

Kelp Growth Report

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Marine Botany (Biol 445 A)
Friday Harbor Labs, University of Washington
Spring 2023

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Keywords: *Saccharina latissima*, growth, meristoderm, intercalary meristem, erosion rate, detritus, POM, FHL dock, depth, light

Kelp Growth Report

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Zoobot 2023 (Biol 445 A)
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1) Where does growth occur on the thallus of *S. latissima*?

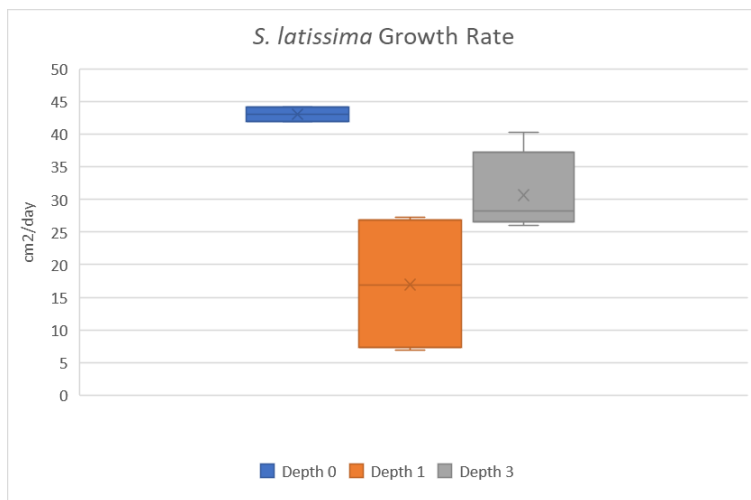
In *S. latissima*, growth occurs on the intercalary meristem above the stipe. This is demonstrated in the largest growth consistently in section A for each of the thalli. While the growth between B and C and between C and D was increasing at very small increments of no more than 3 centimeters, the distance between the stipe and A increased from 5cm to a maximum of 32cm.

2) Is there a relationship between *S. latissima* growth and light level? If so, which of the light levels tested coincides with the highest growth? Which coincides with the lowest growth?

Only two groups (four and five) had 4 weeks' worth of data at all three depths tested (0m, 1m, and 3m). For the most part this was because they were the only trials in which the kelp at 0m did not become dislodged during the experiment. For these two groups, growth rate was highest at 0m (avg = 34.6 cm²/day), lowest at 1m (avg = 15.23 cm²/day), and in between at 3m (25.1 cm²/day). Light available for photosynthesis decreased steadily as depth increased, but the lack of a direct correlation between depth and growth suggests that there is an additional factor besides light availability influencing growth rate. It's possible that growth was highest at 0m because it was the depth with the most light available, but the trend reversed between 1 and 3m because diatoms grew more readily at 1m (covering the photosynthetic surface of the blade) than they did at 3m. Another possibility is that lower light levels could correlate with higher growth rates as *S. latissima* in lower depths must grow faster to reach the surface with greater light levels.

3) Is there a relationship between the erosion rate of *S. latissima* and depth?

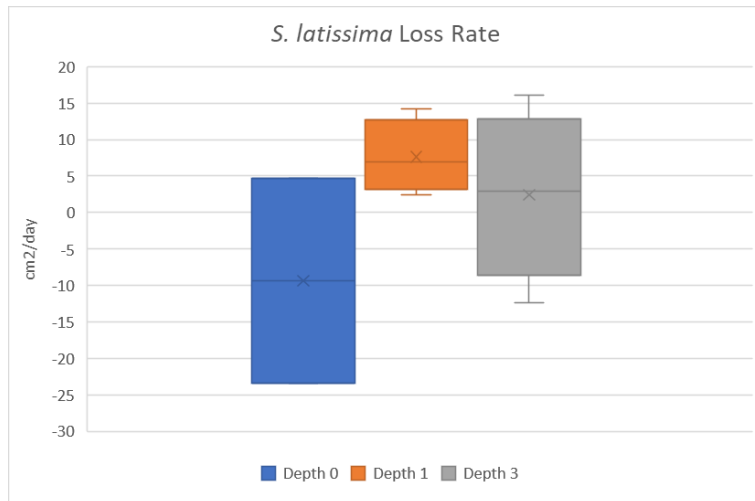
Our data does not show a significant difference in kelp erosion rates across the observed depths ($p = 0.639$). However, kelp forests often extend down forty meters, and a maximum of 3 meters. Depth may not be enough to indicate a change in erosion (Wernberg et al., 2019). Our finding is supported by a meta analysis that was conducted on the data compiled from past FHL spring Botany courses. The meta analysis on this data set spanning from 2014 to 2019, concluded that depth had no effect on the rate of erosion of *S. latissima* (Meng & Mumford, 2020). Notably, in a 1979 experiment on three *Laminaria* species, there was no observed relationship between loss rate and depth (Lüning, 1979).



(Figure 2, *S. Latissima* Growth Rate)

\$Depth	diff	lwr	upr	p adj
3m-1m	13.7150	-3.498802	30.92880	0.1137920
0m-1m	26.0625	4.979984	47.14502	0.0198274
0m-3m	12.3475	-8.735016	33.43002	0.2620368

(Figure 3)



(Figure 4, *S. Latissima* Loss Rate)

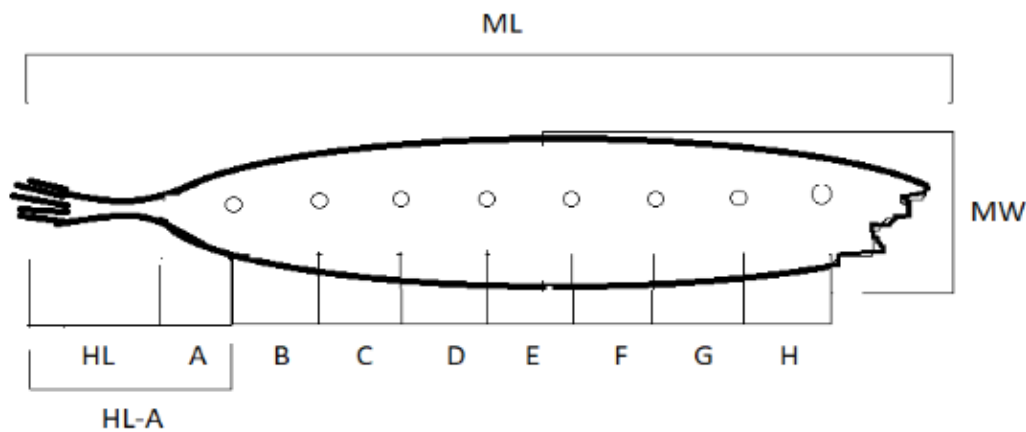


Figure 1 – Diagram of measurements for *S. latissima*.

HL = holdfast length. HL-A = length from tip of holdfast to first hole punch. MW = max width of kelp. ML = Max length of kelp. A = length from base of blade to first hole punch. B,C, D, E ... = length between subsequent hole punches.

References

Lüning, K. (1979). Growth strategies of three Laminaria species (Phaeophyceae) inhabiting different depth zones in the sublittoral region of Helgoland (North Sea). *Marine Ecology. Progress Series (Halstenbek)*, 1(3), 195–207. <https://doi.org/10.3354/meps001195>

Wernberg, T., Krumhansl, K.A., Filbee-Dexter, K., Pedersen, M.F., 2019. Status and trends for the world's kelp forests. In: Sheppard, C. (Ed.), *World seas: An environmental evaluation*, 2nd ed. vol. III. Elsevier. <https://doi.org/10.1016/B978-0-12-805052-1.00003-6>.

Meng, C., & Mumford, T. (2020). Patterns of Growth and Erosion of blades of the kelp *Saccharina latissima*.

<https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/45591/Meng%20Research%20Internship%20Report%202020.pdf?sequence=1&isAllowed=y>

Team 1 Members: Alex, Nikki, Kirsten																			
Depth = 0 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)	Growth Rate (cm ³ /day)	Loss Rate (cm ³ /day)
4/3/23	#NAME?	35	19	4	9	5	5	5	5				0	19	0	0	0	#DIV/0!	#DIV/0!
	#NAME?				0								0	#DIV/0!	#DIV/0!	0	#DIV/0!		#DIV/0!
	#NAME?				0								0	#DIV/0!	#DIV/0!	0	#DIV/0!		#DIV/0!
	#NAME?				0								0	#DIV/0!	#DIV/0!	0	#DIV/0!		#DIV/0!
Depth = 1 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)	Growth Rate (cm ³ /day)	Loss Rate (cm ³ /day)
4/3/23	#NAME?	60	39	7	12	5	5	5	5				-1.5	39.5	-59.25	-10.5	-414.75	#DIV/0!	#DIV/0!
5/2/23	#NAME?	69	40	5.5	5.5								0	40	0	0	0	#DIV/0!	#DIV/0!
	#NAME?				0								0	#DIV/0!	#DIV/0!	0	#DIV/0!		#DIV/0!
	#NAME?				0								0	#DIV/0!	#DIV/0!	0	#DIV/0!		#DIV/0!
Depth = 3 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)	Growth Rate (cm ³ /day)	Loss Rate (cm ³ /day)
4/3/23	#NAME?	56	19	3	8	5	5	5	5				11.5	20.75	238.625	2	41.5	34.42	
4/10/23	#NAME?	65.5	22.5	3.5	8.5	5	7.5	7	6.5	5			8.5	21.95	186.575	10	219.5	17.03	
4/18/23	#NAME?	64	21.4	4.5	9.5	5	10	6.5	9	8			15.2	21.85	332.12	5.2	113.62		
4/25/23	#NAME?	74	22.3	6	20	14	11.5	7	12.5	7.2									
5/2/2023	#NAME?	80.6	23	6.5	22.5	16	12.7	8	13.7	7									

Team 2 Members: Jessica P. and April M.																			
Kelp Growth Measurements																			
Depth = 0 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)	Growth Rate (cm ³ /day)	Loss Rate (cm ³ /day)
4/3/23	#NAME?	37	16	5	10	5	5	5	5				-0.3	17.25	-5.175	-1.7	-29.325	-1.16	
4/10/23	#NAME?	38.4	18.5	4	9	5	5.2	5	5.5				-1	12.25	-12.25	13.4	164.15	8.99	
4/18/23	#NAME?	24	6	3	3								0	6	0	0	0		
	#NAME?				0														
Depth = 1 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)	Growth Rate (cm ³ /day)	Loss Rate (cm ³ /day)
4/3/23	#NAME?	40	16		5	5	5	5	5	5			10.6	16.5	174.9	-0.7	-11.55	19.02	
4/10/23	#NAME?	51.3	17	4.5	12.8	8.3	6.5	6.3	5	5			6.4	17.25	110.4	2.7	46.575	2.34	
4/18/23	#NAME?	55	17.5	4.5	18	13.5	7.5	6.5	5	5			0	17.5	0	0	0		
	#NAME?				0														
Depth = 3 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)	Growth Rate (cm ³ /day)	Loss Rate (cm ³ /day)
4/3/23	#NAME?	39	13		5	5	5	5	5	5			9.6	14.1	135.36	-1.77636E-15	-2.50466E-14	16.70	
4/10/23	#NAME?	48.6	15.2	4.3	11.8	7.5	6.2	5.5	5.6	5.5			7.15	16.1	115.115	-1.25	-20.125	-1.34	
4/18/23	#NAME?	57	17	5	18.5	13.5	6.75	5.5	5.5	5.5			0	17	0	0	0		
	#NAME?				0														

Kelp Growth Measurements

Team 3 Members: Maddie, Nina, Jack G

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
4/3/23	#NAME?	44	17	2	7	5	5	5	5	5		
	#NAME?	45.1	17	3.5	10.8	7.3	6.8	5	6.5	6.5		
	#NAME?				0							
	#NAME?				0							

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
8.6	17	146.2	7.5	127.5
0	17	0	0	0
0	#DIV/0!	#DIV/0!	0	#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
4/3/23	#NAME?	38	12	4	9	5	5	5	5			
	#NAME?	40	12.8	3.5	11	7.5	6	5.5	5			
	#NAME?				0							
	#NAME?				0							

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
3.5	12.4	43.4	1.5	18.6
0	12.8	0	0	0
0	#DIV/0!	#DIV/0!	0	#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
4/3/23	#NAME?	39	11	5	10	5	5	5	5			
	#NAME?	41	11.5	5	11.5	6.5	5	5	5			
	#NAME?				0							
	#NAME?				0							

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
1.5	11.25	16.875	-0.5	-5.625
0	11.5	0	0	0
0	#DIV/0!	#DIV/0!	0	#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Kelp Growth Measurements

Team 4 Members: Tyler, Spencer, Ben

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
4/3/23	#NAME?	30	20	4	13	9	9	5	5			
4/10/23	#NAME?	36	22	4	13	9	7	6	5			
4/18/23	#NAME?	49	30	5.5	26.5	21	8	6	5.5			
4/25/23	#NAME?	63	31.5	6.5	38	31.5	9	6.5	5.5			
5/2/23												

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
-1	21	-21	-7	-147
15	26	390	2	52
13	30.75	399.75	-1	-30.75

Growth Rate (cm ² /day)	34.94
Loss Rate (cm ² /day)	-5.72

Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
4/3/23	#NAME?	32	20	2	7	5	5	5				
4/10/23	#NAME?	35	20.5	3	10	7	6	5.5				
4/18/23	#NAME?	45	21	4	19	15	7	5.8				
4/25/23	#NAME?	52	24	5	26	21	7.5	6				
5/2/23												

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
4.5	20.25	91.125	1.5	30.375
10.3	20.75	213.725	0.3	6.225
7.7	22.5	173.25	0.7	15.75

Growth Rate (cm ² /day)	21.73
Loss Rate (cm ² /day)	2.38

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
4/3/23	#NAME?	31	24	2	7	5	5	5	5			
4/10/23	#NAME?	42	26	2.5	9	6.5	7	5.5	5	5		
4/18/23	#NAME?	51	26	3.5	18	14.5	7.6	6	5.5	5.2		
4/25/23	#NAME?	60	28	4	26	22	9	6	6	5.5		
5/2/23												

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
4.5	25	112.5	-6.5	-162.5
10.8	26	280.8	1.8	46.8
10.2	27	275.4	1.2	32.4

Growth Rate (cm ² /day)	30.40
Loss Rate (cm ² /day)	-3.75

Kelp Growth Measurements													Team 5 Members: Jack S, Hailey, Julia						
Depth = 0 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)		
4/3/23	#NAME?	33	20	3	8	5	5	5	5										
4/10/23	#NAME?	38	26.5	3.5	14	10.5	5.8	7	5				8.8	23.25	204.6	3.8	88.35	Growth Rate (cm ² /day)	34.30
4/18/23	#NAME?	46.5	33.5	4	22	18	6	7.5	5				8.7	30	261	0.2	6	Loss Rate (cm ² /day)	8.93
4/25/23	#NAME?	52	34.5	4	30.5	26.5	7	6.5					8.5	34	289	3	102		
5/2/2023		59	40	3.5		32	6	7											
Depth = 1 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)		
4/3/23	#NAME?	33	11	5		5	5	5	5										
4/10/23	#NAME?	30	13	6	14.5	8.5	6	6					6.5	12	78	9.5	114	Growth Rate (cm ² /day)	8.73
4/18/23	#NAME?	31.5	13.5	6	17.5	11.5	6						3	13.25	39.75	1.5	19.875	Loss Rate (cm ² /day)	10.38
4/25/23	#NAME?	30	13.5	6	23	17							5.5	13.5	74.25	7	94.5		
5/2/2023		33	15	6.5		16													
Depth = 3 m																			
Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)		
4/3/23	#NAME?	30	18	6	11	5	5	5	5										
4/10/23	#NAME?	37	21	7	14	7	6.3	5	5				4.3	19.5	83.85	-2.7	-52.65	Growth Rate (cm ² /day)	19.75
4/18/23	#NAME?	39	21	7	18	11	7.5	6	6.5				7.7	21	161.7	5.7	119.7	Loss Rate (cm ² /day)	4.00
4/25/23	#NAME?	47	21	7	26	19	8.5						9	21	189	1	21		
5/2/23		54	25	7.5		21	12												

Team 1 Members: Alex

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)
4/3/23	#NAME?	35	19	4	9	5	5	5	5
	#NAME?				0				
	#NAME?				0				
	#NAME?				0				

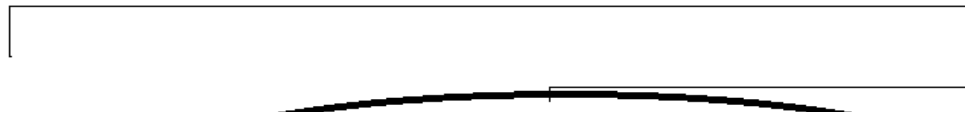
Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)
4/3/23	#NAME?	60	39	7	12	5	5	5	5
5/2/23	#NAME?	69	40	5.5	5.5				
	#NAME?				0				
	#NAME?				0				

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)	B (cm)	C (cm)	D (cm)
4/3/23	#NAME?	56	19	3	8	5	5	5	5
4/10/23	#NAME?	65.5	22.5	3.5	8.5	5	7.5	7	6.5
4/18/23	#NAME?	64	21.4	4.5	9.5	5	10	6.5	9
4/25/23	#NAME?	74	22.3	6	20	14	11.5	7	12.5
5/2/2023	#NAME?	80.6	23	6.5	22.5	16	12.7	8	13.7

ML



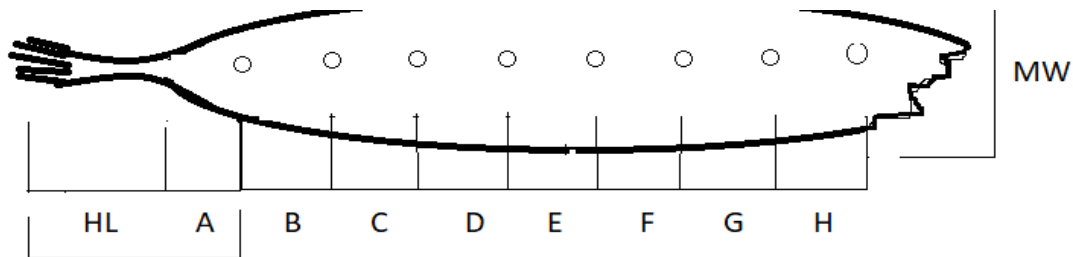


Figure 1 – Diagram of measurements for S. latissima.

HL = holdfast length. HL-A = length from tip of holdfast to first hole punch. MW = max width of kelp. ML = Max length of kelp. A = length from base of blade to first hole punch. B,C, D, E ... = length between subsequent hole punches.

, Nikki, Kirsten

E (cm)	F (cm)	G (cm)

E (cm)	F (cm)	G (cm)

E (cm)	F (cm)	G (cm)
5		
8		
7.2		

7

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)
0	19	0	0
0	#DIV/0!	#DIV/0!	0
0	#DIV/0!	#DIV/0!	0

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)
-1.5	39.5	-59.25	-10.5
0	40	0	0
0	#DIV/0!	#DIV/0!	0

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)
11.5	20.75	238.625	2
8.5	21.95	186.575	10
15.2	21.85	332.12	5.2

**If a kelp was lost in the first week, write N/A
"Growth Rate" and "Loss Rate"**

GROWTH RATE and LOSS RATE

?,

Area Lost (cm²)

0
#DIV/0!
#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Area Lost (cm²)

-414.75
0
#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Area Lost (cm²)

41.5
219.5
113.62

Growth Rate (cm ² /day)	34.42
Loss Rate (cm ² /day)	17.03

A for both

Kelp Growth Measurements

Team 2 M

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	37	16	5	10	5
4/10/23	#NAME?	38.4	18.5	4	9	5
4/18/23	#NAME?	24	6	3	3	
	#NAME?				0	

Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	40	16		5	5
4/10/23	#NAME?	51.3	17	4.5	12.8	8.3
4/18/23	#NAME?	55	17.5	4.5	18	13.5
	#NAME?				0	

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	39	13		5	5
4/10/23	#NAME?	48.6	15.2	4.3	11.8	7.5
4/18/23	#NAME?	57	17	5	18.5	13.5
	#NAME?				0	

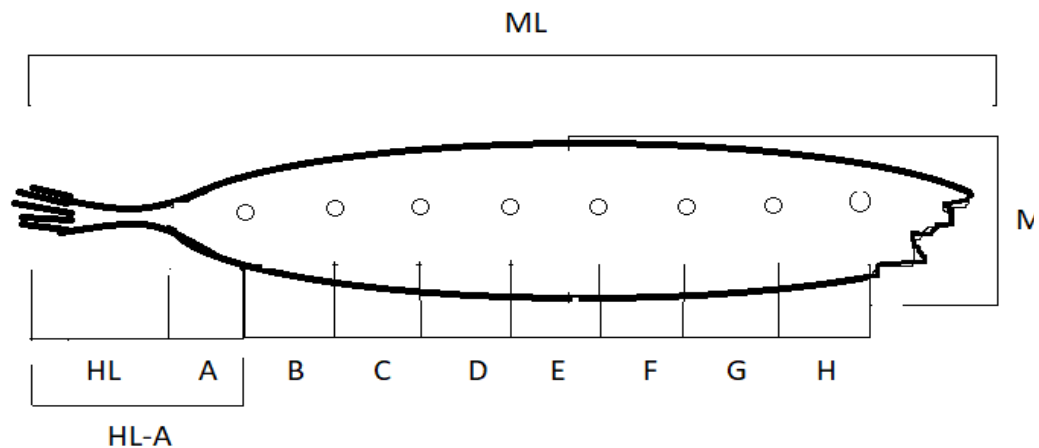


Figure 1 – Diagram of measurements for *S. latissima*.

HL = holdfast length. *HL-A* = length from tip of holdfast to first hole punch. *MW* = max width of kelp. *ML* = Max length of kelp. *A* = length from base of blade to first hole punch. *B, C, D, E ...* = length between subsequent hole punches.

embers:

Jessica P. and April M.

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5			
5.2	5	5.5			

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5	5		
6.5	6.3	5	5		
7.5	6.5	5	5		

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5	5		
6.2	5.5	5.6	5.5		
6.75	5.5	5.5	5.5		

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
-0.3	17.25	-5.175	-1.7	-29.325
-1	12.25	-12.25	13.4	164.15
0	6	0	0	0

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
10.6	16.5	174.9	-0.7	-11.55
6.4	17.25	110.4	2.7	46.575
0	17.5	0	0	0

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
9.6	14.1	135.36	-1.77636E-15	-2.50466E-14
7.15	16.1	115.115	-1.25	-20.125
0	17	0	0	0

If a kelp was lost in the first week, write NA for both "Growth Rate" and "Loss Rate"

Growth Rate (cm ² /day)	-1.16
Loss Rate (cm ² /day)	8.99

Growth Rate (cm ² /day)	19.02
Loss Rate (cm ² /day)	2.34

Growth Rate (cm ² /day)	16.70
Loss Rate (cm ² /day)	-1.34

Kelp Growth Measurements

Team 3 M

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	44	17	2	7	5
	#NAME?	45.1	17	3.5	10.8	7.3
	#NAME?				0	
	#NAME?				0	

Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	38	12	4	9	5
	#NAME?	40	12.8	3.5	11	7.5
	#NAME?				0	
	#NAME?				0	

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	39	11	5	10	5
	#NAME?	41	11.5	5	11.5	6.5
	#NAME?				0	
	#NAME?				0	

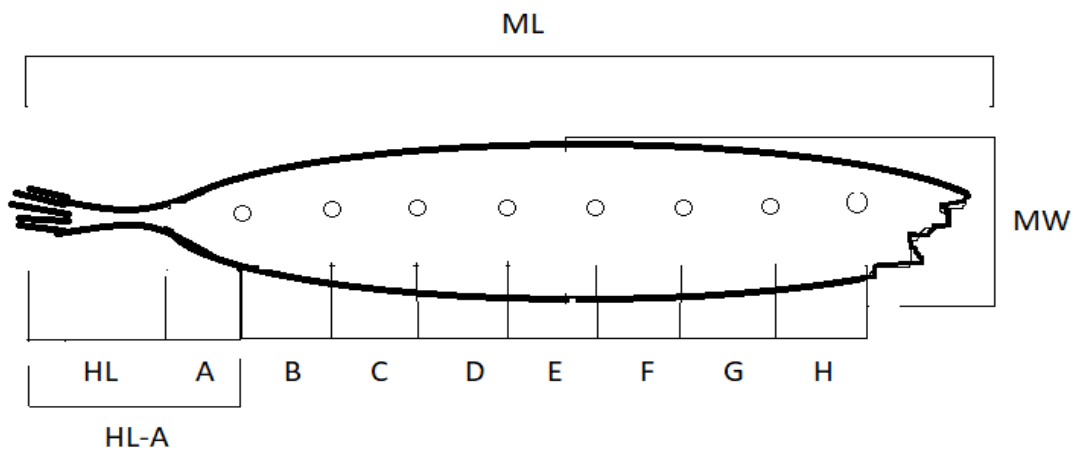


Figure 1 – Diagram of measurements for *S. latissima*.

HL = holdfast length. HL-A = length from tip of holdfast to first hole punch. MW = max width of kelp. ML = Max length of kelp. A = length from base of blade to first hole punch. B, C, D, E ... = length between subsequent hole punches

length between subsequent note punches.

Members:

Maddie, Nina, Jack G

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5	5		
6.8	5	6.5	6.5		

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5			
6	5.5	5			

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5			
5	5	5			

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
8.6	17	146.2	7.5	127.5
0	17	0	0	0
0	#DIV/0!	#DIV/0!	0	#DIV/0!

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
3.5	12.4	43.4	1.5	18.6
0	12.8	0	0	0
0	#DIV/0!	#DIV/0!	0	#DIV/0!

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
1.5	11.25	16.875	-0.5	-5.625
0	11.5	0	0	0
0	#DIV/0!	#DIV/0!	0	#DIV/0!

If a kelp was lost in the first week, write NA for both "Growth Rate" and "Loss Rate"

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Growth Rate (cm ² /day)	#DIV/0!
Loss Rate (cm ² /day)	#DIV/0!

Kelp Growth Measurements

Team 4 M

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	30	20	4	13	9
4/10/23	#NAME?	36	22	4	13	9
4/18/23	#NAME?	49	30	5.5	26.5	21
4/25/23	#NAME?	63	31.5	6.5	38	31.5
5/2/23						

Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	32	20	2	7	5
4/10/23	#NAME?	35	20.5	3	10	7
4/18/23	#NAME?	45	21	4	19	15
4/25/23	#NAME?	52	24	5	26	21
5/2/23						

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	31	24	2	7	5
4/10/23	#NAME?	42	26	2.5	9	6.5
4/18/23	#NAME?	51	26	3.5	18	14.5
4/25/23	#NAME?	60	28	4	26	22
5/2/23						

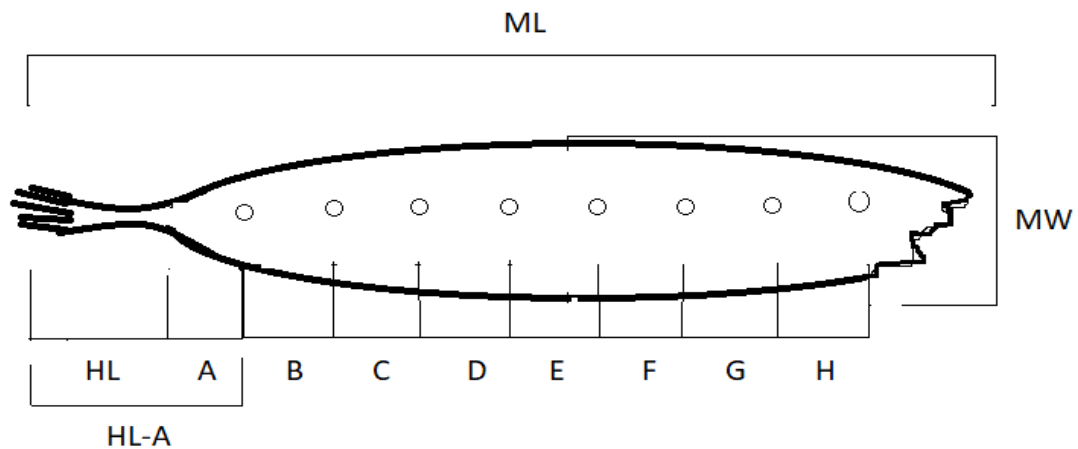


Figure 1 – Diagram of measurements for *S. latissima*.

HL = holdfast length. HL-A = length from tip of holdfast to first hole punch. MW = max width of

kelp. ML = Max length of kelp. A = length from base of blade to first hole punch. B,C, D, E ... = length between subsequent hole punches.

embers:

Tyler, Spencer, Ben

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
9	5	5			
7	6	5			
8	6	5.5			
9	6.5	5.5			

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5				
6	5.5				
7	5.8				
7.5	6				

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5	5		
7	5.5	5	5		
7.6	6	5.5	5.2		
9	6	6	5.5		

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
-1	21	-21	-7	-147
15	26	390	2	52
13	30.75	399.75	-1	-30.75

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
4.5	20.25	91.125	1.5	30.375
10.3	20.75	213.725	0.3	6.225
7.7	22.5	173.25	0.7	15.75

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
4.5	25	112.5	-6.5	-162.5
10.8	26	280.8	1.8	46.8
10.2	27	275.4	1.2	32.4

If a kelp was lost in the first week, write NA for both "Growth Rate" and "Loss Rate"

Growth Rate (cm ² /day)	34.94
Loss Rate (cm ² /day)	-5.72

Growth Rate (cm ² /day)	21.73
Loss Rate (cm ² /day)	2.38

Growth Rate (cm ² /day)	30.40
Loss Rate (cm ² /day)	-3.79

Kelp Growth Measurements

Team 5 M

Depth = 0 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	33	20	3	8	5
4/10/23	#NAME?	38	26.5	3.5	14	10.5
4/18/23	#NAME?	46.5	33.5	4	22	18
4/25/23	#NAME?	52	34.5	4	30.5	26.5
5/2/2023		59	40	3.5		32

Depth = 1 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	33	11	5		5
4/10/23	#NAME?	30	13	6	14.5	8.5
4/18/23	#NAME?	31.5	13.5	6	17.5	11.5
4/25/23	#NAME?	30	13.5	6	23	17
5/2/2023		33	15	6.5		16

Depth = 3 m

Date	Days	ML (cm)	MW (cm)	HL (cm)	HL+A (cm)	A (cm)
4/3/23	#NAME?	30	18	6	11	5
4/10/23	#NAME?	37	21	7	14	7
4/18/23	#NAME?	39	21	7	18	11
4/25/23	#NAME?	47	21	7	26	19
5/2/23		54	25	7.5		21

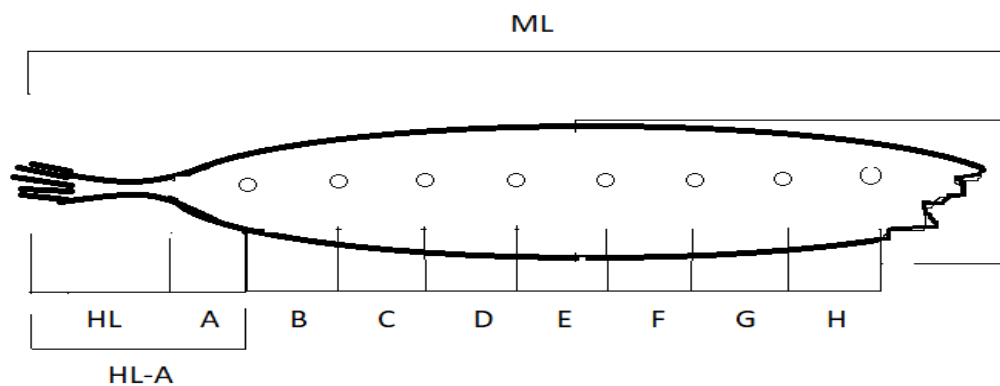


Figure 1 – Diagram of measurements for *S. latissima*.

HL = holdfast length. HL-A = length from tip of holdfast to first hole punch. MW = max width of kelp. ML = Max length of kelp. A = length from base of blade to first hole punch. B,C, D, E ... = length between subsequent hole punches.

embers:

Jack S, Hailey, Julia

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5			
5.8	7	5			
6	7.5	5			
7	6.5				
6	7				

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5			
6	6				
6					

B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)
5	5	5			
6.3	5	5			
7.5	6	6.5			
8.5					
12					

MW

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
8.8	23.25	204.6	3.8	88.35
8.7	30	261	0.2	6
8.5	34	289	3	102

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
6.5	12	78	9.5	114
3	13.25	39.75	1.5	19.875
5.5	13.5	74.25	7	94.5

Growth (cm)	Avg. MW (cm)	New Material Area (cm ²)	Length Lost (cm)	Area Lost (cm ²)
4.3	19.5	83.85	-2.7	-52.65
7.7	21	161.7	5.7	119.7
9	21	189	1	21

If a kelp was lost in the first week, write NA for both "Growth Rate" and "Loss Rate"

Growth Rate (cm ² /day)	34.30
Loss Rate (cm ² /day)	8.93

Growth Rate (cm ² /day)	8.73
Loss Rate (cm ² /day)	10.38

Growth Rate (cm ² /day)	19.75
Loss Rate (cm ² /day)	4.00