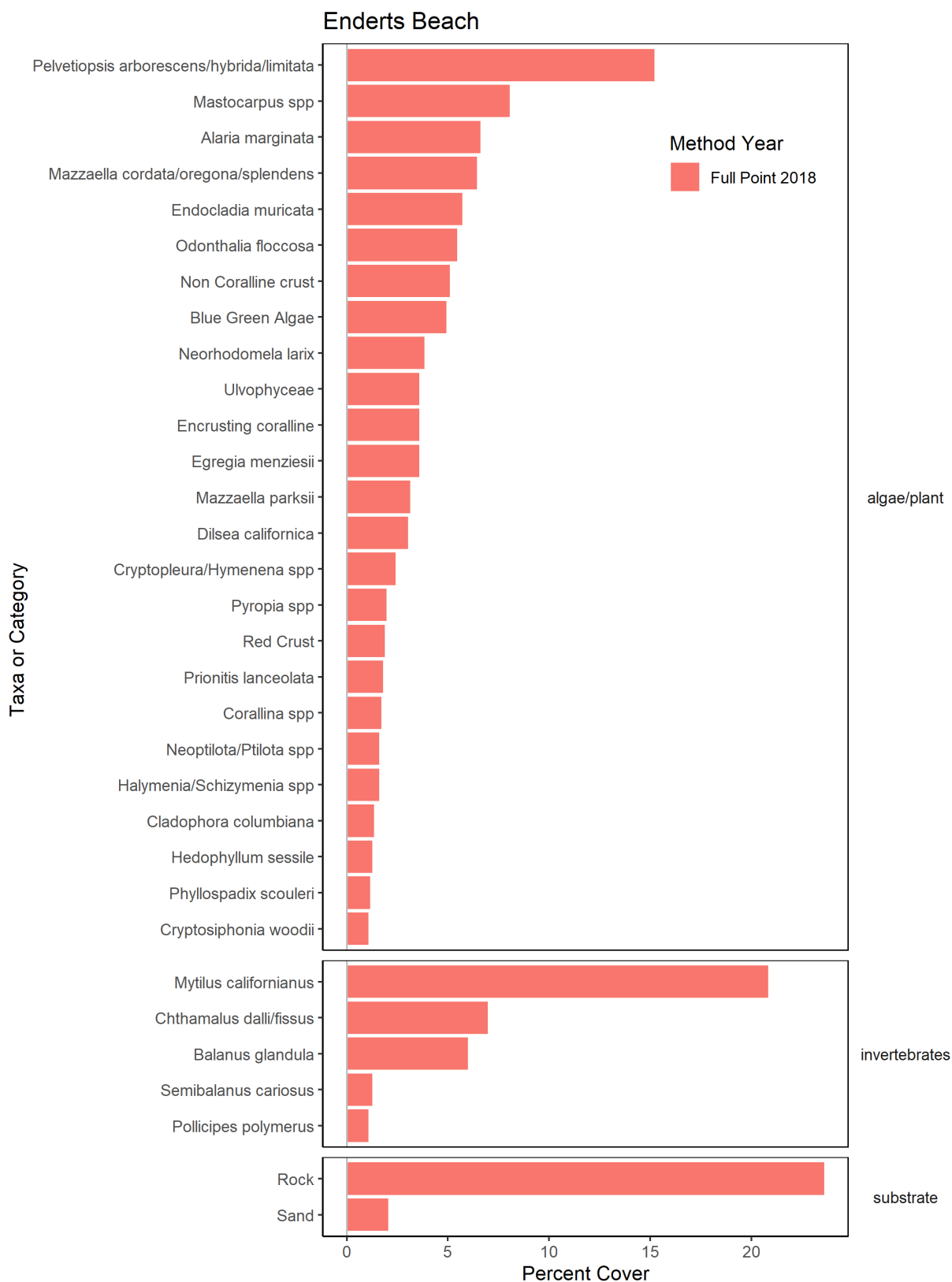


Figure 18. Percent cover of the most common taxa and substrate recorded during biodiversity surveys at Enderts Beach in 2018.

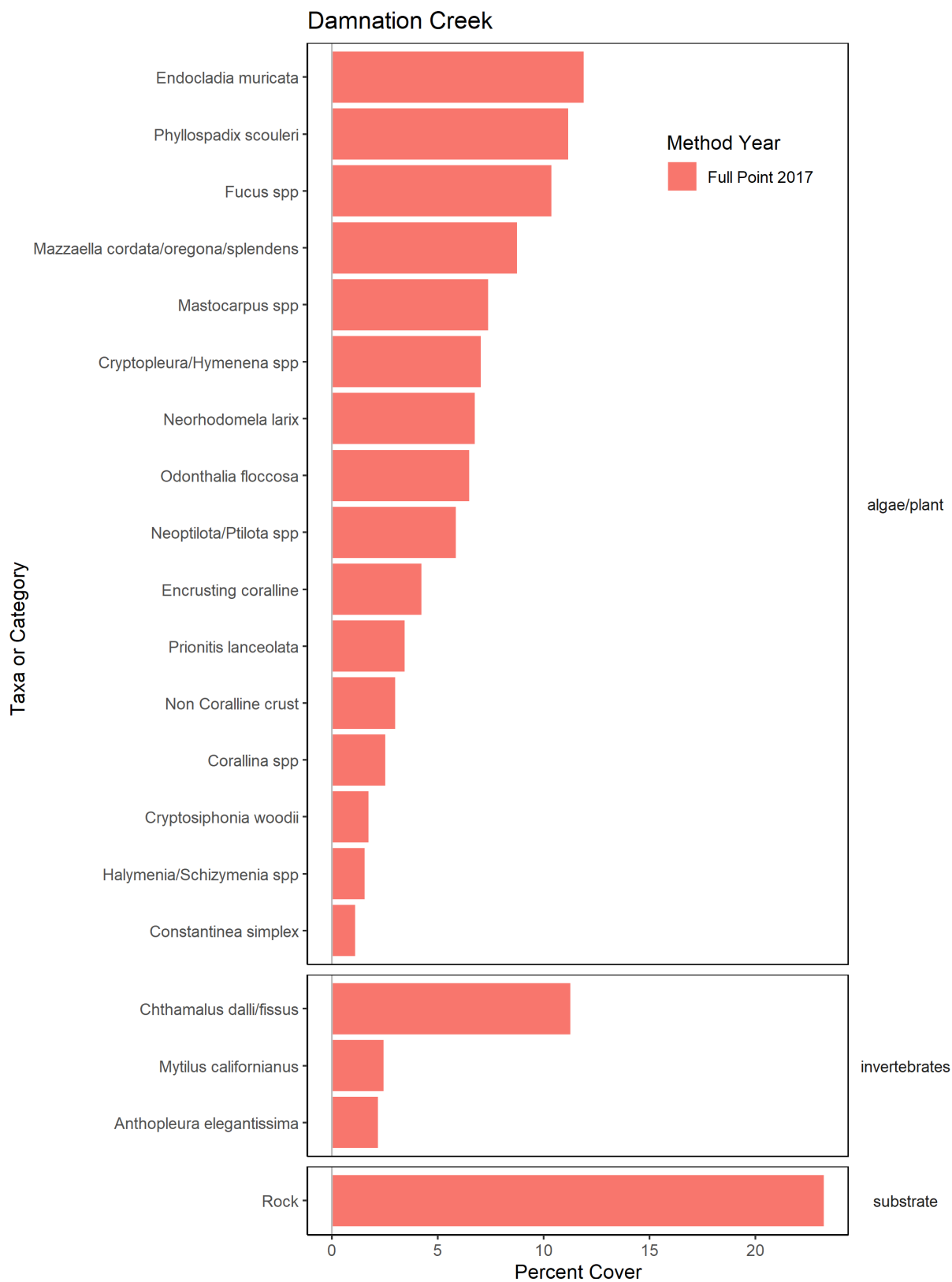


Figure 19. Percent cover of the most common taxa and substrate recorded during biodiversity surveys at Damnation Creek in 2017.

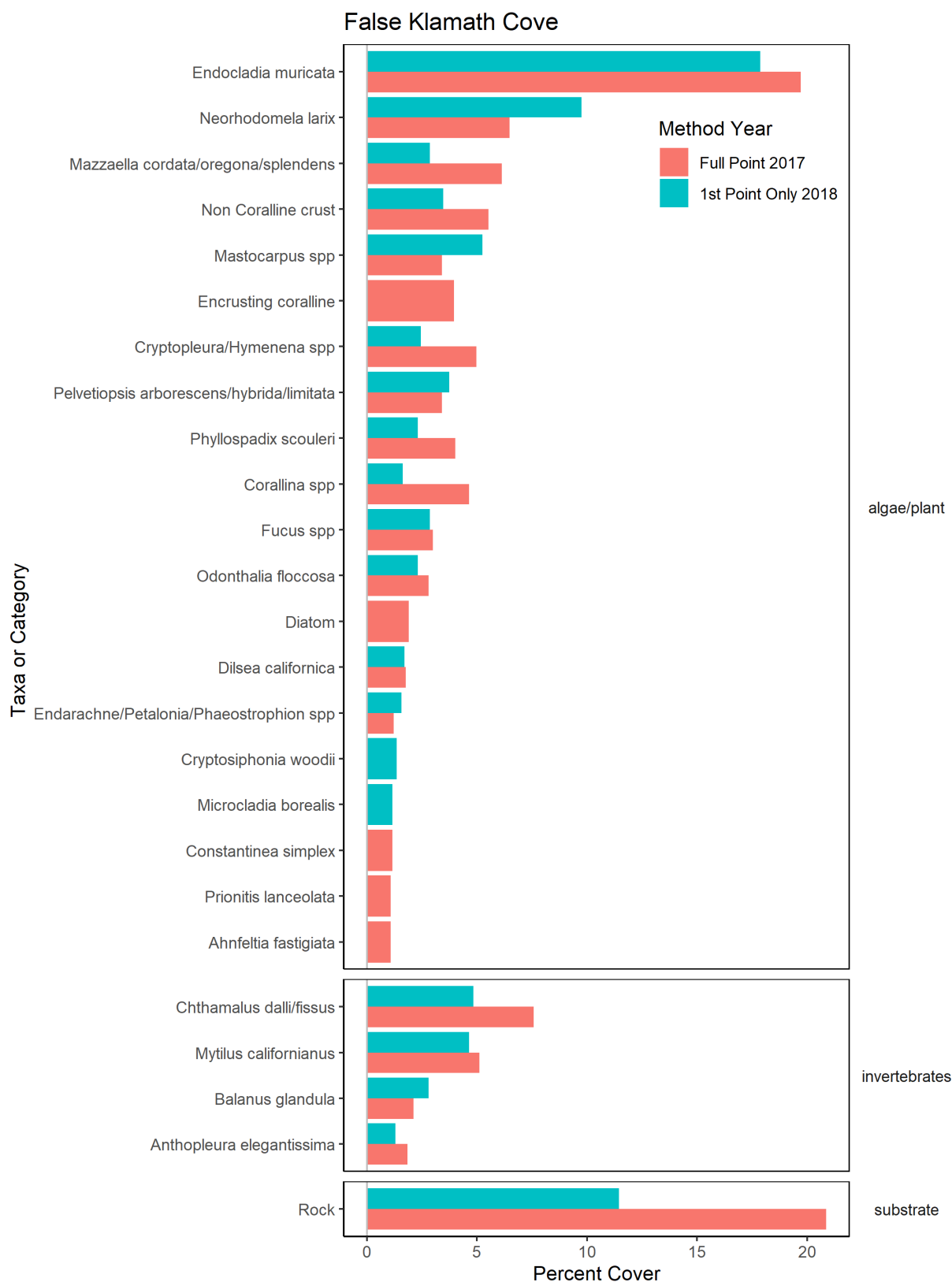


Figure 20. Percent cover of the most common taxa and substrate recorded during biodiversity surveys at False Klamath Cove in 2017 and 2018.

The densities of mobile invertebrate species observed during the quadrat surveys are shown in Figures 21–23. The total number of taxa found using the full point protocol ranged from 96 to 101, while the first point survey at False Klamath Cove found 80 (see Appendix for full list). At all 3 sites, rock was the most common underlying category. While common taxa varied among sites, they included the mussel (*Mytilus californianus*), the algae *Endocladia*, *Pelvetiopsis*, *Mastocarpus*, and the barnacle *Chthamalus* spp. (Figures 18 and 19). The most common mobile invertebrates found at the sites were the snail *Littorina scutulata*, and various limpets in the genus *Lottia* (Figures 21–23).

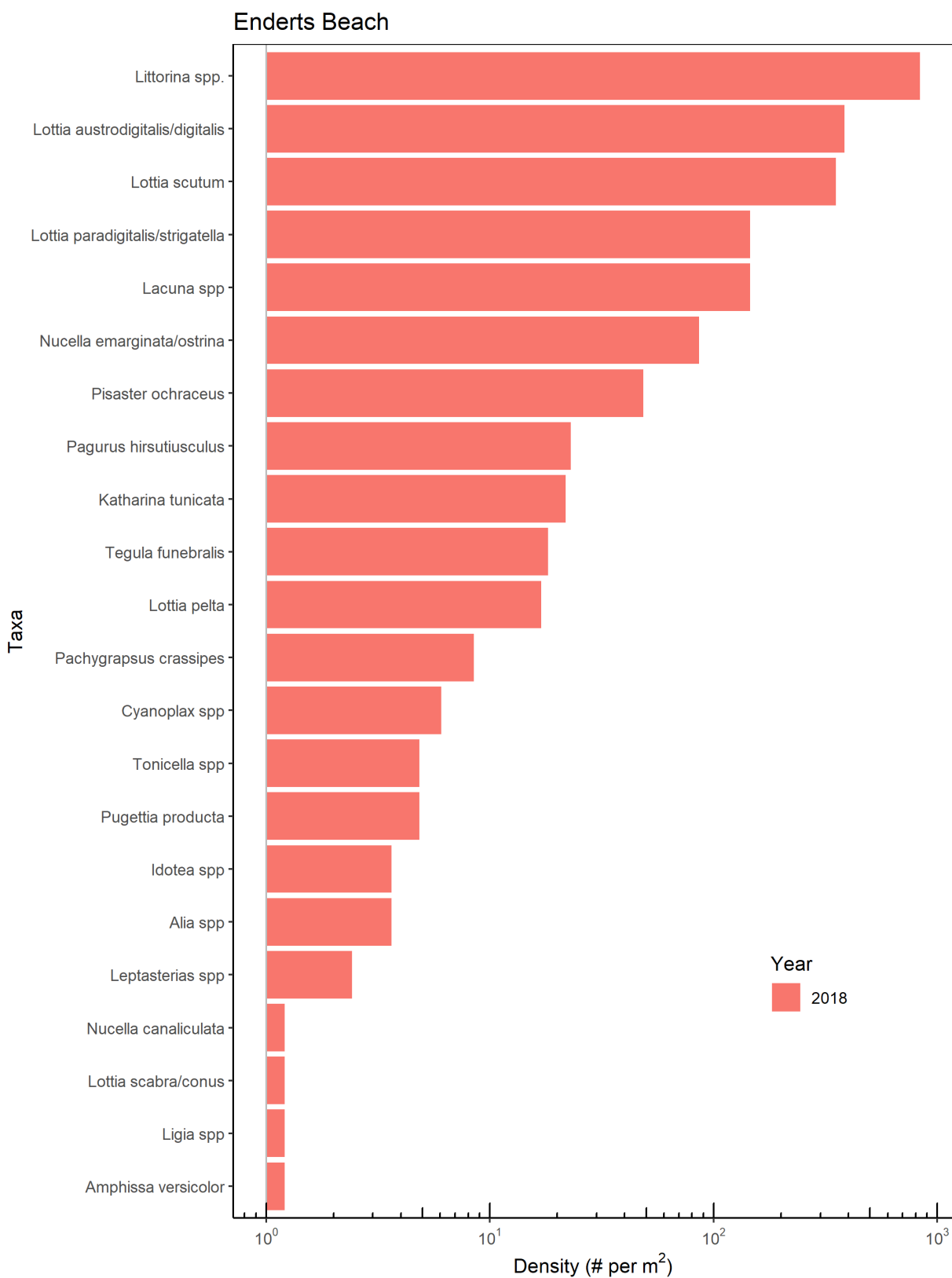


Figure 21. Density of the most common mobile taxa recorded during biodiversity surveys at Enderts Beach in 2018. Note log scale x-axes.

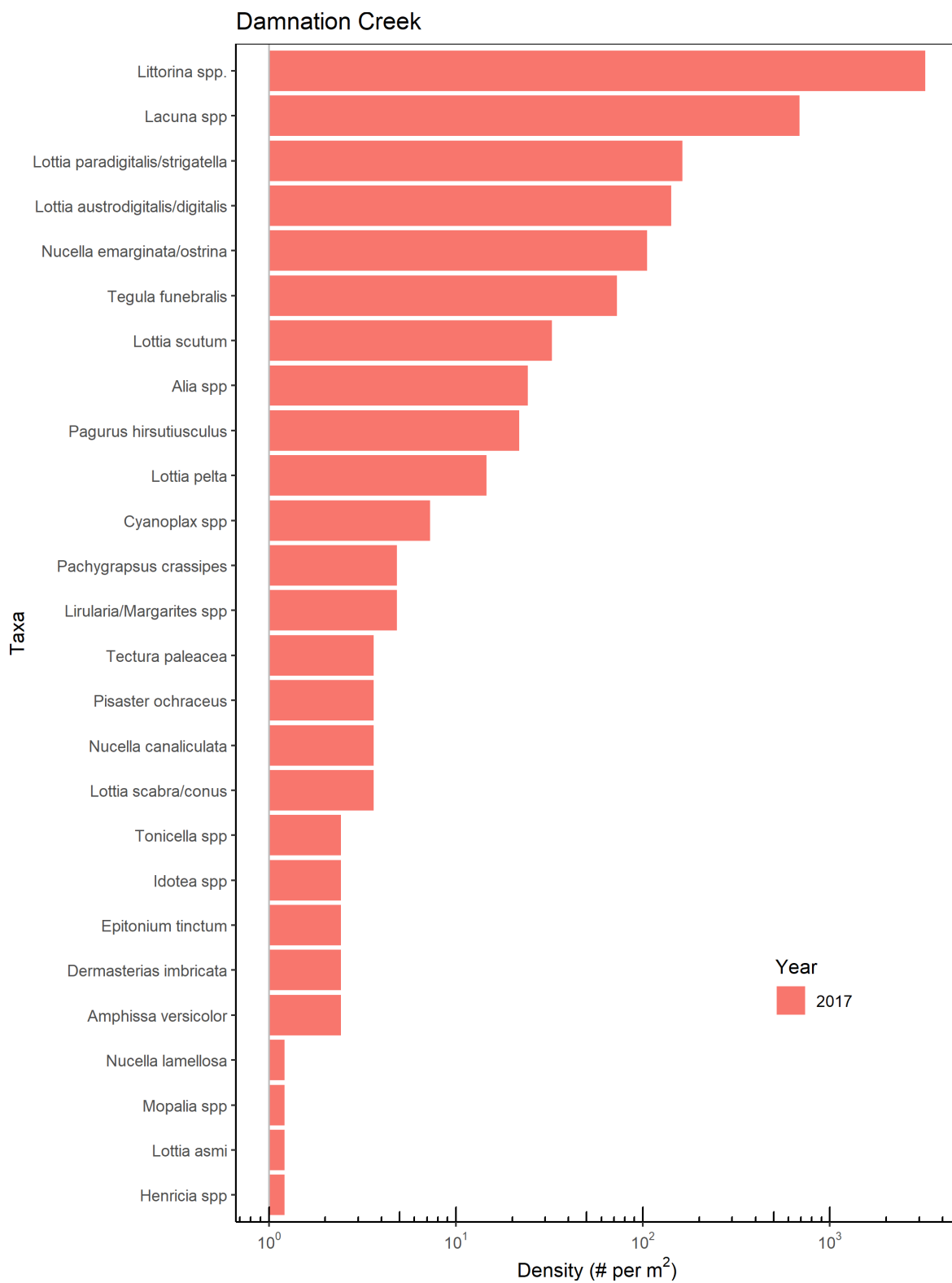


Figure 22. Density of the most common mobile taxa recorded during biodiversity surveys at Damnation Creek in 2017. Note log scale x-axes.

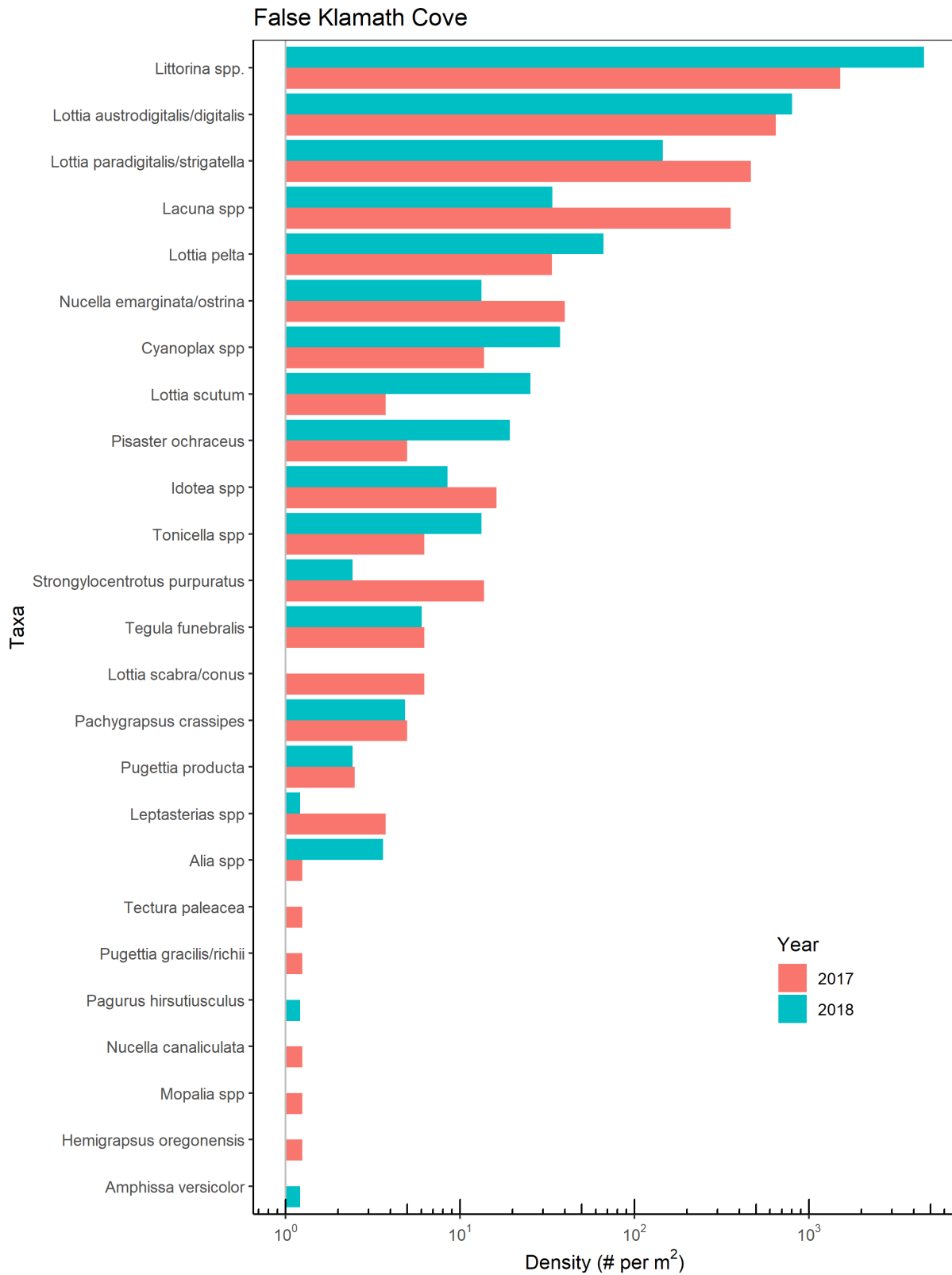


Figure 23. Density of the most common mobile taxa recorded during biodiversity surveys at False Klamath Cove in 2017 and 2018. Note log scale x-axes.

Swath Transects

Very few sea stars were found during the swath surveys at all sites; densities of *Pisaster ochraceus* (ochre sea star) ranged from a low of 0.18 per m² at Damnation Creek, to a high of 1.5 and 1.8 per m² at Enderts Beach and False Klamath Cove (2018), respectively. *Henricia* spp. (blood star) and *Dermasterias imbricata* (leather star) were also observed on swaths at very low densities.

All Taxa Recorded

A complete list of presence/absence data for all taxa found during the Redwood National and State Parks biodiversity surveys between 2007 and 2018 can be seen in the Appendix.

Biodiversity point contact, quadrat, and swath data are available at www.pacificrockyintertidal.org.

Conclusion

A primary objective of the KLMN rocky intertidal monitoring program at RNSP is to track changes in the structure of the intertidal community over time. To accomplish this, data on the distribution, abundance, and sizes of species found at several sites within RNSP have been collected since 2004.

This report covers the sampling during 2017 and 2018, and coincides with a protocol review and revision process. Key elements new to the protocol and report are 1) discontinuing the winter sampling period, 2) removing fixed mobile invertebrate plots, and 3) incorporating community biodiversity sampling. These revisions were trialed as part of the current data collection. Sampling was successful for all elements retained from the prior protocol and revisions were added to the upcoming revised protocol. A final change is that this report begins a shift away from annual in-depth analysis reporting to a simpler data summary, which serves as a timely release of data. A trends report covering 2004 to 2013 is available and provides more in-depth analysis for that time period (Ammann et al. 2017).

All data collected at RNSP through the KLMN rocky intertidal monitoring program contribute to a larger dataset for the MARINe network. This long-term monitoring can detect deviations from baseline conditions, such as disturbance or long-term changes (e.g., climate change). For RNSP and other coastal members of the MARINe network, current trends and syntheses can be found on their website (<http://data.piscoweb.org/marine1/intertidalmmap.html>). This website provides access to interactive data from the long-term intertidal monitoring as well as the coastal biodiversity program. Data summaries are also available for both survey methods under the site info pages of the website (<https://marine.ucsc.edu/sites/index.html>).

The ongoing inventory and monitoring program of the KLMN rocky intertidal community at RNSP continues to generate data vital to our understanding of the dynamics of rocky intertidal communities along the western coastline of North America. These findings will inform managers and policymakers and facilitate marine conservation through public outreach.

Literature Cited

- Ambrose, R. F., P. T. Raimondi, and J. M. Engle. 1992. Final study plan for inventory of intertidal resources in Santa Barbara County. U.S. Minerals Management Service, Pacific OCS Region.
- Ammann, K., and P. Raimondi. 2008. Final long-term monitoring protocol for rocky intertidal communities of Redwood National and State Parks, California. Natural Resource Report. NPS/KLMN/NRR—2008/034. National Park Service, Fort Collins, Colorado.
- Ammann, K. N., P. T. Raimondi, D. P. Lohse, and N. Fletcher. 2017. Inventory and monitoring of rocky intertidal communities of Redwood National and State Parks, California: 2004–2013 trends and synthesis report. Natural Resource Technical Report NPS/KLMN/NRR—2017/1469. National Park Service, Fort Collins, Colorado.
- Cox, K., and C. McGary. 2006. Marine resources of Redwood National and State Parks: Comprehensive report (2004–2005) for Humboldt and Del Norte County, California. Departments of Fisheries Biology and Biological Sciences, Humboldt State University, Arcata, California. REDW-00008.
- Davis, G. E. 2005. National park stewardship and vital signs monitoring: a case study from Channel Islands National Park, California. *Aquatic Conservation: Marine Freshwater Ecosystems* 15:71–89.
- Davis, G. E., and W. L. Halvorson. 1996. Long-term research in national parks: From beliefs to knowledge. Pages 3–10 *in* W. L. Halvorson and G. E. Davis, editors, *Science and ecosystem management in the national parks*. University of Arizona Press, Tucson.
- Engle, J. M. 2008. Unified monitoring protocols for the Multi-Agency Rocky Intertidal Network. USDI Minerals Management Services, Santa Barbara, California.

Appendix: Species List

Table A-1. Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey		Full Point Survey	
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Snails	<i>Alia</i> spp.	X	X	X	X
	<i>Amphissa versicolor</i>	X	X	–	X
	<i>Aplidium californicum/solidum</i>	X	–	–	–
	<i>Epitonium tinctum</i>	–	X	–	–
	<i>Lacuna</i> spp.	X	X	X	X
	<i>Lirularia</i> spp./ <i>Margarites</i> spp.	–	X	–	–
	<i>Littorina keenae</i>	–	–	X	X
	<i>Littorina plena/scutulata</i>	X	X	X	X
	<i>Littorina</i> spp.	–	–	X	–
	<i>Nucella canaliculata</i>	X	X	X	–
	<i>Nucella emarginata/ostrina</i>	X	X	X	X
	<i>Nucella lamellosa</i>	–	X	–	–
	<i>Tegula funebris</i>	X	X	X	X
Chitons	<i>Cryptochiton stelleri</i>	–	X	–	–
	<i>Cyanoplax</i> spp.	X	X	X	X
	<i>Katharina tunicata</i>	X	–	–	–

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey			Full Point Survey
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Chitons (continued)	<i>Mopalia</i> spp.	–	X	X	–
	<i>Tonicella lineata/lokii</i>	X	X	X	X
Nudibranch	<i>Hermisenda crassicornis</i>	X	X	–	–
Bivalves	<i>Mytilus californianus</i>	X	X	X	X
	<i>Mytilus trossulus/edulis/galloprovincialis</i>	X	X	X	X
Limpets	<i>Lottia asmi</i>	–	X	–	–
	<i>Lottia austrodigitalis/digitalis</i>	X	X	X	X
	<i>Lottia paradigitalis/strigatella</i>	X	X	X	X
	<i>Lottia pelta</i>	X	X	X	X
	<i>Lottia scabra/conus</i>	X	X	X	–
	<i>Lottia scutum</i>	X	X	X	X
	Small limpet	X	X	X	X
	<i>Tectura paleacea</i>	–	X	X	–
Crustaceans (crabs)	<i>Hemigrapsus nudus</i>	–	X	–	–
	<i>Hemigrapsus oregonensis</i>	–	–	X	–
	<i>Pachygrapsus crassipes</i>	X	X	X	X
	<i>Pagurus beringanus</i>	–	–	X	–

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey		Full Point Survey	
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Crustaceans (crabs) (continued)	<i>Pagurus granosimanus</i>	–	X	–	–
	<i>Pagurus hirsutiusculus</i>	X	X	X	X
	<i>Pagurus samuelis</i>	–	X	–	–
	<i>Pugettia gracilis/richii</i>	–	–	X	–
	<i>Pugettia producta</i>	X	–	X	X
Crustaceans (isopods)	<i>Idotea</i> spp.	X	X	X	X
	<i>Ligia</i> spp.	X	–	–	–
Crustaceans (barnacles)	<i>Balanus crenatus</i>	–	X	X	–
	<i>Balanus glandula</i>	X	X	X	X
	<i>Balanus glandula</i>	X	–	–	–
	<i>Chthamalus dalli/fissus</i>	X	X	X	X
	<i>Pollicipes polymerus</i>	X	X	X	X
	<i>Semibalanus cariosus</i>	X	X	X	X
Worms	<i>Chone minuta</i>	–	–	X	–
	<i>Phragmatopoma</i> spp./ <i>Sabellaria</i> spp.	X	X	X	X
	<i>Spirorbis</i> spp.	X	–	X	–
Echinoderms (sea stars)	<i>Dermasterias imbricata</i>	X	X	X	X
	<i>Henricia</i> spp.	X	X	X	X

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey		Full Point Survey	
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Echinoderms (sea stars) (continued)	<i>Leptasterias hexactis</i>	X	X	X	X
	<i>Pisaster ochraceous</i>	X	X	X	X
Echinoderms (sea urchins)	<i>Strongylocentrotus purpuratus</i>	–	–	X	X
Porifera (sponges)	<i>Halichondria panicea</i>	X	–	–	X
	<i>Halichondria</i> spp.	–	X	X	–
	<i>Haliclona</i> spp.	–	–	X	–
	<i>Ophlitaspongia pennata</i>	X	–	X	–
Urochordota (tunicate)	<i>Clavelina huntsmani</i>	X	–	–	–
	<i>Eurystomella bilabiata</i>	–	X	–	–
Cnidaria (sea anemone)	<i>Anthopleura elegantissim</i>	X	X	X	X
	<i>Anthopleura xanthogrammica</i>	X	X	–	X
	<i>Urticina coriacea</i>	–	X	–	–
Bryozoan	<i>Tricellaria</i> spp.	–	X	X	–
Cyanobacteria	<i>Callothrix</i> ; blue green algae	X	–	X	X
Fishes	Sculpin	–	–	–	X
Seagrass	<i>Phyllospadix scouleri</i>	X	X	X	X
Microalgae	Diatoms	X	X	X	–
Brown Algae	<i>Alaria marginata</i>	X	–	X	–

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey			Full Point Survey
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Brown Algae (continued)	<i>Analipus japonicus</i>	–	–	X	–
	<i>Colpomenia</i> spp./ <i>Leathesia</i> spp.	–	X	X	–
	<i>Egregia menziesii</i>	X	X	X	X
	<i>Endarachne</i> spp./ <i>Petalonia</i> spp./ <i>Phaeostrophion</i> spp.	X	X	X	X
	<i>Fucus</i> spp.	X	X	X	X
	<i>Laminaria setchellii</i>	X	X	X	–
	<i>Laminaria sinclairii</i>	–	X	X	X
	<i>Pelvetiopsis</i> spp.	X	X	X	X
	<i>Saccharina sessilis</i>	X	–	X	X
Green Algae	<i>Acrosiphonia</i> spp.	X	–	–	–
	<i>Chaetomorpha</i> spp.	–	X	–	–
	<i>Cladophora columbiana</i>	X	X	X	–
	<i>Cladophora</i> spp.	–	–	X	X
	<i>Cladophora stimpsonii</i>	–	–	X	–
	<i>Codium fragile</i>	X	–	–	–
	<i>Clothrix</i> spp.	X	–	–	–
	<i>Ulva</i> spp./ <i>Kornmannia</i> spp./ <i>Monostroma</i> spp.	X	–	X	X

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey		Full Point Survey	
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Red Algae	<i>Ahnfeltia fastigiata</i>	X	X	X	X
	<i>Ahnfeltiopsis linearis</i>	–	–	X	X
	<i>Callithamnion pikeanum</i>	X	X	X	X
	<i>Centroceras</i> spp./ <i>Ceramium</i> spp./ <i>Polysiphonia</i> spp.	X	X	X	X
	<i>Constantinea simplex</i>	X	X	X	X
	<i>Cryptopleura</i> spp./ <i>Hymenena</i> spp.	X	X	X	X
	<i>Cryptosiphonia woodii</i>	X	X	X	X
	<i>Desmarestia ligulata</i>	X	X	–	–
	<i>Dilsea californica</i>	X	X	X	X
	<i>Endocladia muricata</i>	X	X	X	X
	<i>Farlowia</i> spp./ <i>Pikea</i> spp.	X	X	–	–
	<i>Feldmannia cylindrica</i>	–	–	X	–
	<i>Gelidium coulteri</i>	X	X	X	X
	<i>Gloiopeltis furcata</i>	X	X	X	X
	<i>Hildenbrandia</i> spp./ <i>Peyssonnelia</i> spp.	X	X	X	X
	<i>Mastocarpus</i> spp.	X	X	X	X
	<i>Mazzaella cordata/splendens</i>	X	X	X	X

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey		Full Point Survey	
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Red Algae (continued)	<i>Mazzaella oregona</i>	X	X	X	X
	<i>Mazzaella parksii</i>	X	X	–	–
	<i>Mazzaella</i> spp.	–	–	–	X
	<i>Microcladia borealis</i>	X	X	X	X
	<i>Microcladia coulteri</i>	–	–	–	X
	<i>Neoptilota</i> spp./ <i>Ptilota</i> spp.	X	X	X	X
	<i>Neorhodomela larix</i>	X	X	X	X
	<i>Neorhodomela oregona</i>	X	X	X	X
	<i>Odonthalia floccosa</i>	X	X	X	X
	<i>Odonthalia washingtoniensis</i>	X	–	–	–
	<i>Osmundea spectabilis</i>	X	X	X	X
	<i>Plocamium oregonum</i>	–	–	X	–
	<i>Plocamium pacificum</i>	X	–	X	–
	<i>Plocamium violaceum</i>	X	X	X	X
	<i>Polysiphonia</i> spp.	X	X	X	X
	<i>Prionitis filiformis</i>	–	X	–	–
	<i>Prionitis lanceolata</i>	X	X	X	X
	<i>Prionitis</i> spp.	X	–	–	–

Table A-1 (continued). Presence and absence of all taxa found at Redwood National and State Parks sites during 2017 and 2018 biodiversity surveys. The X in the table below indicates species present.

Category	Taxa	First Point Only Survey			Full Point Survey
		Enderts Beach 2018	Damnation Creek 2017	False Klamath Cove 2017	False Klamath Cove 2018
Red Algae (continued)	<i>Prionitis sternbergii</i>	–	X	X	–
	<i>Pterosiphonia bipinnata</i>	X	X	X	X
	<i>Pterosiphonia dendroidea/pennata</i>	X	X	X	X
	<i>Pterosiphonia</i> spp.	–	X	–	–
	<i>Pyropia</i> spp.	X	X	X	X
	<i>Schizymenia</i> spp./ <i>Halymenia</i> spp.	X	X	X	X
	<i>Sphacelaria</i> spp.	–	–	–	X
Red Algae (red crusts)	<i>Petrocelis</i>	X	X	X	X
	<i>Ralfsiaceae</i>	X	X	X	X
Red Algae (red corallines)	<i>Bossiella</i> spp.	X	X	X	X
	<i>Calliarthron</i> spp.	–	X	X	–
	<i>Corallina</i> spp.	X	X	X	X
	Crustose corallines	X	X	X	X
Substrate	Other crust	–	X	–	–
	Rock	X	X	X	X
	Sand	X	–	–	–
Total taxa	n/a	96	98	101	80

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
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