Marine Plan Partnership for the North Pacific Coast (MaPP)

MAPP KELP MONITORING METHODS 2021

Updated: July 2021

Disclaimers:

The purpose of this document is to support the MaPP Partners to conduct kelp monitoring training, field work and data collection and to provide guidance and examples for other organizations or practitioners wishing to conduct kelp monitoring. Users of this document should review and implement their organizational safety protocols as required prior to conducting monitoring in the field.

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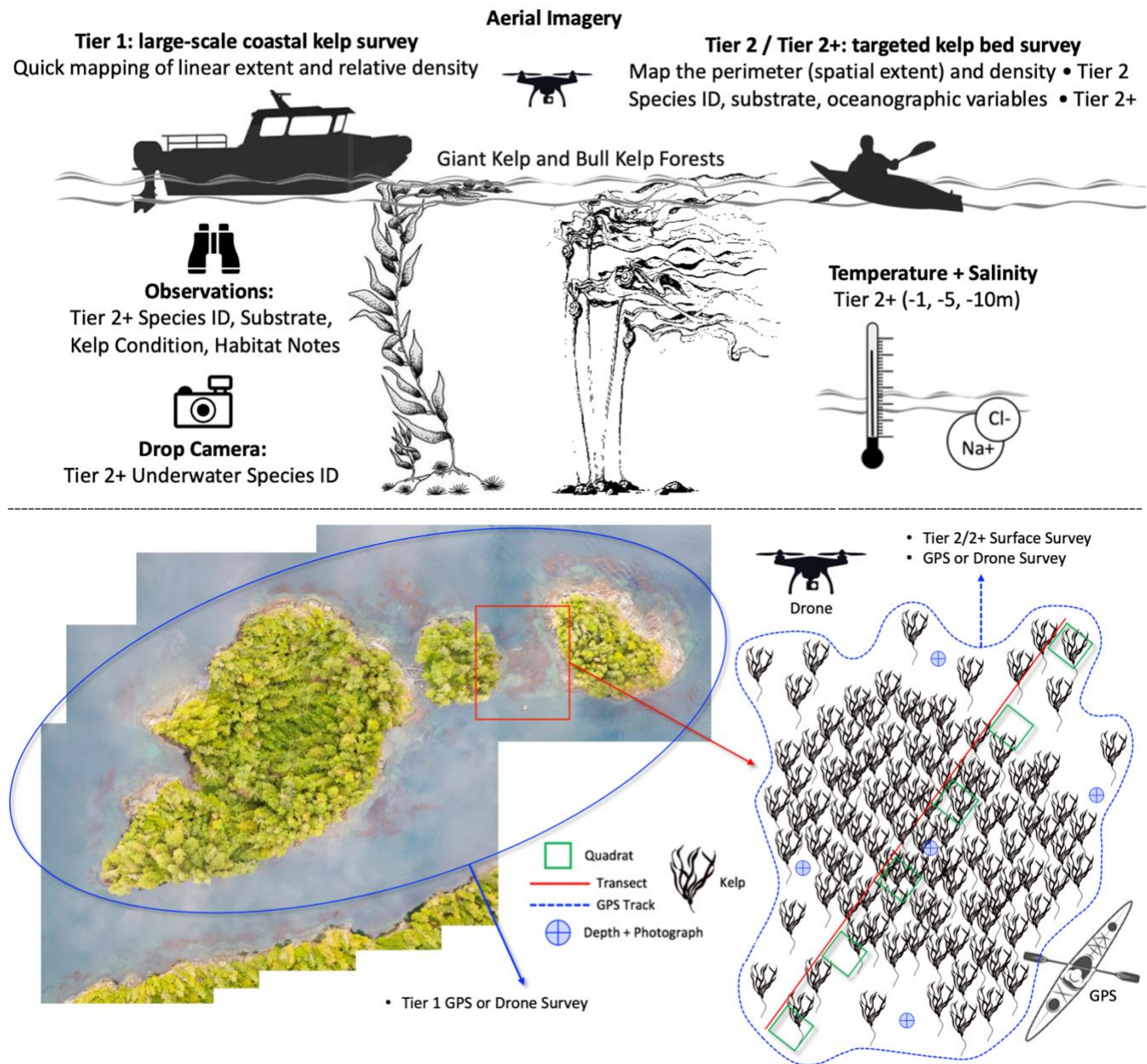
Prepared for:
Marine Plan Partnership Initiative (MaPP)

This document will be updated as necessary

Canopy Kelp Monitoring Overview

Canopy kelp monitoring requires a blend of Tier 1 (p.3) and Tier 2/2+ (p.4) survey methods:

- Tier 1 methods are designed for the first field season of surveying to efficiently collect baseline information (kelp location and extent) over large coastal areas. Observations from Tier 1 surveys build local ecological knowledge and provide the information required to map and select ecologically important kelp beds for subsequent Tier 2/2+ surveys.
- Tier 2/2+ methods collect detailed observations from preselected kelp beds, including measures of spatial coverage and kelp density (Tier 2), species ID, oceanographic parameters, and high-resolution UAV images (Tier 2+). Where time allows, Tier 1 methods can be paired with Tier 2/2+ surveys to collect additional observations (see Figure 1 below).

Figure 1: Surface view (top) and aerial view (bottom) examples of Tier 1 and 2 canopy kelp surveys.

Tier 1 Kelp Monitoring Methods

Tier 1 Step 1: Kelp reference information
- Location mapping should be completed at tides below 2.5m.
- Kelp bed definition guidelines:
  - A cluster of bull kelp or giant kelp spanning ~3 metres or more in any direction.
  - Gaps greater than ~10 metres between plants separate individual kelp clusters / beds.
- Use a data collection app (e.g.: Avenza, Coast Tracker) or the datasheet to record reference information:
  - Date, Time, and Tide.
  - Kelp species (bull kelp, giant kelp, or mixed kelp bed).
  - Guardian crew, and names of Guardians collecting data.
  - Site location: name of the island, bay, or other nearby identifiable location.
  - Site Identification: provide a unique identification number for each site. For example, the first Tlowitsis kelp survey could be identified as TL–K01 (Tlowitsis – Kelp Bed number 1).

Tier 1 Step 2: Map the extent or perimeter of the kelp bed
- Use a data collection app or the datasheet to map the location of kelp with GPS points:
- For kelp fringing the shoreline: map the offshore edge with GPS points (enough to connect the dots and show the edge on a map) and record width (distance across the kelp to the shoreline) at each GPS point.
  - Example: map the kelp along a curving coastline by placing a GPS point at each location where the shoreline curves (e.g.: along an S shaped coastline record GPS points on the inside and outside of each curve, this will allow you to connect the dots on a map, retracing the kelp).
- For kelp bed reefs map the perimeter with enough GPS points to record the general shape.
  - Example: map a circular bed with 4 GPS points – inshore, offshore, left and right sides. Irregularly shaped beds should include additional points to record the general shape (width measurements are not required here as we can later measure the width with the GPS points).
- Estimate the density (percent coverage) of the kelp bed observed at each GPS point using a score from 1 to 5 (very low to very high):

1. Very low density: less than 20 percent coverage. Patchy and fragmented.
2. Low density: 20 – 40 percent coverage.
3. Medium density: 40 – 60 percent coverage.
4. High density: 60 – 80 percent coverage.
5. Very high density: 80 – 100 percent coverage. Continuous and unbroken.

Option: UAV (drone) survey for kelp bed extent mapping
- Tier 1 drone surveys are most feasible when conducted with Tier 2/2+ surveys: map a preselected area around the Tier 2 kelp bed (Figure 1) using the drone to map perimeter extent (Step 2). Detailed local information collected with Tier 2 surveys is complemented with the Tier 1 survey in adjacent areas.
- Refer to Tier 2: Step 7 and the Guide for Drone Surveys for detailed instructions.

Tier 1 Step 3: Comments and photographs.
- Use a data collection app or the datasheet to provide informative comments.
  - Brief description: informative details not included in steps 1 and 2 (fringe or reef; proximity to human activities; exposed or sheltered; notable impacts).
  - Substrate – bedrock, boulder, cobble, pebble, and sand (note primary and secondary).
  - Bryozoans (present / absent). Sea urchins (species, present / absent).
  - Other species observed – schools of fish, predators (sea lions, otters, etc.).

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Tier 2 / Tier 2+ Kelp Monitoring Methods

Tier 2 Step 1: Kelp reference information.
- Spatial mapping and data collection should be completed at tides below 1.5m
- Kelp bed selection: The selected kelp bed should be large enough to complete a minimum of 10 quadrats. If the selected kelp bed is not adequate in size, move to the nearest adequate kelp bed.
  - If the entire kelp bed cannot be surveyed due to size, select a representative area that can be surveyed within the 2-hour tide window (1 hour before and 1 hour after the low tide).
- Use a data collection app (e.g.: Avenza, Coast Tracker) or the datasheet to record reference information:
  - Site Identification: provide a unique identification number for each site. For example, the first Tlowitsis kelp survey could be identified as TL–K01 (for Tlowitsis – Kelp Bed number 1).
  - Location – record a brief description of the kelp bed location. For example: 'south side of Cook Island in Beware Passage'.
  - Site GPS coordinate – position the boat to record a UTM coordinate that can be used to find the kelp bed again. Set the GPS to NAD 83, UTM, and decimal degrees. Record the coordinates using a data collection app or the datasheet. For example: 50.589038, -126.863560.
  - Guardian crew, and name of Guardian recording the data.
  - Weather – record marine weather conditions (wind, current, waves, etc.).
  - Substrate – bedrock, boulder, cobble, pebble, and sand cover (primary and secondary).
  - Tide – record the time and tide when you start and when you complete the survey.
  - Species observed – schools of fish, predators (sea lions, sea otters, etc.).
  - Sea urchins – species (red, purple, or green), and estimated abundance for each within the site (abundance guidelines: high: $> 3/m^2$, medium: $1–2/m^2$, low: $< 1/m^2$).
- Refer to Checklist (p. 7) for guidance on differences between Tier 2 and Tier 2+.

Tier 2 Step 2: Set-up transects and mark their locations

Identify representative transects (an imaginary line spanning the kelp) through the kelp bed. Set one or more straight lines (transects) across the kelp bed that include similar proportions (high and low area of density) of kelp when compared to the entire bed (see below and Figure 2).
- Multiple transects should be used when necessary. For large kelp beds, complete as many quadrats as time will allow (while the tide is below 1.5m).
- Record GPS points and the depth at the beginning and end of each transect.
- Use a handheld GPS, data collection app, or the boat sounder to record a GPS points at the start of each transect (Transect 1 start = T1a) and end (Transect 1 end = T1b).
  - Use a small inflatable boat, punt, or kayak to get into the kelp bed if needed.
- Use a depth sounder or a drop line to record the depth at the beginning and end of each transect.
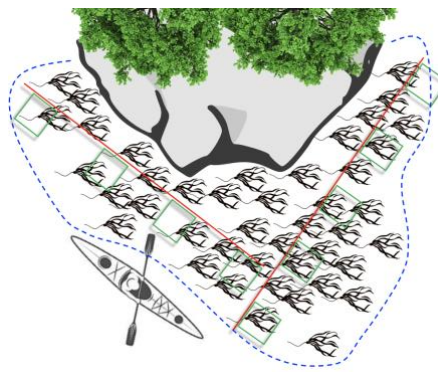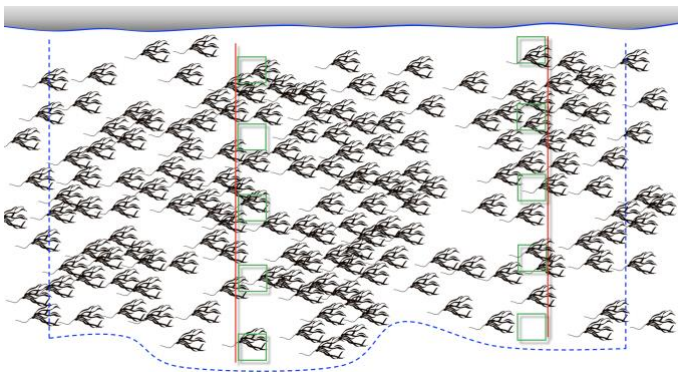
Tier 2 Step 3: Collect quadrat data along the transect

Bull kelp (Nereocystis luetkeana)
- Use a 1 m² quadrat to count and measure kelp bulbs along the transect.
  - Count all of the kelp bulbs found inside the quadrat on the water surface.
  - Estimate bryozoan coverage using a score from 0.5 to 5 (note the added 0.5 category):

0.5	Rare: less than 5 percent coverage – few and far between.
1.	Very low density: Less than 20 percentt coverage. Patchy and Fragmented.
2.	Low denssity: 20–40 percent coverage.
3.	Medium density: 40–60 percent coverage.
4.	High density: 60–80 percent coverage.
5.	Very high density: 80–100 percent coverage. Continuous and unbroken.

- Measure the diameter of up to 10 kelp stipes at their widest point (typically ~10cm below the bulb) using calipers (e.g.: 28 mm). Only measure stipes that are attached to bulbs inside the quadrat.
  - Flip the quadrat 3 times to move 3 meters along the transect to reach the next quadrat location.

Giant kelp (Macrocystis pyrifera)
- Use a 1 m² quadrat to count kelp fronds along the transect.
  - Place the transect perpendicular to the direction fronds are sitting in the current to ensure you don't count the same individual fronds again in multiple quadrat locations (if your transect points in the same direction as the kelp fronds, the same fronds may be counted 2 or 3 times).
  - If more than 1 transect is needed, additional transects must be separated by a minimum of 6m.
  - Flip the quadrat 3 times to move 3 meters along the transect to reach the next quadrat location.
  - Count kelp fronds (one frond = a single branch, including all attached floats and blades) that are inside the quadrat, on the surface (counts will vary from 0 to 60+).
  - Estimate bryozoan coverage observed on the kelp in each quadrat using a score from 1 to 5 (very low to very high):

1.	Very low density: less than 20 percent coverage. Patchy and fragmented.
2.	Low density: 20 – 40 percent coverage.
3.	Medium density: 40 – 60 percent coverage.
4.	High density: 60 – 80 percent coverage.
5.	Very high density: 80 – 100 percent coverage. Continuous and unbroken.

Mixed (giant kelp + bull kelp)
- Complete quadrat counts (Step 2) separately for each species.

Tier 2 Step 4: Map the extent or perimeter of the kelp bed

Option: UAV (drone) survey
- Use your drone to record survey images of the entire kelp bed from a height of 60–120m (Tier 2+).
  - Adjust height based on size of survey area, tree heights, weather, etc.
  - It is very important to be sure the entire kelp bed has been surveyed.

- If time and battery power allow, use your drone to record survey images of kelp surrounding the survey area from a height of 120m (see Figure 1).
  - Open the Pix4D app to review the areas selected for the survey (this area should be planned and selected before you leave for the field). You can adjust the area the drone will survey if you suspect that any part of the kelp bed might fall outside of the preplanned survey area.
  - Check battery levels on all devices and ensure an adequate SD card is onboard.
  - Check conditions (weather, tides, lighting, and safety).
  - Ensure air space is clear and flight altitudes will be enough to clear trees.
  - Test lighting levels and focus of the camera by taking test photos.
  - Start and end your flight using the DJI GO 4 app. Fly the mission with Pix4D.
  - Complete your flight log, including start and end times, weather conditions, and crew.
- Refer to the Guide for Drone Surveys for detailed instructions.

Option: GPS survey *(when a drone survey is not possible)*
- If you cannot complete a drone survey, map the kelp bed perimeter using GPS.
  - Use a kayak, inflatable, or punt to move around the kelp bed while recording a GPS track or GPS points. Stay within 1m of the kelp bed edge (see Figure 2).
- Draw a map of the kelp bed.
  - Identify areas where transects were positioned and where CTD measurements were taken.
  - Identify areas on the map that contain continuous distribution (unbroken surface coverage) and areas that contain patchy distribution (uneven, fragmented coverage). Estimate the density (percent coverage) of the kelp bed in each area identified on the map using a score from 1 to 5.

    1. Very low density: less than 20 percent coverage. Patchy and fragmented.
    2. Low density: 20 – 40 percent coverage.
    3. Medium density: 40 – 60 percent coverage.
    4. High density: 60 – 80 percent coverage.
    5. Very high density: 80 – 100 percent coverage. Continuous and unbroken.

Tier 2+ Step 5: Oceanographic data.
- Use a CTD water quality instrument to measure temperature and salinity at –1m, –5m, and –10m.
  - Measurements should be recorded near the center of the bed via kayak, if possible.
- Use the Secchi disk to measure water visibility.
  - Record the depth (marked on the Secchi line) where the disk is no longer visible.
- Record a GPS point where you measured oceanographic parameters using a GPS or data collection app.

Tier 2+ Step 6: Kelp bed observations.
- Use a smart phone, tablet, or data collection app to record photographs and observations, including notable comments on health and the presence of wildlife.
- Record the presence and abundance of kelp-encrusting bryozoans (thin, circular colonies of white crust).
  - Use guidelines in Step 2: Bull Kelp (p.4) to estimate average cover for the entire bed.
- Record underwater observations: from the boat, using a drop camera, or mask and snorkel.
  - Urchin species (red, purple, green) and abundance (high: > $3/m^2$, medium: $1–2/m^2$, low: $1/m^2$).
  - Sea star and rockfish species (use an ID book for identification).
  - Substrate type: bedrock, boulder, cobble, pebble, and sand cover (note primary and secondary).
- Take wide angle photographs that are representative of the kelp bed. (see Figure 2 for photo locations).

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Survey Guidelines and Checklist

Survey Data Guidelines and Checklist:

- Record all measurements in metric (meters, centimeters, and millimeters).
  - Set all relevant equipment to metric: DJI GO 4, YSI, depth sounder, range finder, etc.
- Record all GPS points in Decimal Degrees (i.e.: 50.589038, -126.863560).
  - Set all relevant equipment to decimal degrees: Avenza, depth sounder, etc.
- All data from the same site must include the same Identification number (i.e.: TL-K001).
  - The site ID number must be recorded with each method used for data collection (Table 1).

Tier 1:

○ Fill in all kelp reference information

○ GPS points recorded in a data collection app or datasheet, including width and density estimates

○ Notes recorded on species, habitat, and substrate (include photographs if needed)

Tier 2:

○ Fill in all kelp reference information

○ Quadrat counts and kelp measurements recorded on the data sheet

○ Record kelp bed perimeter GPS points using a GPS unit or data collection app (boat survey option)

○ UAV survey of the entire kelp bed completed / flight log completed (drone survey option)

○ Survey start and end times recorded, including estimated tide elevations

Tier 2+ add-ons:

○ Oceanographic data (temperature and salinity) recorded at -1, -5, and -10m using the CTD

○ Visibility recorded using the Secchi Disk

○ Depth, width, and substrate recorded at selected locations throughout the kelp bed

○ Drop camera observations recorded, including urchin presence and abundance

○ Photographs (surface and UAV) and notes on species and habitat recorded

UAV:

○ Survey is planned in Pix4D before leaving for fieldwork / adjusted in the field if needed

○ Before flight: batteries are fully charged + SD card has adequate space

○ After flight: photos are in focus + survey area has been covered
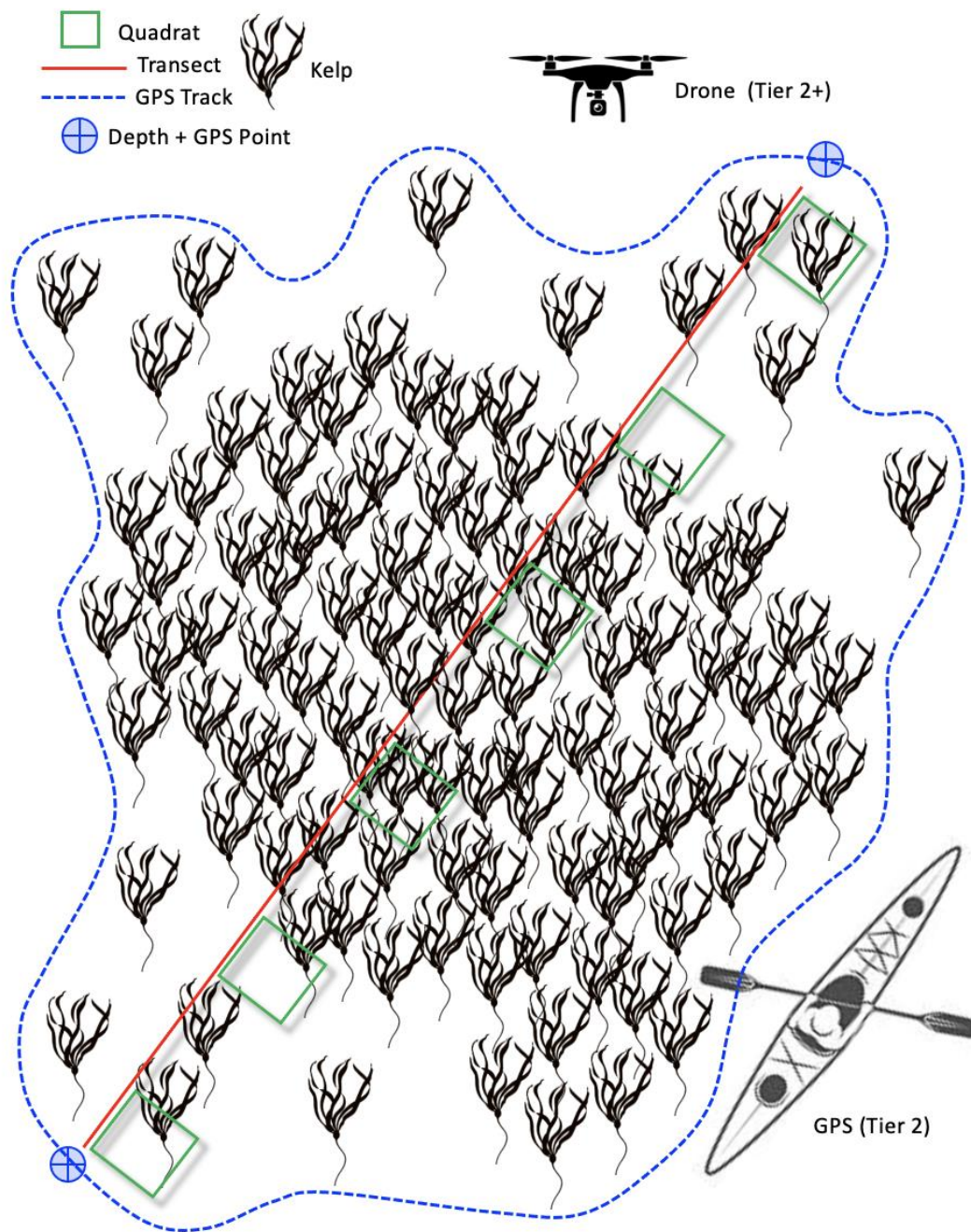
Figure 2: Tier 2 kelp bed mapping. Step 1: record location and site ID. Step 2: using transects and quadrats count and measure kelp stipes (bull kelp) or fronds (giant kelp) + estimate bryozoan percent cover. Step 3: record the location and depth of each transect. Step 4: use the CTD instrument to record temperature and salinity. Step 5: record key observations, including species (urchins, sea stars, and marine mammals), kelp condition, and substrate. Step 6: complete an aerial survey using Pix4D, or map the kelp bed perimeter with GPS.

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- Canopy kelps are large seaweeds that form the canopies of dense marine kelp forests along British Columbia's coastline. Kelp forests are typically found in rocky subtidal areas along semi-exposed shorelines up to 10 m deep. These habitats are often composed of multiple species that form a three-dimensional community structure, including benthic, understory, and canopy layers. The dominant canopy species found in the North Vancouver Island region are bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis pyrifera*).

- Bull kelp is an annual seaweed (growing from spore to maturity in a single year) that can reach over 20 m in length. Each plant is composed of a holdfast anchoring the plant to the seafloor, a long flexible stipe, a single gas-filled float, and long narrow blades that form the surface canopy. Reproduction in bull kelp occurs when patches of spores (sori) are released from reproductive blades, settling on nearby rocky substrate. Fully matured bull kelp is typically washed away in winter storms, creating space for the growth of new plants in the following year. Under optimal conditions kelp can grow up to 25 cm per day.
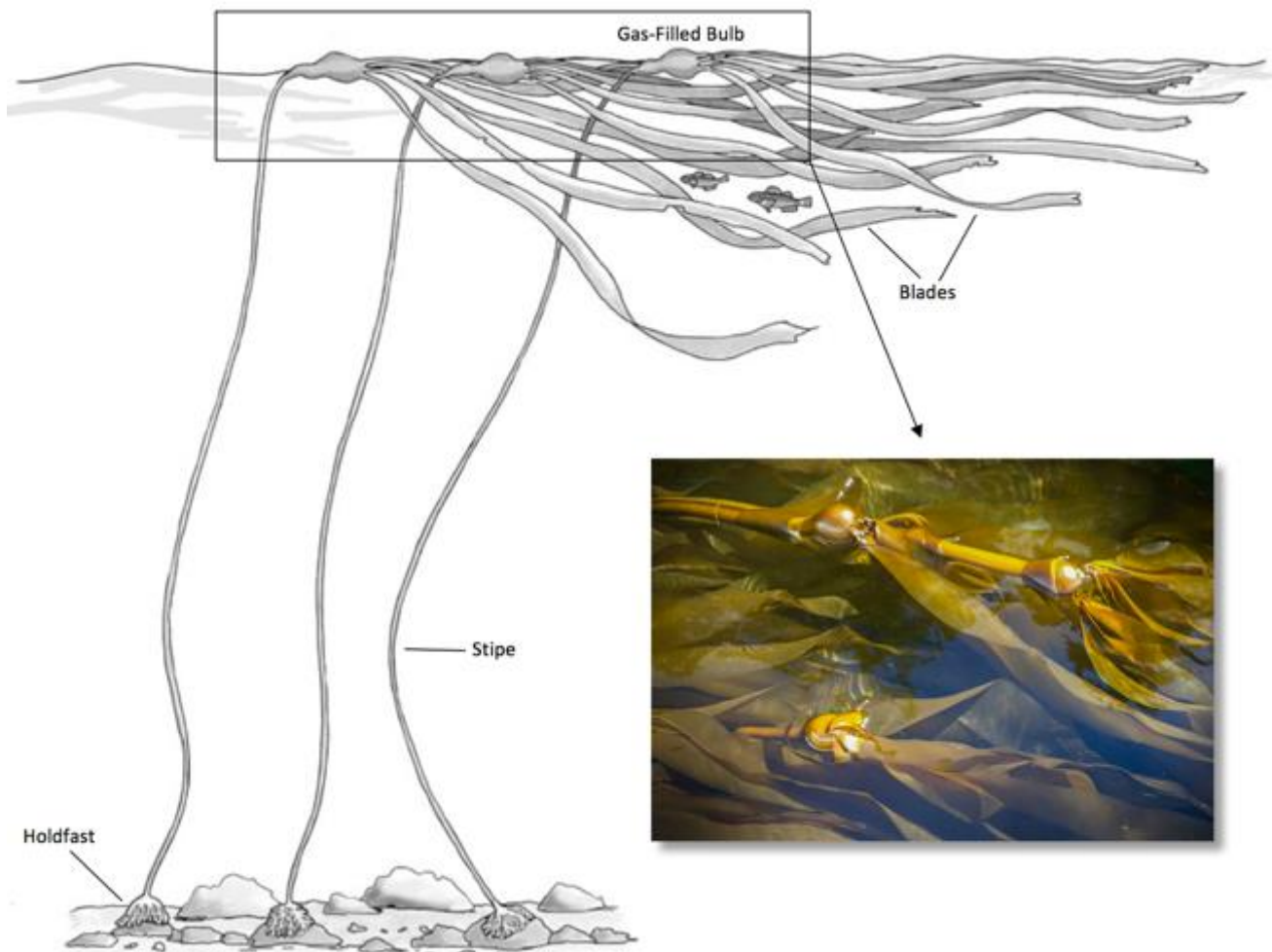

Figure A1: Bull kelp (*Nereocystis luetkeana*) identification.

- Giant kelp is a perennial seaweed (persisting for multiple years) that can grow to 30 m in length. Each plant is composed of a cone-shaped mass of branching haptera (a holdfast) anchoring the plant to the seafloor,

and multiple branching vine-like fronds; each frond includes a single stipe many gas-filled floats and blades, pulling the plant to the surface where it forms a dense canopy. Reproduction in giant kelp occurs when specialized blades (sporophylls) release spores that settle on rocky substrate. Under optimal conditions giant kelp can grow up to 35 cm per day.

A kelp frond includes the stipe and all attached floats and blades
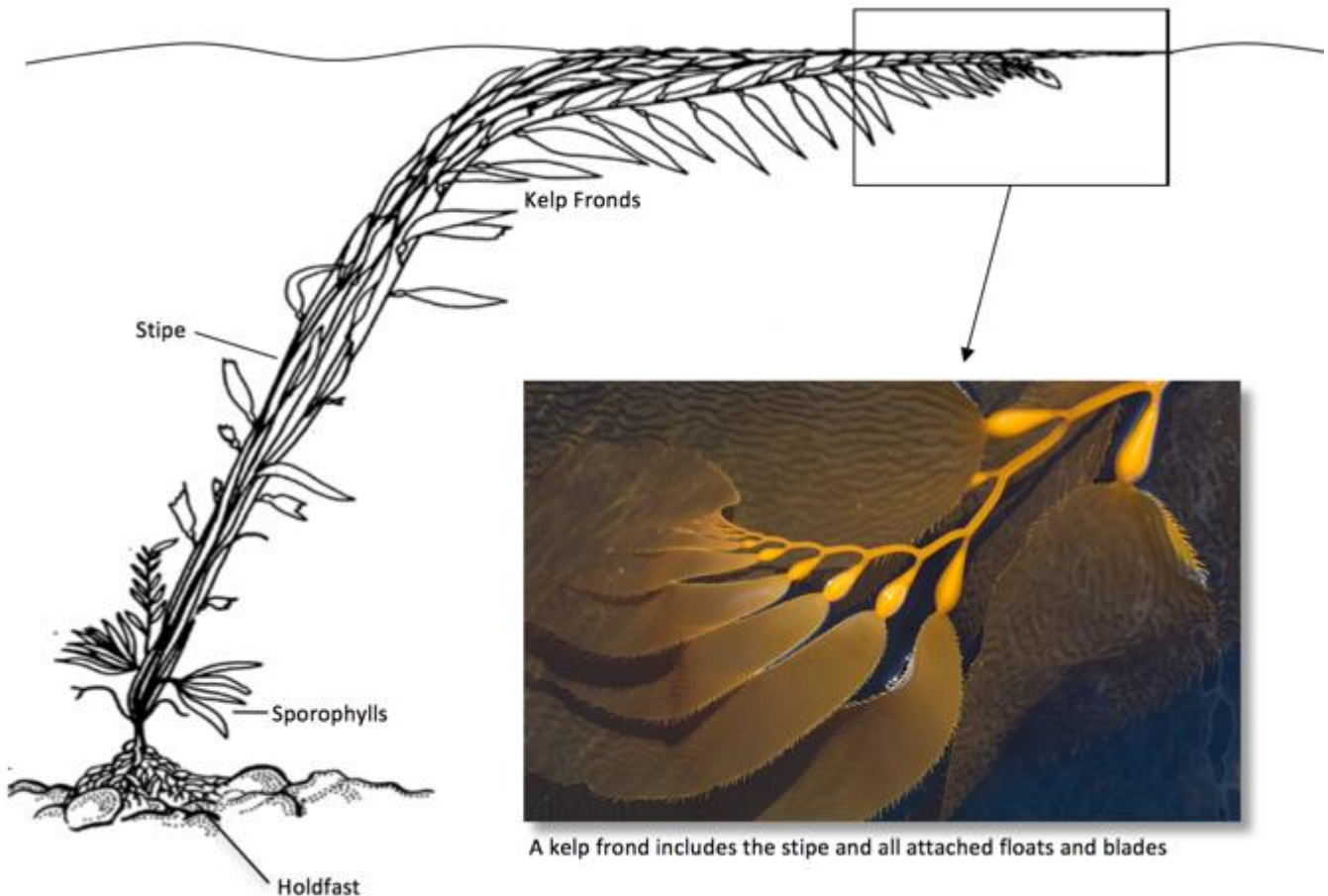
Figure A2: Giant kelp (*Macrocystis pyrifera*) identification.

- Bull kelp is common throughout the entire North Vancouver Island region, from Quadra Island in the south to Cape Scott in the north; the distribution of giant kelp is restricted to the Queen Charlotte Strait, from Malcolm Island to Cape Scott.

- Canopy kelps were selected as MaPP indicator species for their ecological value and sensitivity to shifts in oceanographic conditions and human pressures. Kelp forests provide food and shelter for an extensive range of marine life, including marine mammals, birds, and many species of commercially important fish and shellfish. Canopy kelps provide the architecture for these dynamic kelp forest habitats, shifting their distribution and density with changes in temperature, salinity, turbidity, marine weather, and grazing pressure. Sensitivity to oceanographic conditions also make canopy kelps an ideal indicator for tracking the effects of climate change.

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References:

Bishop, E. (2014). A kayak-based survey protocol for Bull Kelp in Puget Sound Prepared for the Northwest Straits Commission. National Oceanic and Atmospheric Adminstration, (October), 26.

Coastal Ocean Research Institute. (2018). MaPP Pilot Regional Indicators Phase 2: Kelp report # 1.

O'Neill, J. (2015). Spatial temporal extent of bull kelp (*Nereocystis leutkeana*) floating canopy area on the west coast of Canada. Salish Sea Marine Survival Project, 1–39.

Pfister, C. A., Berry, H. D., & Mumford, T. (2017). The dynamics of Kelp Forests in the Northeast Pacific Ocean and the relationship with environmental drivers. Journal of Ecology, (June), 1–14.

Springer, Y., Hays, C., Carr, M., Mackey, M., & Bloeser, J. (2006). Ecology and management of the bull kelp, *Nereocystis luetkeana*: A synthesis with recommendations for future research. LenFest Ocean Program, 1–53.

Resources:

MaPP marine plan portal: www.seasketch.org

BC marine conservation atlas: www.bcmca.ca

ShoreZone coastal habitat mapping system: www.shorezone.org

Biodiversity of the Central Coast: www.centralcoastbiodiversity.org

Global algae database: www.algaebase.org

Equipment List:
- Kelp field manual
- Waterproof notebooks, datasheets, and pencils
- Tablet / iPad equipped with a data collection app.
- Tide table (printed or electronic)
- Species ID book
- Binoculars
- 100 x 100 cm quadrats (1.0m^2)
- Data collection boat (inflatable, punt, canoe, or kayak)
- Weighted tape or drop line for measuring depth
- CTD instrument (for temperature and salinity measurements)
- Drop Camera
- DJI Phantom or Mavic UAV
- Rangefinder
- Secchi disk

Tier 1 Monitoring Datasheet – Kelp / Eelgrass (Circle One)   Page Number: /

Date		Tide		Crew / Guardian	/
Time		Species		Site Location / Site ID	/

Perimeter	1	2	3	4	5
GPS Point					
Density					
Depth					
Width					

Notes: observations (kelp condition, bryozoan presence, habitat description, etc.), substrate (bedrock, boulder, cobble, sand), species observed (note urchin species / abundance)

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Tier 2 – Bull Kelp (Nereocystis) Monitoring Datasheet									

Site ID + Location:			Weather:			Low Tide:		Time:	
Site GPS:			Substrate:			Survey	Time	Current	Tide
Date:			Species:			Start			
Crew:			Urchins:			End			

Transect Locations						Oceanographic Data		
Point	Depth	GPS	Point	Depth	GPS	GPS:		
T1a			T3b			Depth	Temperature	Salinity
T1b			T4a			−1m		
T2a			T4b			−5m		
T2b			T5a			−10m		
T3a			T5b			Secchi Disk:		

Quadrat Data

Quadrat	% Bryozoans	# Bulbs	Stipe Diameter (10)	Quadrat	% Bryozoans	# Bulbs	Stipe Diameter (10)
1				21			
2				22			
3				23			
4				24			
5				25			
6				26			
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Tier 2 – Giant Kelp (Marcrocystis) Monitoring Datasheet										

Site ID + Location:			Weather:		Low Tide:	Time:		
Site GPS:			Substrate:		Survey	Time	Current	Tide
Date:			Species:		Start			
Crew:			Urchins:		End			

Perimeter Data | **Oceanographic Data**

Point	Depth	GPS	Point	Depth	GPS		GPS:		
T1a			T3b				Depth	Temperature	Salinity
T1b			T4a				−1m		
T2a			T4b				−5m		
T2b			T5a				−10m		
T3a			T5b				Secchi Disk:		

Quadrat Data

Quadrat	# Fronds	% Bryozoans	Quadrat	# Fronds	% Bryozoans	Quadrat	# Fronds	% Bryozoans	Quadrat	# Fronds	% Bryozoans
1			21			41			61		
2			22			42			62		
3			23			43			63		
4			24			44			64		
5			25			45			65		
6			26			46			66		
7			27			47			67		
8			28			48			68		
9			29			49			69		
10			30			50			70		
11			31			51			71		
12			32			52			72		
13			33			53			73		
14			34			54			74		
15			35			55			75		
16			36			56			76		
17			37			57			77		
18			38			58			78		
19			39			59			79		
20			40			60			80		

5. Very high density: 80–100 percent coverage. Continuous and unbroken.

4. High density: 60–80 percent coverage.

3. Medium density: 40–60 percent coverage.

2. Low density: 20–40 percent coverage.

1. Very low density: < 20 percent coverage. Patchy and fragmented.