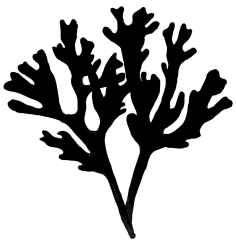
Exploring the Biodiversity of California Seaweed Through Art-Science.

An Illustrated Field Guide of Southern California Seaweeds.

Madison Churchill

June 2024
Masters of Advanced Studies Candidate- Marine Biodiversity and Conservation
Scripps Institution of Oceanography, San Diego CA



Capstone Advisory Committee:

Chair: Jennifer Smith, PhD

Signature: [redacted] Date: 6/10/2024

Jennifer Smith, PhD. Scripps Institution of Oceanography at UC San Diego

Josie Iselin, MFA

Signature: [redacted] Date: June 6, 2024

Josie Iselin, MFA. SFSU School of Design

Andrea Dingeldein, MS

Signature: [redacted] Date: 6/4/24

Andrea Dingeldein, MS. CSU Monterey Bay

Abstract
This capstone project is a completed draft of an illustrated field guide of Southern California seaweeds. The purpose of this was to create a region-specific and user-friendly guide for readers to learn about local seaweeds. This was done by collecting life specimens and illustrating them by hand with watercolor. The illustrations were digitized and put into a draft, along with supporting information about each species. The completed draft will be prepared and submitted for publication in print.

Introduction

Southern California has an incredible host of seaweed biodiversity. There are thought to be over 700 species of seaweed in California alone. There is a local community of ocean-goers interested in learning about marine vegetation, but there are limited accessible resources geared towards this part of the ecosystem.

This illustrated field guide features over 60 Southern California seaweed species with supporting information and detailed scientific illustrations. It is intended to be an educational resource for anyone wishing to learn about local seaweeds. Publishing an entire book within the confines of a 10-week project was not realistic, so a more humble deliverable was to complete a book draft. This 90-page draft includes introductory information, seaweed ecology, individual species pages, glossary, and other supporting information. The intention is to submit it for print publication.

About the Book

This illustrated field guide attempts to capture the immense biodiversity of seaweed. All of the illustrations were painted by hand, and I have done my best to highlight the unique features of each species, while staying true to scientific accuracy. While this book focuses mainly on Southern California, many of these species can be found in other parts of the world. These are many of the common species I see out in the water while diving, swimming, tide-pooling, and beach-combing.

This is by no means an exhaustive list of seaweeds in Southern California. There are hundreds of different species, many of which need a microscope to be identified. I have stuck mainly to the species you might encounter out in the wild, and which will be possible to identify with the naked eye. My goal is for this book to be accessible to non-scientist seaweed enthusiasts, and anybody wanting to learn more about local seaweeds. The appendix of this book includes a list of resources for those who want to dive deeper into phycology, the study of seaweeds.

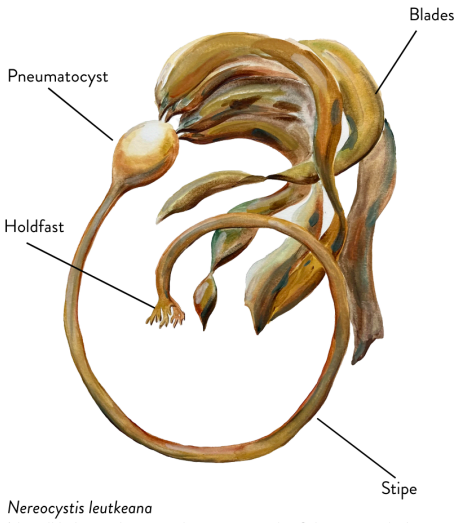
Mock Pages

All mock pages are shown in spreads of two pages, as they would appear in a book.

This draft begins with a handful of introductory pages with foundational seaweed information to guide the reader through the rest of the book. This introductory section includes morphology and terminology, conservation, climate change impacts, Indigenous uses of seaweed, edible seaweeds, collecting ethics, and kelp anatomy.

Introduction Pages

Anatomy of Kelp



Nereocystis leutkeana
Not all kelps and seaweeds contain each of these morphological features. Some also contain unique reproductive features.

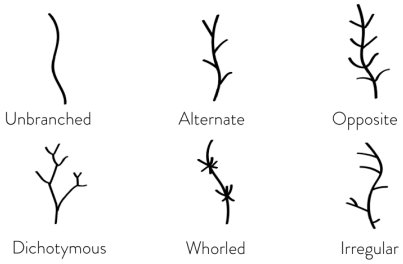
Holdfast- The rootlike structure at the base of a kelp or seaweed that helps it attach to rocks or other substrate. Unlike plant roots, they are not used to take up water from the soil, it is just used to anchor them to the benthos.

Stipe- The "stem" that gives a kelp or seaweed structure. This may be very pronounced, like in ***N. leutkeana*** (pictured) or it might be quite small in some seaweeds.

Pneumatocyst- The air-filled bladders that help a kelp float. This allows a kelp to reach higher in the water column to photosynthesize. Kelps may have one or multiple.

Blades- The "leaves" on a kelp or seaweed. They give the algae more surface area to photosynthesize.

Branching Patterns



Holdfast Types

Seaweeds have different types of attachments depending on the substrate and environment they grow on. Large kelps, or kelps in high energy surge zones might have more substantial holdfasts to keep them securely anchored.

Hapterous
Finger-like roots to grip substrate.

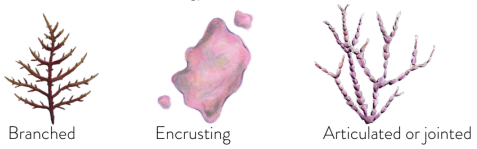
Discoid
Small disk attachment.

Rhizoids
Creeping hairlike roots. Used to anchor in sand.

Morphology

Seaweeds come in many shapes and sizes! Seaweed **thallus** (body) types have a nearly endless range of features. Here are a few you will learn about through this book.

Flat blades | Stringy tubes | Globular



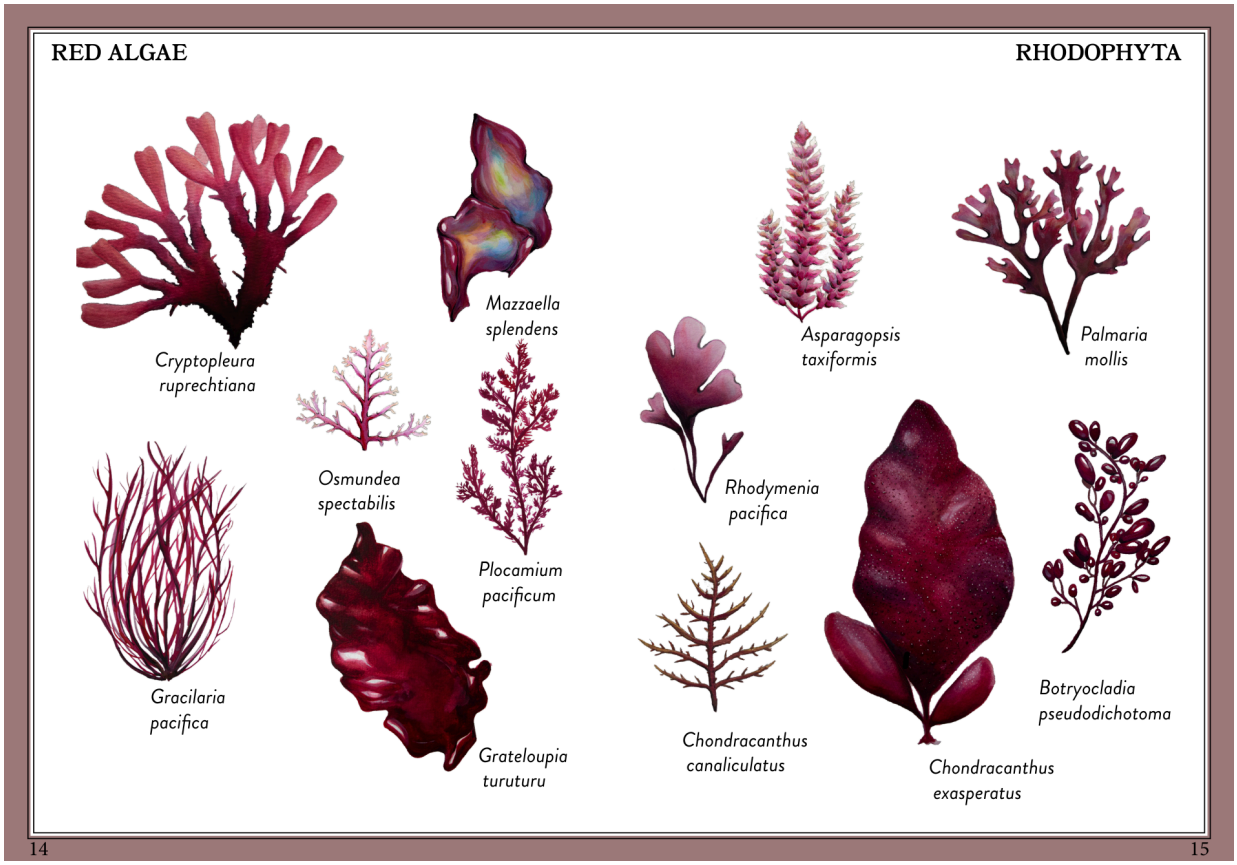
Branched | Encrusting | Articulated or jointed

Textured blades | Complex forms | Fluid-filled sacs

These pages feature branching patterns, holdfast types, anatomy, and different seaweed structure. The intention is to give some base knowledge to guide the reader through descriptions that appear throughout the book.

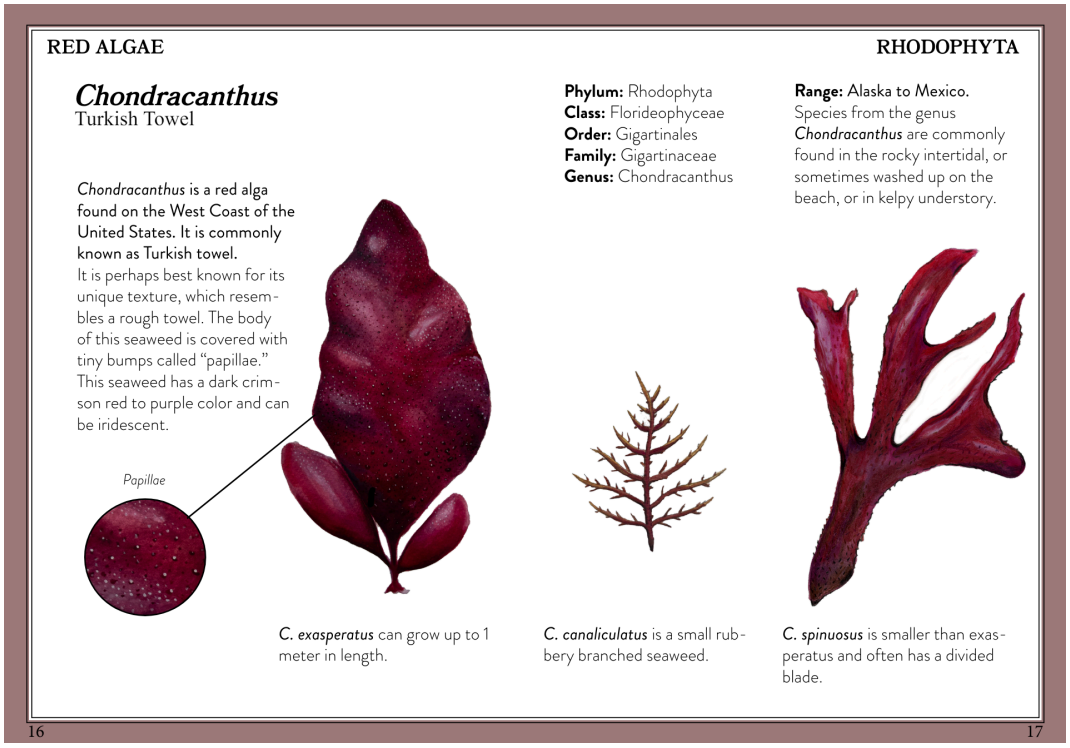
Species Pages

Species are sorted and organized taxonomically. Primarily, they are divided into three main phyla. The beginning of each section contains an illustrated spread of the upcoming species, before diving into individual species. Here is an example of Red *Rhodophyta* seaweeds.

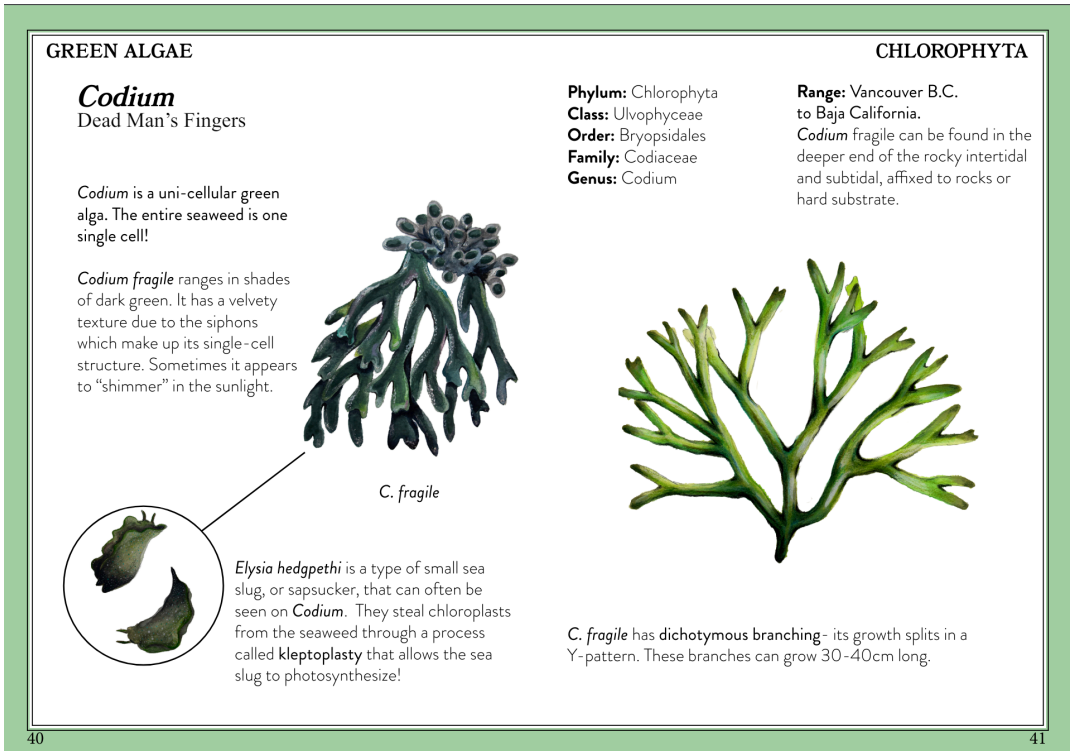


Individual Species

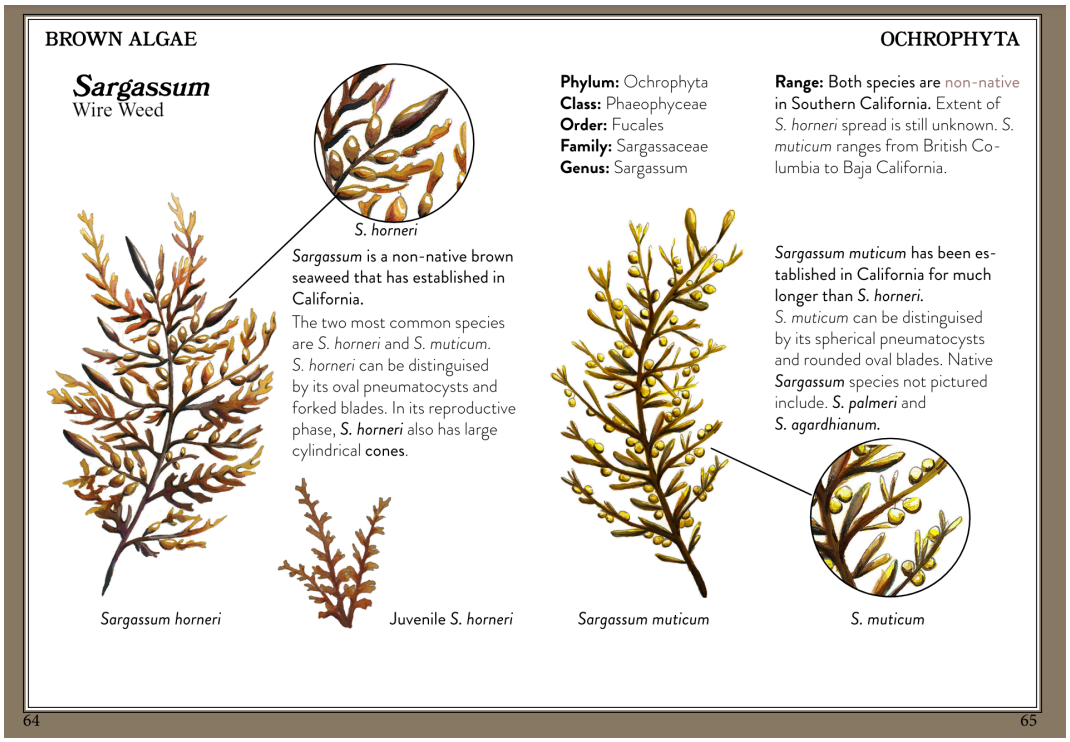
These are some mock-up pages for individual species. There are about 60 species in total, many with multiple illustrations, and most of the pages follow a similar format. Some species of key importance have more detailed descriptions, while some are just focused on visual identification. The page borders are color coded for ease of identification between phyla. Each species has the taxonomic layout, common range, and visual description. The pages are sorted by genus, but feature species representatives within each genus. The range for each species was determined by cross-referencing Algaebase, MacroAlgal Herbarium Portal, and iNaturalist, detailed in the references section.



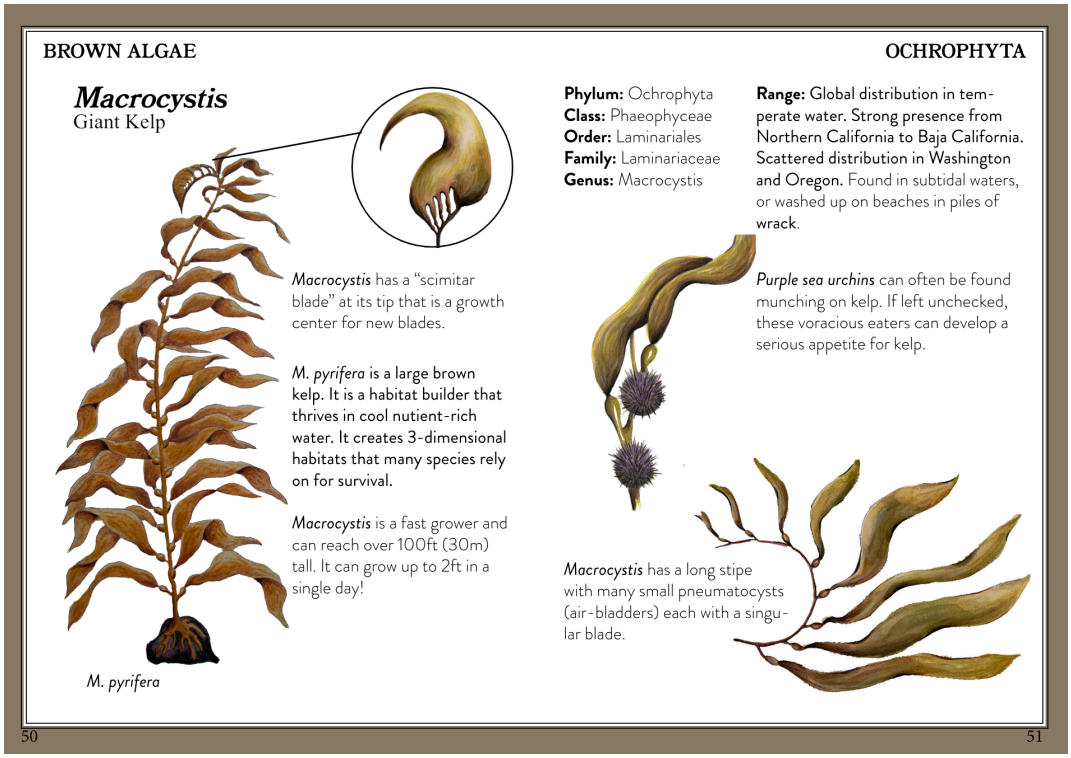
Species like *Chondracanthus* with unique key features have these little pop-out bubbles to highlight specific areas. The high resolution version in the final product will further enunciate key features.



Some species have interesting relationships with other species in their ecosystem such as *Codium* and *Elysia hedgpethi* that have been included as additional education opportunities. While many marine species rely on seaweed for survival, the invertebrate features were limited to species with particularly unique or interesting relationships.



Sargassum is a common non-native species in Southern California. Non-native and invasive species have been included, as many of them are quite common. The *Sargassum* pages went into a higher level of identification detail, because these species are commonly surveyed and studied. The pop-out bubbles show different shapes of blades and pneumatocysts to tell the two species apart. It also features a juvenile *S. horneri* for further identification.



Macrocystis is a very important local species. These pages show a pop-out with the scimitar tip, a unique growth form. It also includes the relationship with purple urchins and a bit of ecological context.

These are just a few of the species included in this draft, to give a sense of the style, artwork, and information presented. Each genus has at least one page, and some have two or more.

The species included in this draft are:

Red Seaweeds

Chondracanthus exasperatus (Turkish towel)
Chondracanthus canaliculatus
Chondracanthus spinuosus
Mazaella splendens (iridescent seaweed)
Palmaria mollis (dulse)
Asparagopsis taxiformis (red sea plume)
Rhodymenia pacifica
Rhodymenia californica
Botryocladia pseudodichotoma (red sea grapes)
Osmundea spectabilis (pepper dulse)
Grateloupia turuturu
Prionitis linearis
Gelidium robustum (agarweed)

Corallina vancouveriensis
Plocamium pacificum (red sea comb)
Microcladia coulteri (delicate sea lace)
Cryptopleura ruprechtiana (grape tongue)
Pyropia lanceolata (nori)
Gracilaria pacifica (ogo)

Green Seaweeds

Codium fragile (dead man's fingers)
Bryopsis corticulans (hair algae)
Chaetomorpha spiralis
Caulerpa prolifera
Ulva californica
Ulva lactuca (sea lettuce)
Ulva intestinalis (gut weed)

Brown Seaweeds

Macrocystis pyrifera (giant kelp)
Pelagophycus porra (elk kelp)
Laminaria farlowii (oar weed)
Laminaria setchellii
Nereocystis leutkeana (bull kelp)
Agarum fimbriatum (sieve kelp)
Pterygophora californica (woody kelp)
Undaria pinnatifida (wakame)
Eisenia arborea (Southern sea palm)
Egregia menziesii (feather boa kelp)
Sargassum horneri (wire weed)
Sargassum muticum
Stephanocystis osmundacea (chain-bladder kelp)
Stephanocystis dioica
Zonaria farlowii (banded fan weed)
Dictyopteris undulata
Dictyota flabellata (Y-branched algae)
Dictyota cyanoloma
Colpomenia peregrina (bubble algae)
Petalonia binghamiae (false kelp)
Scytosiphon lomentaira (bean weed)
Hydroclathrus clatharatus
Silvetia compressa (golden rockweed)
Desmerestia ligulata (flattened acid kelp)

Invertebrate Mentions

Haliotis kamtschatkana (pinto abalone)
Aplysia californica (California sea hare)
Elysia hedgpethi (Hedgpeth's sapsucker)
Strongylocentrotus purpuratus (purple urchin)
Norrisia norrisii (norris top snail)

Methods

Curating the Species List

Arguably the hardest part of this project was curating the species list. This list is pared down to the most common species one might find on Southern California beaches or while in the water. These are all species that can be identified by the naked eye, within reason, at least to the genus level. There are many more seaweeds that require a microscope to identify.

To curate the list, a variety of sources were used and cross-referenced. Dr. Jen Smith (capstone chair) taught a Phycology (seaweed science) lab course in Winter Quarter 2024 which helped structure the foundation of this list. Many of the species included were the ones we studied in that lab course. As a scientific diver, much of my time spent in the field was used to gather information on commonly seen species. I also included many commonly submitted species in the Smith Lab herbarium.

Additionally, I consulted online references like research-grade iNaturalist submissions to view commonly seen species, and always cross-referenced these with sources such as the *Marine Algae of California* textbook.

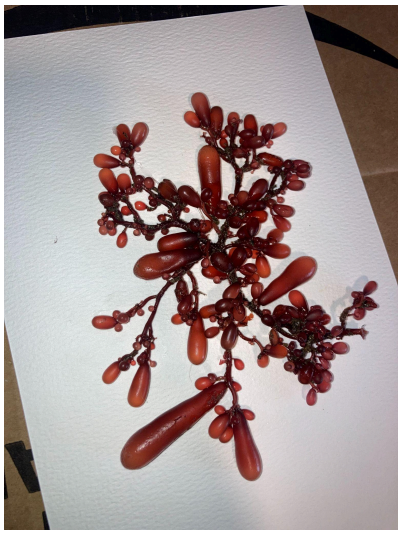
Collection

Live specimens were used as art reference whenever possible. Seaweeds were collected and suspended in saltwater while I painted them, to capture movement in water. Many were also pressed and dried for preservation. Preserved specimens were particularly helpful in detailing morphology and structure. For dried seaweeds, photos were taken while fresh to preserve accurate coloring. For some harder to find species, pressings from the Smith Lab were used as well, but the majority were my own. Additionally, many photos were taken in the field, in tidepools or while scuba diving. These were used as reference as well, but were less ideal than fresh samples.

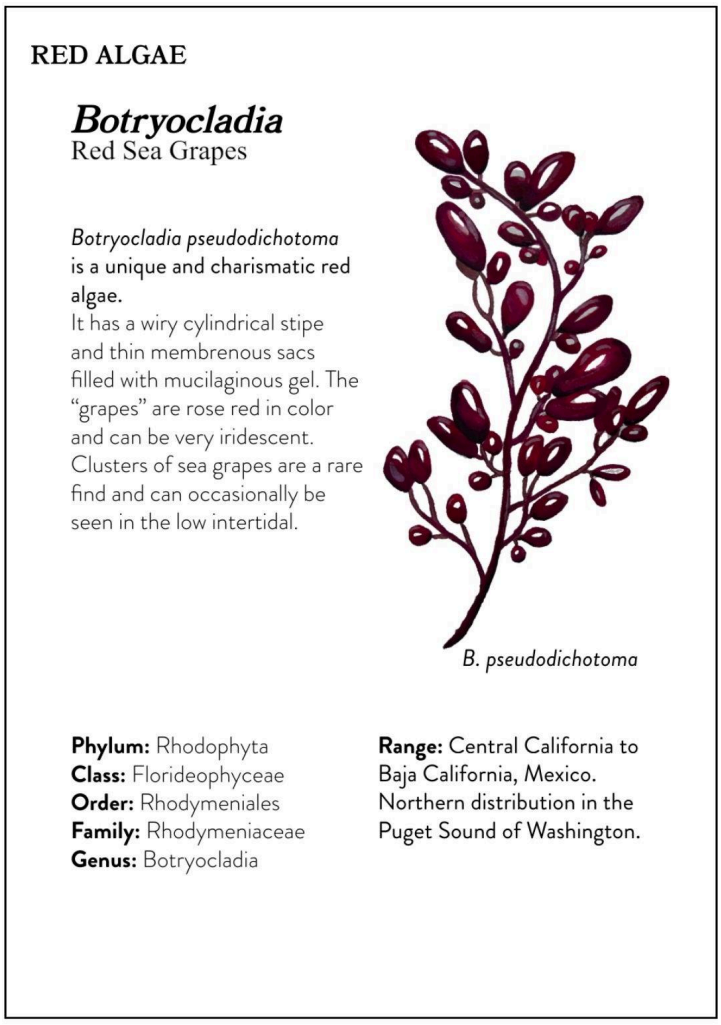
Art

All of the illustrations were painted by hand with watercolor. These scientific illustrations were created in a way that highlights key features and morphology. Each illustration had a watercolor base, and some had colored pencil overlaid to create structure and dimension. The illustrations were started months prior to the creation of the draft, and took over 100+ hours to complete. Many illustrations were created that did not make it into the final product. Many species had multiple illustrations to show different parts or life stages.

All illustrations were digitized and retouched with Adobe Suite. Lightroom, Illustrator, and Photoshop were used to touch up images and remove backgrounds. Adobe InDesign was used to create the final book draft.


Here is an example workflow for one species, *Botryocladia pseudodichotoma* (red sea grapes.) I collected this specimen while diving. I photographed it and sketched it while it was suspended in saltwater at my desk. I then pressed it to dry and preserve the specimen, and to observe the branching patterns to ensure accuracy of my illustration. I then painted it with watercolor, and digitized my painting. I retouched it and removed the background using Adobe Photoshop, and transferred it to Adobe InDesign to be part of my draft.
I researched its range and habitat using a combination of AlgaeBase, Macro Algal Herbarium Portal, and verified iNaturalist submissions. I also recorded its current taxonomy from AlgaeBase. All of that information was compiled to create the finished page:



Publication and Next Steps

After the 2024 capstone symposium, I intend to apply for publication in print. I will focus on California publishers, and those who specify in nature field guides.

Sources

1. Abbott, Isabella A., and George J. Hollenberg. *Marine Algae of California.* Stanford Univ. Pr., 1982.
2. Fylling, Marni. *Fylling's Illustrated Guide to Pacific Coast Tide Pools*. Heyday, 2015.
3. Druehl, Louis D., and Bridgette Clarkston. *Pacific Seaweeds: A Guide to Common Seaweeds of the West Coast*. Harbour Publishing, 2016.
4. Iselin, Josie. *The Curious World of Seaweed*. Heyday, 2019.
5. Stewart, Joan G. *Marine Algae and Seagrasses of San Diego County.* California Sea Grant College, 1991.

6. Behrens, David W., et al. *Nudibranchs & Sea Slugs of the Eastern Pacific.* MolaMarine, 2022.
7. Swinimer, Amanda. *Science and Spirit of Seaweed: Discovering Food, Medicine and Purpose in the Kelp Forests of the Pacific Northwest*. Harbour Publishing, 2022.
8. Ainis, Amira F., et al. *The potential use of seaweeds and marine plants by Native peoples of Alta and Baja California. An archaeology of abundance: reevaluating the marginality of California's islands*. Gainesville: University Press of Florida 2019. 86 87

Internet Resources

1. AlgaeBase, algaebase.org
2. Macroalgal Herbarium Portal, https://macroalgae.org/portal/collections/map/index.php
3. iNaturalist, inaturalist.org
4. Jepson Herbaria, https://ucjeps.berkeley.edu/
5. Biodiversity of the Central Coast, https://www.centralcoastbiodiversity.org/seaweeds-algae-and-seagrasses.html
6. CDFW Kelp and Other Marine Algae, https://wildlife. ca.gov/Conservation/Marine/Kelp
7. CA SeaGrant, https://caseagrant.ucsd.edu/our-work/discover-california-seafood/seaweed-aquaculture
8. Smith Lab, Scipps Institution of Oceanography, https:// coralreefecology.ucsd.edu/
9. NW Straits, The Cultural Importance of Kelp for Pacific Northwest Tribes, https://nwstraits.org/ media/2925/appendix_b_the-cultural-importance-ofkelp-for-pacific-northwest-tribes.pdf
10. Common Seaweeds of Cabrillo, https://cnmvipvoice. org/common-seaweeds-of-cabrillo/ Smithsonian, https://invasions.si.edu/nemesis/species_ summary/-449
11. CDWF Marine Management News, https://cdfwmarine. wordpress.com/2021/04/29/californias-ocean-habitats-kelp-forests/
12. Port of San Diego Press Release, San Diego Area Agencies Responding to Discovery of Invasive Seaweed in San Diego Bay, https://www.portofsandiego.org/press-releases/general-press-releases/san-diego-area-agencies-responding-discovery-invasive-seaweed
13. NOAA Fisheries, Kelp Forest Habitat on the West Coast, https://www.fisheries.noaa.gov/west-coast/habitat-conservation/kelp-forest-habitat-west-coast
14. NOAA Fisheries, Seaweed Aquaculture, https://www. fisheries.noaa.gov/national/aquaculture/seaweed-aquaculture