N A T U R A L

R E S O U R C E S

Sori Collection Protocols for Commercial Kelp Aquaculture in Washington State

Version: August 2024

WASHINGTON STATE DEPT OF NATURAL RESOURCES

1 Purpose

This document provides protocols for lessees of state-owned aquatic land (SOAL) to responsibly-source reproductive material from native, wild kelp used in commercial kelp farming practices.

The following core principles that minimize impacts to wild kelp stocks from commercial kelp aquaculture are emphasized in this document:

1. Ensure sustainable collection practices of reproductive material.
2. Maintain genetically diverse commercial farmed kelp stock and protect the genetic diversity of wild kelps.
3. Control transfer of invasive or pest species and disease

This protocol describes the considerations required for sourcing, collecting, and transporting reproductive material for commercial kelp farms on SOAL, and the needed information to prepare and submit a sori collection plan to DNR for approval. These protocols refer to three native Washington kelps considered for commercial aquaculture – Sugar Kelp (*Saccharina latissima),* Bull Kelp *(Nereocystis luetkeana)*, and Ribbon Kelp (*Alaria marginata)*. Each of these species has a different distribution and natural history, which requires a different approach to sori collection. The lease agreement lists authorized use that identifies which species are allowed for propagation on the leasehold.

2 Introduction

Kelp forests provide important ecosystem structure and are a critical source of food for aquatic organisms around the world. In recent years, many kelp forests in Washington State have declined dramatically. Locations that have been most affected are associated with elevated temperature, lower nutrient concentrations, and low water current velocities. Future losses spurred by climate change are of particular concern as elevated water temperatures reduce the tolerance of kelps to other stressors.

Kelp farming is gaining interest worldwide for both food and non-food applications. With high nutritional value, low input requirements, and rapid growth, kelps may provide an alternative or integrated aquaculture crop. Kelp aquaculture may be less impactful than other forms of floating aquaculture, potentially providing secondary benefits such as nutrient absorption, additions of primary productivity to the food chain, and structured habitats for species. Despite these potential benefits, there may also be environmental risks that come with commercial seaweed farming, including changes to benthic light availability, wave attenuation, crop-to-wild-gene flow, and increased disease risk.

3 Sori Collection Protocol

Kelps have two life stages – a microscopic stage and a visible stage which produces darkened patches of spores called the sorus (plural, *sori*). Sori collected each year are the sources of reproductive material used to seed the farms. The location and size of the sori on a kelp individual differs depending on species. The following list of sori collection requirements applies to all commercial kelp aquaculture species:

1. Sori shall not be collected unless done in accordance with a Sori Collection Plan (*See Section 4*) approved by DNR.

2. Sori shall be collected from a wild population as close to the farm site as possible, or within the same oceanographic sub-basin as the farm, according to the sub-basins defined for the Floating Kelp Forest Indicator for Washington State (https://wadnr.maps.arcgis.com/apps/webappviewer/index.html?id=f10864050bf14f57ba751ae53bc061f5). The lessee shall identify a primary and alternative sori collection site to include in the Sori Collection Plan.

3. Sori shall not be collected from areas of kelp concern (Check with DNR for most up-to-date areas). Areas of kelp concern include beds that are experiencing declines or total loss (e.g. Floating Kelp): https://wadnr.maps.arcgis.com/apps/webappviewer/index.html?id=f10864050bf14f57ba751ae53bc061f5)

4. Sori shall be collected from at least 50 individuals from the approved wild population source.

5. Sori shall be collected from dispersed individuals in the collection area, to improve potential genetic diversity of farmed stock.

6. Sori shall be collected by hand. Rakes shall not be used for collecting kelp, regardless of whether individuals are submerged or floating. The method of collection shall be included in a sori collection plan.

7. One sorus patch shall be collected from each individual using techniques that will not result in the death of the kelp (*See section 5 for Species-Specific Sorus Collection Protocols*).

8. Non-motorized boats shall be used if accessing the interior of floating kelp beds to avoid physical damage to the habitat. If target populations are submerged, or exposed at low tide, minimize unnecessary trampling or disturbance of native intertidal species.

9. Each sorus shall be closely examined at the collection site. Scan for bumps, discolorations, rot, signs of grazing. Do not collect sorus from kelp blades hosting aggregations of eggs, larvae, other fouling organisms or known invasive species (see examples in Figures 11-14). Fouled kelp shall be discarded at the site of collection or in an upland disposal to avoid the spread of these organisms.

10. Unblemished sori shall be cleaned as soon as possible to remove potential microscopic organisms. Thoroughly rinse collected sori with sterilized seawater and wipe with a cloth. A betadine dip can also be used as part of the sorus cleansing process. This can be achieved by dipping clean sorus tissue in an iodine bath for 30 seconds (using a Betadine® solution at 5 mL/L sterilized seawater at 10°C), rinsing, then soaking in clean seawater for 5--10 minutes, and wiping again with a clean paper towel.

11. If a kelp population appears to be suffering from a disease outbreak or severe fouling, do not collect from the site. The WDFW urges reporting of any widespread or unknown diseases to the Shellfish and Seaweed Health Unit (https://wdfw.wa.gov/licenses/fishing/shellfish-import-transfer#quarantine).

4 Sori Collection Plan

1. To account for the transport and use of reproductive material within the state, Lessee's shall complete a collection plan and submit to DNR for approval **prior** to a physical collection.
2. After the sori collection occurs, lessees must resubmit the same table with updated information to document the actual data and material collected.

The Sori Collection Plan Template is provided below as Table 1. Complete one template for each species planned for collection.

Table 1. Sori collection plan template

Field	**Description**
Farm	Name of the farm for which the collection is being performed and WDFW Aquatic Registration Number
Collection Site Name	Provide a name for the waterbody or beach.
Collection Site Coordinates	Provide coordinates of general collection location (decimal degrees).
Collection Site Owner (if applicable)	If you plan to enter private aquatic lands, a separate DNR lease, or tribal lands, identify the owner and attach written permission.
Alternative Collection Site Name	Provide information on an alternative collection site, in case collection at the primary site is not workable.
Alternative Collection Site Coordinates	Provide coordinates of general collection location (decimal degrees).
Alternative Collection Site Owner	If you plan to enter private aquatic lands, a separate DNR lease, or tribal lands, identify the owner and attach written permission.
Collection Date Range	Expected month, days, and year of collection.
Species	List the species collected. Provide the Latin name and common name (e.g. *Saccharina*

	latissima, sugar kelp). This shall be limited to only species authorized in Section 2 of the Lease.
Collection amount	Total number of sori expected to collect.
Collection method	Decribe the method used to collect sori. Refer to species-specific protocols below (Sec 5)
Outplant Location	Intended outplant/farm location coordinates and site name for kelp to be grown from collected sori
Outplant Date Range	Expected month, days, and year of outplant.

5 Species-Specific Protocols

5.1 Sugar Kelp (*Saccharina latissima*)

Sugar kelp (*Saccharina latissima*) is an understory kelp species that is often confused with Split kelp (*Hedophyllum nigripes*). Sugar kelp is composed of a single, unbroken blade with varying undulations, frills, or dimples. Sugar kelp may be distinguished from split kelp by a rounded blade shape where the stipe connects (Figure 1). Split kelp has more of a rectangular shape. Sugar kelp has thinner blades, with a papery feel whereas split kelp is thicker and deeper olive-brown in color. It is likely that some of these physical features are artifacts of the local environment, and so these features are not “hard” identifiers.

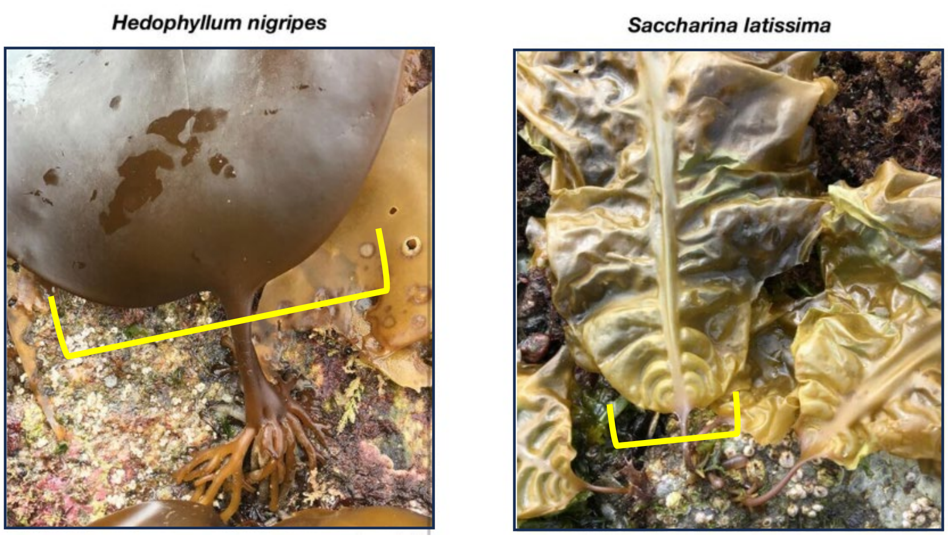

Figure 1. Split kelp (left) and sugar kelp (right) are two species that are commonly misidentified as the same (Greenwave 2023). Yellow brackets in both photos compare the “square” base of split kelp to the “rounded” base of sugar kelp.

Sugar kelp is widespread in Washington, growing in the lower intertidal and shallow subtidal zones throughout the state. Most research finds that wild sugar kelp reaches peak reproductivity in fall. However, spring is a smaller reproductive peak, and smaller numbers of sugar kelp will reproduce throughout the year, depending on local conditions.

Sugar kelp sori develop along the middle of the blade from the stipe to the tip and do not form easily detachable segments. In order to allow each individual to continue to grow, a patch of the sorus shall be cut out with a knife or hole punch well above the intercalary meristem (Figure 2). Sorus collection will not kill the individual if material is removed toward the top of the blade.

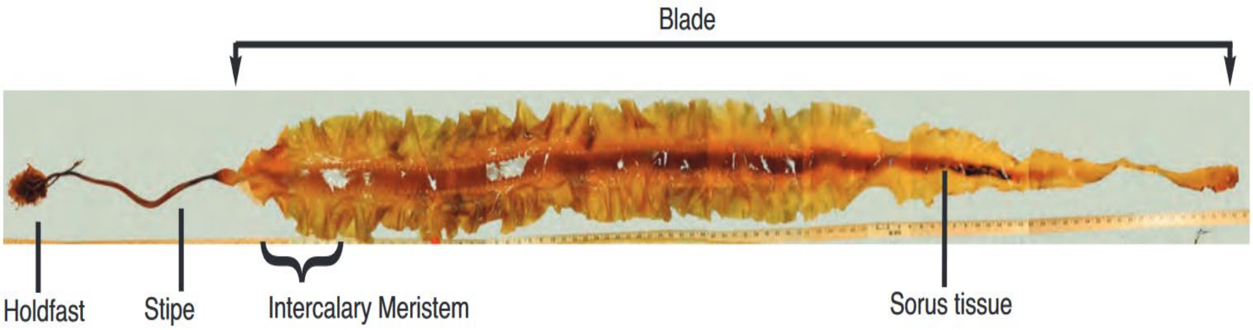

Figure 2. Location of tissue types on Sugar Kelp (note: pictured Sugar Kelp is not from Washington) Image from: https://marine-aquaculture.extension.org/seaweed-aquaculture-kelp/

5.2 Bull Kelp (*Nereocystis luetkeana*)

Bull kelp grows along the Pacific Coast, the Strait of Juan de Fuca, and within Puget Sound. It is the only canopy forming or 'floating' kelp species that inhabits the Salish Sea. Bull kelp has a single stipe topped with an air-filled bulb that floats at the waters' surface. Many blades will grow from the bulb, and these may reach lengths of 8-12 m. Bull kelp reproductive season varies throughout the Salish Sea. Sori patches have been observed as early as March with peak density of sori patches observed at sites from May through August. Sori mature at the tips of the blades first and are released to the water column as the blade tissue disintegrates from the blade tip toward the bulb in a conveyor belt sequence. Sori release continues through November. Depending on the locations, some reproductive bull kelp may be encountered year-round.

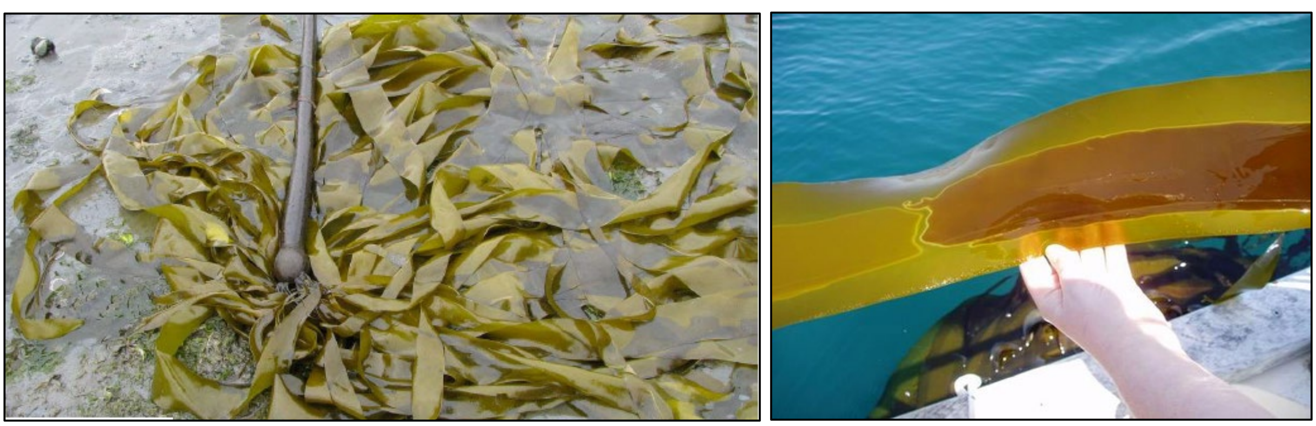

Figure 3. (left) Exposed bull kelp showing the stipe (long stem), air filled bulb, and many blades (WDNR Aquatic Vegetation Guide, 2011). (right) Bull kelp (Nereocystis luetkeana) blade with darkened "ripe" sorus tissue (cfb.unh.edu).

Bull kelp sori occur in a series of patches on each blade and will naturally detach from the blade when mature (Figure 3). The oldest and most viable sori are located nearest the tip of each blade furthest from the bulb and will be darker in color. Bull kelp sori may be collected by gently pulling the thinner blade tissue away from the "ripe" sori patch, or by removing the ripe sorus patch from the blade with a knife. Leave at least 24 inches between the sampled sorus and the bulb.

5.3 Ribbon Kelp (*Alaria marginata*)

Ribbon kelp is and understory kelp species, with a single blade that is rippled on either side of a distinct midrib. Ribbon kelp grow in the mid intertidal to subtidal rocky zones. This kelp grows wing-shaped reproductive blades (called sporophylls) near its base. Information on the reproductive season is limited, although some evidence suggests sporophylls may develop as early as March and peak in October. Ribbon kelp sori are located on the sporophylls which grow from the lower part of the stipe (Figure 4). The sporophylls may be large and noticeable, or if newly formed, they may appear only as tiny protrusions on the stipe. Remove only one sporophyll from the Ribbon kelp.


Figure 4. (left) Ribbon kelp exposed at a low tide (WDNR Aquatic Vegetation Guide, 2011; Druehl and Clarkston 2016). (right) Large Sporophylls containing sori are directly attached to stipe. Photo by Jenn Burt Central Coast Biodiversity

6 Resources:

- Floating Kelp Monitoring in Washington State: Statewide Summary Report: https://www.dnr.wa.gov/publications/aqr_nrsh_kelp_statewide_summary_report_23.pdf
- Kelp Bed Status, Floating Kelp Forest Indicator (Bull Kelp Only): https://wadnr.maps.arcgis.com/apps/webappviewer/index.html?id=f10864050bf14f57ba751ae53bc061f5
- Washington Department of Fish and Wildlife Shellfish and Biosecurity Website: https://wdfw.wa.gov/licenses/fishing/shellfish-import-transfer
- Map of Marine Protected Areas in Washington State: https://wdfw.wa.gov/fishing/management/mpa

- Map of documented herring spawning areas: https://wdfw.maps.arcgis.com/home/webmap/viewer.html?webmap=19b8f74e2d41470cbd80b1af8dedd6b3&extent=-126.1368,45.6684,-119.6494,49.0781
- Examples of herring eggs:
  - https://www.flickr.com/photos/wastatednr/sets/72157630049550012/
  - https://www.snocomrc.org/media/20172/mrc-training2021.pdf (p. 40-56).
- Species Identification: *Marine Life of the Pacific Northwest* (Lamb et al 2005).
- NEMESIS, the National Estuarine and Marine Exotic Species Information System (https://invasions.si.edu/nemesis/)
- Call the WDFW invasive species question hotline at 1-888-WDFW-AIS or email ais@dfw.wa.gov.
- Report new invasive species to the Washington Invasive Species Council (https://invasivespecies.wa.gov/).
- Washington marine plant importation and transfer https://wdfw.wa.gov/licenses/fishing/shellfish-import-transfer#marineplants

7 Glossary

- Holdfast: Root-like tissue that connects kelp to the ground – usually to bedrock or cobble.
- Stipe: The central stem like part of the algae. Serves to transport nutrients throughout the plant.
- Blade: The leafy zones of algae, which function to photosynthesize and provide energy to the plant.
- Sorus: (*plural, sori*) Kelp reproductive tissue which produces microscopic spores.
- Meristem: Location where cells capable of division are present and growth occurs in plants (known as meristematic tissue). In kelp, this is where the blades and stipe meet.
- Sporophyll: Leaf-like structures that produces spores. The kelp species *Alaria marginata* is a common species of kelp in Washington that produces spores in this way.