

The epiphytic community of *Pterygophora californica*:

Race Rocks MPA, British Columbia

Ryan M. J. Murphy

**December 4, 2002
Biology 4251: Special Topics
Dr. I. Kaczmarek**

Abstract

Epiphytic algal growth comprises a large and complex community of the sublittoral Pacific Northwest. However, very little is known concerning population composition or dynamics in non-obligate epiphytic communities. This study aims to shed light on the epiphytic community on *Pterygophora californica* stipes through the population interactions of *Nereocystis luetkeana* and *Laminaria saccharina*.

P. californica individuals at 8 and 12 m depth were identified and the location of any epiphytic *N. luetkeana* and *L. saccharina* along a stipe were noted. Digital video of the actual sampling and a digital herbarium were created in conjunction with this project.

N. luetkeana and *L. saccharina* showed distinct banding along the stipes of *P. californica*. At both depths, *N. luetkeana* inhabited the 70 to 110 cm range (uppermost region) of the stipe, while *L. saccharina* mostly inhabited stipes between 40 and 80 cm (mid-stipe) from the host's holdfast. Overall epiphytic population densities increased with depth.

Arguments concerning when the colonisation of the stipe takes place and light intensity requirements are put forward. Further work is needed to explain this community structure.

Introduction

The waters of the Pacific Northwest in general, and the Race Rocks area of the Juan de Fuca Strait in particular, are nutrient rich and support an astounding biomass. The kelp forests found there are often cited as one of the most productive ecosystems on this planet (Lüning, 1990). *Nereocystis luetkeana* (Mertens) and *Macrocystis integrifolia* (Bory), two annual kelps of the Laminariales order which dominate these forests can grow up to 40 metres in a single season.

This high productivity leads to strong competition for resources, in particular available space. Darley (1982) states that space is the principal limiting resource in rocky intertidal habitats where organisms must have firm attachments to the substrate. However, the nature of the substrate is often less important than other environmental parameters such as light intensity when determining the distribution of algae communities (Darley 1982). Lobban (1994) discusses epiphytism as one solution to the “space race”. Though very few algae are obligate epiphytes, epiphytism is a common strategy employed by both terrestrial and aquatic algae. While helping to solve the space problem, the epiphytes create new problems for the basiphyte, or the host organism. Both plant and animal epiphytes shade the basiphyte, and may impede gas and nutrient exchange, thus decreasing its growth rate (Lobban 1994). One other implication of epiphytes pertinent to this study is that they increase drag on the fronds of the basiphyte. The most common cause of death of *Pterygophora californica* (Ruprecht), a common laminarian of the Pacific Northwest, is being torn from the substrate during storms (Lee 1999). Considering the above, epiphytes have colonised a surface that has a definite

lifespan, a lifespan determined more often than not by extrinsic rather than intrinsic factors (Lobban 1981).

Boney (1969) discusses this 'epiphyte load' in terms of its weakening effect on the first established plants near rocky shores. This densely crowded habitat is subject to huge densities of spores—*Nereocystis luetkeana* will produce approximately 3,000,000 spores litre⁻¹ day⁻¹ during the summer months—that settle and develop on every type of substratum, including other plants. Consequently, the first established plants (perennial species in particular) are colonised (and weakened) by layer upon layer of epiphytic spores every season. Lobban (1994) adds that the composition of an epiphytic community will be determined by the time of crucial events, such as spore release and establishment.

Basiphytes are rarely willing partners in this symbiotic relationship. Since epiphytes are often detrimental to the basiphyte, many macroalgae have developed strategies that help to deter colonisation. Two major strategies employed by macrophytes are periodic sloughing of their surfaces and the production of antifouling compounds. Epiphytes can avoid being sloughed off in two ways, either by attaching to wounds and pits on the hosts surface or penetrating the host's deeper tissue with rhizoids. The process of production and release of compounds that inhibit the growth of other algae is termed alleopathy. In brown algae such as the laminarians, phenolics are thought to serve as antifouling compounds (Lobban 1994). Round (1985) states that *Laminaria saccharina* is less well colonised than many other macro-algae, and then on their lowermost region. However, Lobban (1994) states *Laminaria* stipes that are long-lived

bear a rich epiphytic flora. In general, the degree of colonisation is positively correlated with the age of the host (Round 1985)

This study examined the interaction between two members of the epiphytic community on *Pterygophora californica*: *Laminaria saccharina* (L.) and *Nereocystis luetkeana*. *P. californica* belongs to the Order Laminariales, as do *N. luetkeana* and *L. saccharina*; as such, the bodies of these plants are comprised of a holdfast, stipe, and blades. *P. californica*'s stipe is tough because the cortex is both strong and flexible. The stipe's surface however is brittle, and cracks or grazing marks are common. The stiff stipe of this plant is up to 2 metres long, straight or gnarled, and persists for up to 25 years (Lobban 1981). It is this perennial nature that makes *P. californica* an ideal substrate for many epiphytic algae, so much so however that the community that develops is complex, including rhodophytes, phaeophytes, chlorophytes, and several animal phyla. To narrow the scope of this investigation, two phaeophyte species (*Laminaria saccharina* and *Nereocystis luetkeana*) were chosen for sampling, to determine the pattern in the epiphytic community composition on stipes of *Pterygophora californica*.

Race Rocks is a small archipelago off the southern coast of Vancouver Island located at 48°17'45"N, 123°31'50"W. The area is subject to a large tidal range (~3 m), powerful wave action, and strong currents. Mean seawater temperatures range from 9 – 11°C during the summer months (IOS 2002). Large beds of *N. luetkeana* extend from the islands to a depth of ~20m (or until exposure to currents prevent growth), in the summer months. Below the *N. luetkeana* canopy, *P. californica* forms a perennial mid-sublittoral canopy both at Race Rocks and in much of the Pacific Northwest (Lüning 1990). In the

winter months, the bladeless stipes of *P. californica* are the only remnants of the macroalgal forest that once existed. All members of the Laminariales inhabit the upper and mid-sublittoral zones because of the relatively high light levels required to build up their large thalli (Boney 1969). Sampling for this study occurred in early June as the *N. luetkeana* stand was reaching seasonal maturity.

Materials and Methods

Materials:

Sony Digital Camcorder	Ruler	Pencil
Aquabuddy camera housing	Pen	Mares scuba gear
Paper	Dive slates	Field guide and keys
Thermometer	Tide tables	Quadrat

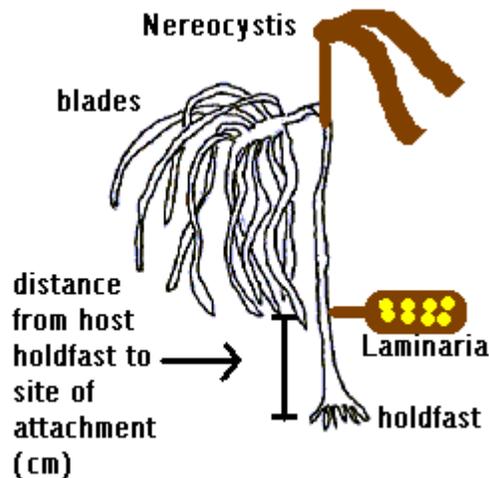
Methods:

The subtidal area off the Race Rocks jetty was surveyed to determine the abundance of *Pterygophora californica*. The survey area was divided into two sections, site A at 8 m and site B at 12 m (both measured at high tide). Site A consisted of approximately 30 m² of sea floor, site B was near 70 m². A number of *P. californica* individuals were heavily colonised by epizootic growth that would have precluded epiphytic spore settlement, and these were excluded from the survey. 15 stipes from group A and 17 stipes from group B that were free of heavy epizootic growth and showed *N. luetkeana* and/or *L. saccharina* as epiphytes were selected for sampling. The basiphyte stipes ranged in length from 87 to 114 cm at site A (mean 104 cm, ± 8.7 cm, n = 15), and from 82 to 120 cm in group B (mean 99 cm, ± 8.6 cm, n = 17).

The locations of epiphytes were recorded by the distances from the centre of their holdfast on *P. californica*'s stipe to the host's holdfast.

It is important to note that this study sampled for only two epiphytic species. *P. californica* is host to epiphytic other Laminarians, filamentous brown and red algae, as well as bryozoans, cnidarians, and hydroids. The two species chosen were based on local abundance and ease of identification, and may not be important epiphytic species in other communities.

Figure 1: Illustration of measuring protocol.



Results

Pterygophora californica for site A at 8 m were characterized by moderately colonised stipes and mostly complete blades at their apices. Population density was approximately two individuals per square metre ($1.8/m^2$). Sea temperature was 10°C on the June 3, 4, and 5 and 11°C on June 7 and 8. The sea floor was obscured by dense cover of other laminarians at this site. The substrate was comprised of large boulders and bedrock.

More heavily colonised stipes and scarcity of complete *Pterygophora* blades at their apices characterized *Pterygophora californica* at site B at 12 m. *Pterygophora* density was approximately one individual per square metre (0.8/m²). Sea temperature was 10°C on June 3 and 5, and 11°C on June 4, 7, and 8. The sea floor at this site was mostly free from plant growth, and the substrate was covered with small *Taelia* sp. anemones. The substrate is comprised of small boulders and rocks.

Table 1: Epiphytic locations on *Pterygophora californica* at Site A

Individual and Length	<i>Nereocystis luetkeana</i> location from holdfast (cm)						<i>Laminaria saccharina</i> location from holdfast (cm)						
	0-69	70-79	80-89	90-99	100-109	110-119	0-39	40-49	50-59	60-69	70-79	80-89	90-119
1. 95 cm	0	0	3	1	0	0	0	0	3	0	0	0	0
2. 107 cm	0	0	0	1	2	0	0	0	2	0	1	1	0
3. 98 cm	0	0	1	1	0	0	0	0	0	0	0	0	0
4. 105 cm	0	0	0	1	1	0	0	1	1	1	0	0	0
5. 112 cm	0	0	0	1	2	1	0	0	3	1	1	1	0
6. 110 cm	0	0	0	0	2	0	0	0	1	0	0	0	0
7. 87 cm	0	0	0	1	0	0	0	1	0	1	0	0	0
8. 114 cm	0	0	0	0	0	0	0	0	2	0	1	0	0
9. 90 cm	0	0	1	0	0	0	0	1	1	0	0	0	0
10. 103 cm	0	1	0	0	0	0	0	0	3	1	0	0	0
11. 105 cm	0	1	2	1	1	0	0	0	2	2	1	1	0
12. 97 cm	0	0	0	1	0	0	0	0	0	0	0	0	0
13. 120 cm	0	0	0	1	0	2	0	0	1	1	1	1	0
14. 104 cm	0	0	1	1	0	0	0	1	2	0	0	0	0
15. 108 cm	0	1	0	1	0	0	0	0	0	0	0	0	0
Total	0	3	8	12	7	3	0	3	21	6	5	4	0

Table 1 is a presentation of the results from the master data table (see Appendix A). It shows a general pattern of these two kelp species to colonise one area of the *P.*

californica stipe over another. Another pattern seen here as well as in Table 2 is a

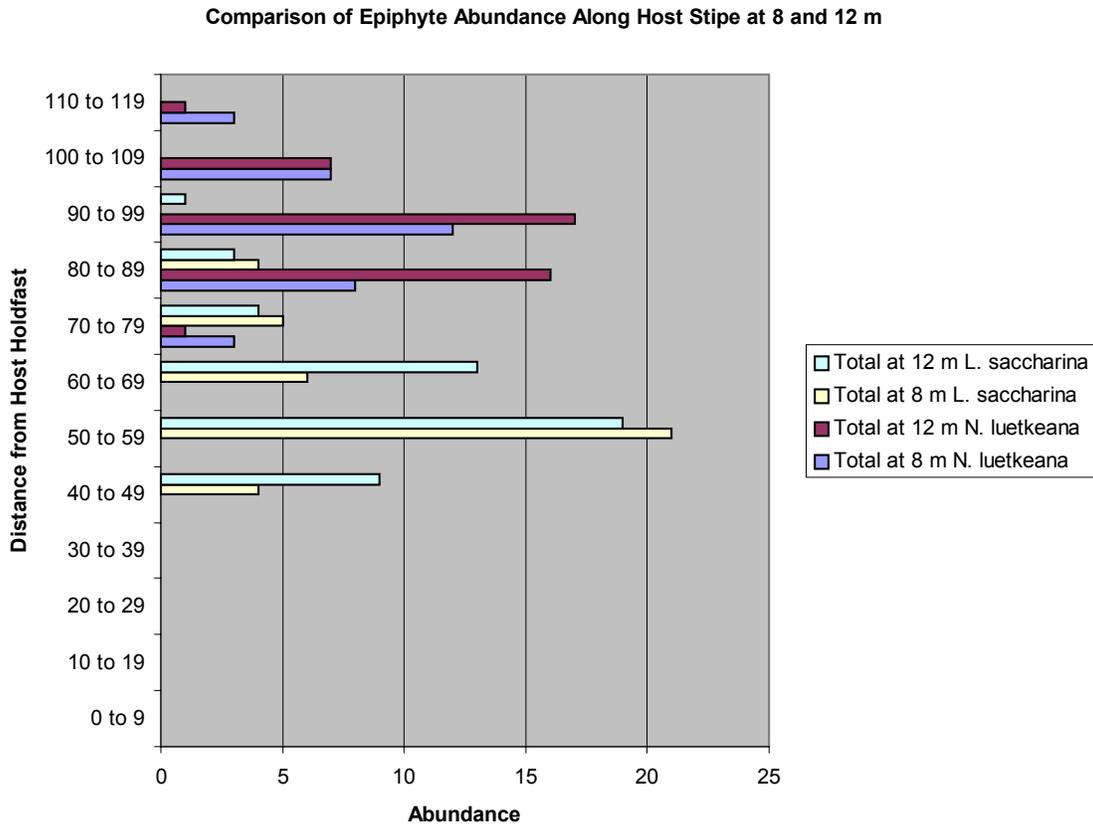
tendency for a stipe with high numbers of one epiphytic species to have relatively high numbers of both species, see Individual 5 above and Individual 8 below. These may be examples of older individuals showing the correlation with higher epiphyte counts.

Table 2: Epiphytic locations on *Pterygophora californica* at Site B

Individual and Length	<i>Nereocystis luetkeana</i> location from holdfast (cm)						<i>Laminaria saccharina</i> location from holdfast (cm)						
	0-69	70-79	80-89	90-99	100-109	110-119	0-39	40-49	50-59	60-69	70-79	80-89	90-119
1. 90 cm	0	0	0	0	0	0	0	2	0	0	0	0	0
2. 97 cm	0	0	3	1	0	0	0	0	2	1	0	0	0
3. 108 cm	0	0	2	0	1	0	0	0	1	1	0	0	0
4. 96 cm	0	0	0	1	0	0	0	0	0	0	0	0	0
5. 97 cm	0	0	3	2	0	0	0	2	1	2	1	0	0
6. 102 cm	0	0	1	2	1	0	0	0	0	0	0	0	0
7. 90 cm	0	0	0	0	0	0	0	1	2	0	0	0	0
8. 118 cm	0	0	0	3	2	1	0	0	0	3	2	2	1
9. 82 cm	0	1	1	0	0	0	0	1	0	0	0	0	0
10. 105 cm	0	0	1	2	0	0	0	0	1	2	0	0	0
11. 111 cm	0	0	1	2	1	0	0	0	1	4	1	1	0
12. 103 cm	0	0	1	1	1	0	0	0	2	0	0	0	0
13. 95 cm	0	0	1	1	0	0	0	1	1	0	0	0	0
14. 106cm	0	0	0	0	0	0	0	0	1	0	0	0	0
15. 99 cm	0	0	2	1	0	0	0	1	2	0	0	0	0
16. 96 cm	0	0	1	1	0	0	0	2	2	0	0	0	0
17. 90 cm	0	0	0	0	0	0	0	0	2	0	0	0	0
Total	0	1	17	17	6	1	0	10	18	13	4	3	1

Table 2 shows a continuance of the pattern seen in Table 1 of preferred zones of colonisation. Most epiphytes choose a relatively narrow range along the host stipe.

Figure 2:



In Figure 2 we see a zone of overlap between 70 and 89 cm from the host's holdfast, with *N. luetkeana* inhabiting 30 cm above this zone and *L. saccharina* inhabiting the 30 cm below this. *L. saccharina*'s range is slightly larger than that of *N. luetkeana* and was represented by more individuals in this sample. *N. luetkeana* abundance increased at deeper depths, as did that of *L. saccharina*. Slightly more *L. saccharina* were epiphytic on *P. californica* than *N. luetkeana* (89 individuals versus 75).

Discussion

Host density at 12 metres was half as dense than at 8 metres; yet on average, hosts carried a larger epiphytic load at 12m. Round (1985) states the depth distribution of an epiphytic species below the low tide line does not always follow changes of host abundance. Here this phenomenon can be explained in part by epiphytic loads. Algae in intertidal habitats often bear smaller epiphytic loads than their counterparts in deeper water (Boney 1969). Wave action and water turbulence is often a major factor in this, and no less so than at Race Rocks. The large swells and swift currents there wreak havoc on the upper subtidal region. This mechanical energy may limit the amount of epiphytic drag that a host *P. californica* can handle before being torn from the substrata. Thus, it may not be so much that fewer *N. luetkeana* and *L. saccharina* spores colonise *P. californica* at this depth, but that here the young epiphytes face a higher mortality due to wave action.

The substrate differed slightly between the two sample sites as well. In deeper water, the substrate was comprised of smaller particles compared with the bedrock of the shallow water group. The population decrease in deeper water can be explained in part by epiphytic load (and increased basiphyte mortality) here as well. This group is sheltered more from wave action, but exposed more to the swift currents. Perhaps epiphytes can develop to maturity more readily in this 'protected' environment to a point where their holdfasts firmly grasp their host. These mature plants then in turn increase an epiphytic drag substantial enough to allow currents to carry epiphytes, host, and substrate away at peak ebb and flood currents. Physical tests of friction, drag, and current strength would be of great interest here.

The timing and location by which species colonise a basiphyte may be controlled by environmental factors including water temperature and salinity, or less noticeable biological factors related to the surface and/or chemical activity of host (Round 1985). One general pattern of epiphytic colonisation however is that as the growth of a basiphyte slows, epiphytic colonisation increases (Lobban 1994). *N. luetkeana* was found to colonise closest to the blades of the *P. californica* stipe, in the area of highest growth. *L. saccharina* was found to colonise the mid-stipe, the area where growth is slow (Round 1985). This apical positioning by *N. luetkeana* could indicate this species' ability to settle and survive on the basiphyte's surface over those of *L. saccharina*. Microscopic inspection over the early growing season would be of great interest here.

Finally, the impact of light availability and intensity must be considered. It is possible that in this case that shading from *N. luetkeana* is beneficial to the inferior epiphyte, and that this interaction is not competitive. *N. luetkeana* comprises the canopy of the kelp forest, and thus is much better adapted to intensely irradiated environments.

L. saccharina is a major constituent of the mid-sublittoral canopy that has a lower flux intercepted per unit area than the upper canopy (Lobban 1985). *L. saccharina* seems to be adapted to this lower irradiance, as the results here indicate. Thus, in terms of irradiance preference, it might be said that *N. luetkeana* colonises the apical positions as a matter of necessity, while *L. saccharina* colonises positions inferior to this as a matter of habit. Specific irradiance tolerances and suitabilities for the three species considered here is of interest. A de Wit replacement scheme, where either of the two epiphytes were selectively removed might shed further light on this population dynamic (Lobban 1994).

The lower 40 cm on all *P. californica* stipes was free of all epiphytic growth. I propose that predation pressure from *Strongylocentrotus droebachiensis* (the green sea urchin) is significant in this region, and above this height, *S. droebachiensis* predation does not impact so heavily. Further observation would be of interest here.

Conclusion

The non-obligatory epiphytic relationship between *P. californica* and two of its epiphytes, *N. luetkeana* and *L. saccharina*, was investigated. Two groups of plants, one at 8 m and another at 12 m were sampled. Population densities of 2 epiphytes were compared and interpretations of patterns found is based on intrinsic and extrinsic properties of the species involved and their environments.

N. luetkeana was found to be epiphytic near the apex of *P. californica* at both sites. *L. saccharina* was found to overlap slightly with the range of *N. luetkeana* and then colonise the stipe below this region. Epiphytic densities increased with depth, while host density decreased. Possible reasons for this pattern were discussed. More work is of interest here to fully understand the pattern found here.

References

- Boney, A. D. (1969). *A Biology of Marine Algae*. Hutchison Educational. London, UK.
- Darley, W. Marshall (1982). *Algal Biology: a physiological approach*. Blackwell Scientific Publications. Oxford, UK.
- Institute of Ocean Sciences. 2002. Available online:
<http://www-sci.pac.dfo-mpo.gc.ca/osap/data/lighthouse/raceroct.txt>
- Lee, Robert Edward (1999). *Phycology*. 3rd Edition. Cambridge University Press. Cambridge, UK.
- Lobban, Christopher S. and Paul J. Harrison (1994). *Seaweed Ecology and Physiology*. Cambridge University Press, Cambridge, UK.
- Lobban, Christopher S., Paul J. Harrison, and Mary Jo Duncan (1985). *The physiological ecology of seaweeds*. Cambridge University Press, Cambridge, UK.
- Lobban, Christopher S. and Michael J. Wynne (1981). *The Biology of Seaweeds*. Botanical Monographs Volume 17. Blackwell Scientific Publications. Oxford, UK.
- Lüning, Klaus (1990). *Seaweeds Their Environment, Biogeography, and Ecophysiology*. John Wiley & Sons, Inc. New York.
- Round, F. E. (1985) *The ecology of algae*. Cambridge University Press. Cambridge, UK.