Hakai

Nearshore Report

July–December 2018

Recent Key Findings:

- *BioBlitzes have collected a combined 4,556 specimens*
  - *Submitted over 4,000 voucher specimens to museums and 1,582 sequences to Barcode of Life Database*
- *Seagrasses have a distinct associated microbial community at each life stage*
- *Seagrass wasting disease is prevalent at both of Hakai's ecological observatories*
- *Remote sensing tools and coupled surveys show promise for scaling up habitat parameters coastwide*
- *Following a devastating wasting disease, Central Coast sea stars are showing signs of resilience*

Scientific Context and Goals

Spending time near the water's edge is a quintessential part of life for those living in coastal British Columbia. Unfortunately, the shoreline that has inspired so many has seen numerous changes due to mounting human pressures.

Climate change, coastal development, shipping, and pollution are among the factors affecting invaluable ecosystem services provided by the nearshore environment. This environment plays an essential role for subsistence communities, provides habitat for commercial fisheries, and has global importance for the carbon cycle. However, these services are often overlooked and undervalued.

The Hakai Institute's Calvert Island Ecological Observatory is located in the heart of British Columbia's Central Coast—a region vibrant in First Nations communities that are intimately linked with diverse marine ecosystems. The island and its surrounding areas are home to a rich variety of habitats in a small area. This makes it possible to efficiently study everything from soft sediment estuaries and seagrass meadows, to rocky outer coasts and kelp forests.

This location allows us to apply the latest technologies to 1) inventory local marine life and describe interconnected marine habitats, 2) understand how the nearshore environment perseveres and recovers when faced with disturbance, and 3) elucidate the myriad linkages between the marine and terrestrial environments.

The ecological observatory on Calvert Island is uniquely located at the intersection of temperate and more subpolar species' ranges, which boosts local diversity. To capture both habitat and species diversity, we use a combination of hands-on surveys, remote sensing technologies, and genomic libraries to quantify local phenomena, and scale trends regionally.

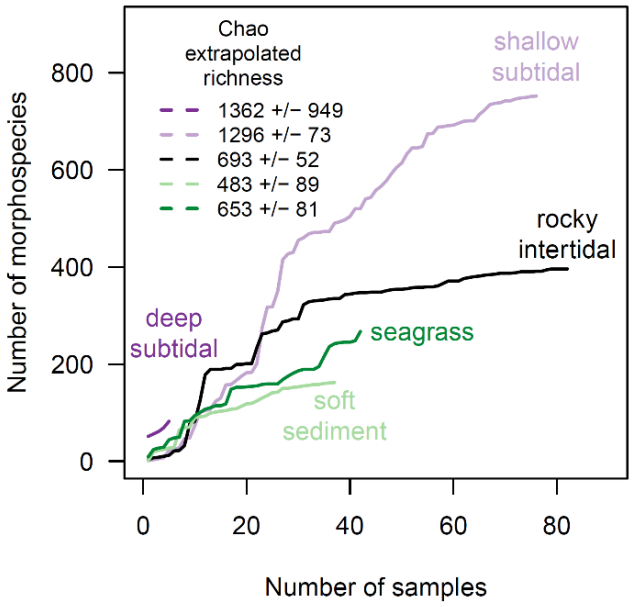

Figure 1: Collector curves showing estimates of species richness in habitats sampled during Hakai BioBlitz efforts. (M. Whalen)

Figure 2: Representative collected specimens from 20 phyla as part of understanding the microbiome of meiofauna. Specimens were collected from Hakai's Calvert and Quadra Island Ecological Observatories and Curaçao in the Caribbean. (Keeling and Leander Labs)

Understanding the resilience of marine communities faced with natural and anthropogenic stressors is a key objective of our work. Our research investigates a range of disturbances and stressors, from site-specific response to storm waves to understanding the longer-term effects of marine heatwaves and devastating infections driven by climate change. Through the study of resilience in the nearshore environment we are deciphering the numerous stressors shaping nearshore communities and habitats.

Nearshore habitats are interconnected with the coastal ecosystem as a whole. In addition to their value supporting marine food webs, nearshore habitats also dissipate storm damage, buffer the ocean from terrestrial disturbance, and produce and store carbon, to name a few of the important ecosystem functions they provide. However, it remains unclear how connectivity, between habitats and ecosystems, contributes to these important habitat functions. The close proximity of diverse nearshore habitats at our ecological observatory directly adjacent to both the open ocean and forested watersheds makes this an ideal location to study ecosystem connectivity, and its effects on ecological function.

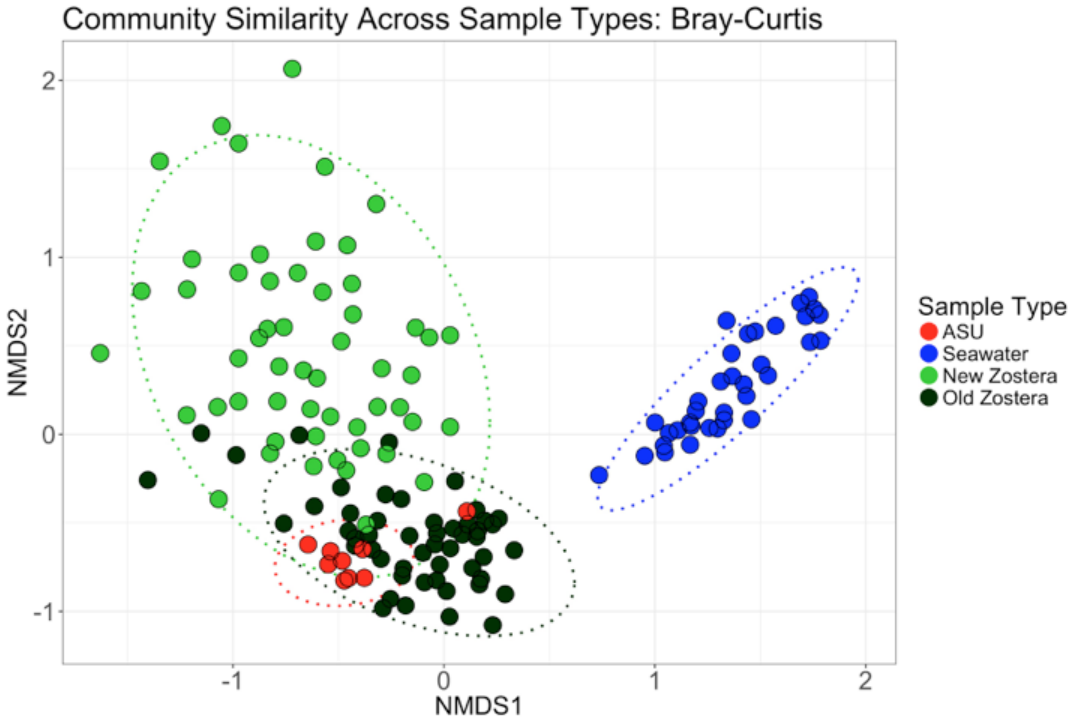

Figure 3: Bacteria (16S) cluster with the age of the seagrass plant (new vs. old) and are unique from seawater communities. The communities on old plants are similar to those on artificial seagrass units (ASU). (R. Sanders-Smith)

Recent Progress

Last field season we successfully completed our third year of seasonal surveys for seagrass, kelp, and soft sediment habitats and second season for rocky intertidal habitats. This detailed work significantly advances our understanding of these nearshore habitats and their seasonality. In addition to completing our second BioBlitz, sampling programs were also focused on Calvert over six months, where field objectives were met. Following the field season, considerable organizational and analytical progress has been made in managing the data. These efforts, and associated projects, have culminated in the publication of nine new peer-reviewed articles during this period and an additional six that are currently in review.

Nearshore Diversity

A highlight of the sampling season was completing our second marine BioBlitz in conjunction with Hakai's Biodiversity initiative. Building on the successes of the 2017 BioBlitz, 10 leading scientists in their field were invited to Calvert for a week of sampling focused on seagrass and soft sediment habitats. Combined with last year, the BioBlitz collection is now more than 4,500 samples that are diligently being identified, genetically barcoded, and submitted to the Barcode of Life Data (BOLD) System. Additionally, over 4,000 physical specimens have been contributed to museums from the Royal BC Museum in Victoria to the Florida Museum of Natural History in Gainesville. Currently, work is ongoing to process samples, advance collaborative manuscripts, and examine the diversity data set for gaps in our understanding of the current biodiversity of Calvert Island.

Microbes—BioBlitzes are essential to inventory the visible macro species in the environment, but they also provide imagery of very small meiofauna through microscopy. Building a collection through these events enables further objectives such as characterizing the microbial communities associated with these samples. In the past year, work to determine whether meiofauna host a discreet microbial community, or microbiome, has produced and identified more than 1,000 specimens representing 21 of the 36 phyla in the animal kingdom.

Marine microbial ecologists are also investigating the microbiomes of the seaweeds and seagrasses growing in nearshore marine habitats. Two publications stemmed from this work in the second half of 2018, focused on kelps and other macrophytes. While a majority of the microbes were consistent with those found in the environment, some microbes were distinct

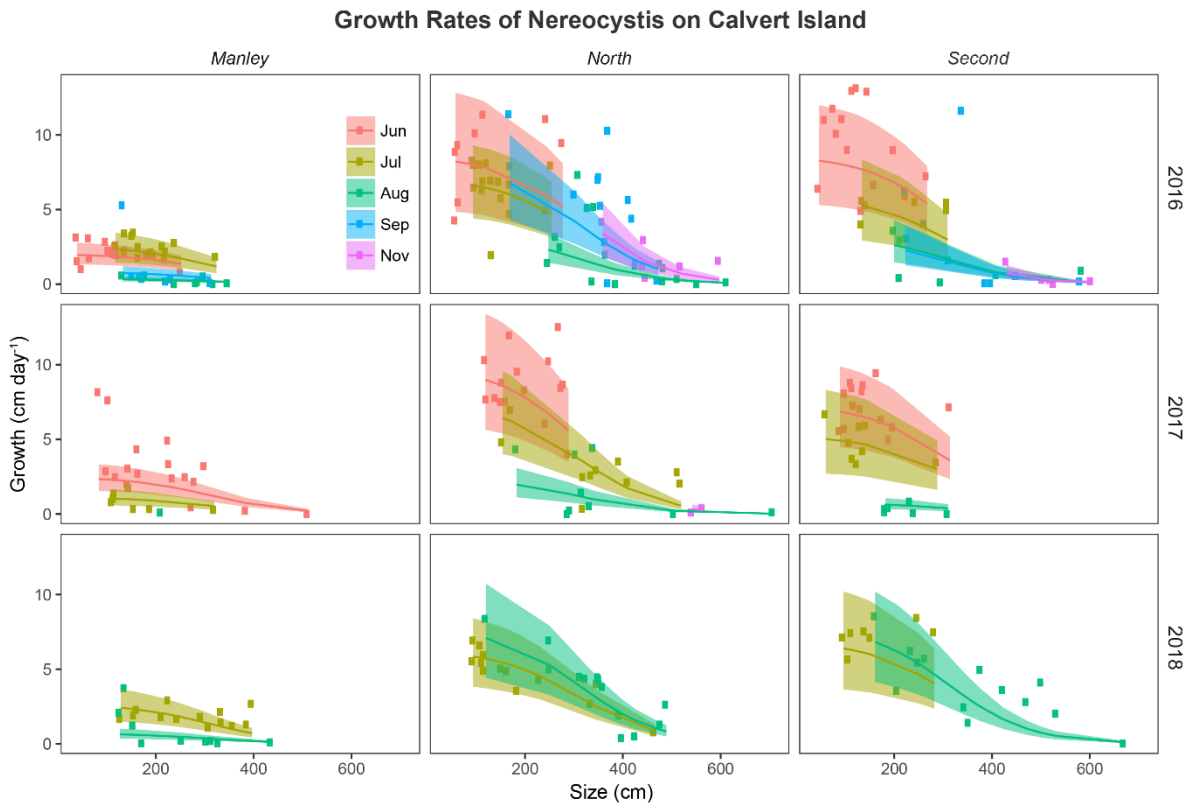

Figure 4: Seasonal peaks in Nereocystis kelp growth at three Calvert beaches (Manley, North, and Second). (O. Pontier, J. Burt, N. Okamoto)

between kelp species. Similarly, distinct microbial communities have been found on seagrasses and their life stages. Another indicator alga, *Fucus distichus*, demonstrates microbial community shifts throughout the year.

Macrophytes—Following the field season, Nearshore staff have been busy synthesizing the three-year observational data set for seasonal and interannual signals. This team effort has determined periods of peak growth and productivity in key indicator species (seagrass, kelp, and other macrophytes) and is currently investigating correlations with ocean productivity and climate, which will form the basis of future publications. In addition, data review is informing planning for annual seagrass and kelp research this coming field season.

Fish—Our understanding of fish diversity around Calvert Island is exceptional. It is now rare for a new species to be documented outside of the nearly 100 that have been cataloged. Beach seining data, conducted since 2014 alongside seagrass research surveys, is showing interannual trends in fish species associated with seagrass and other nearshore habitats. These data are proving vital to regional and global assessments of fish diversity in relation to human impacts. Samples are also facilitating the early interpretation of eDNA sampling that began in the summer of 2018. Analyses of these data are ongoing.

Invertebrates—Invertebrate diversity is also becoming well characterized across nearshore habitats thanks to seasonal and annual surveys. Rocky intertidal methods follow PISCO protocols and will allow data to be compared with other North American sites. Nearshore sampling also contributed to genetic sampling of *Pisaster* sea stars and studies of invertebrate recruitment dynamics, both of which are part of international collaborations. In addition, analyses of seagrass grazers, among other habitat-associated species, are showing us that maintaining diversity is dependent on habitat connectivity.

Environmental Conditions—The Nearshore team ramped up corresponding environmental data collections in 2018 with a designated CTD and newly revised, more efficient water sampling, including cross training across Oceanography and Nearshore field crews. All corresponding data from previous years through 2018 is being summarized and will provide

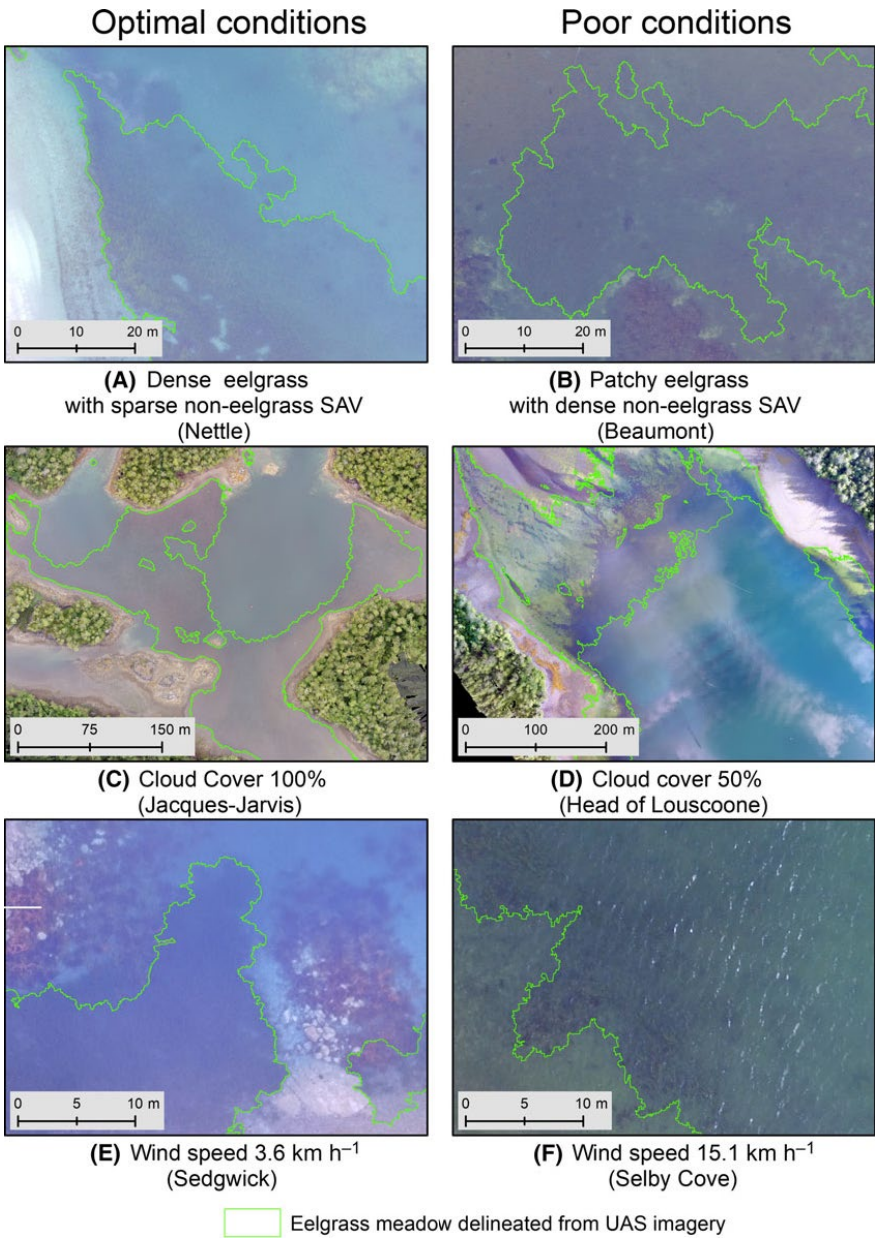

Figure 5: Visual comparison of sites with optimal and poor conditions for drone mapping of seagrass. Valuation based on bed characteristics (A, B), cloud cover (C, D), and wind speed (E, F). (Nahirnick et al. 2018)

critical site characterizations that correspond to many hypotheses-driven short-term studies. For instance, the *Pyropia*-focused research will be supported by extensive environmental data to determine the causes of the poor subsistence harvest in 2016.

Habitat Mapping—Nearshore scientists are working closely with Hakai's Geospatial team to scale up observations from field surveys using remote sensing techniques. In so doing, remote sensing is providing insights into the productivity and biodiversity of the coast on a larger scale. Through a partnership with Parks Canada (2017 and 2018) seagrass mapping was conducted in all of British Columbia's coastal national parks. This contributed to a publication which sets the scene for future drone-based mapping of seagrass habitats in temperate climates. At the regional scale, WorldView-2 satellite imagery was also collected to map kelp extent, as part of a continuing partnership with scientists at Fisheries and Oceans Canada (DFO). Results from these remote sensing investigations are being correlated with dive-based assessments of kelp biomass.

Collaboration with Geospatial is also generating 3D terrain models that are being used to quantify changes in mussel beds, the role of habitat roughness on larval recruitment, and bivalve distributions in soft sediments. The strong collaboration with the Geospatial team sets Nearshore research apart in the field of marine benthic

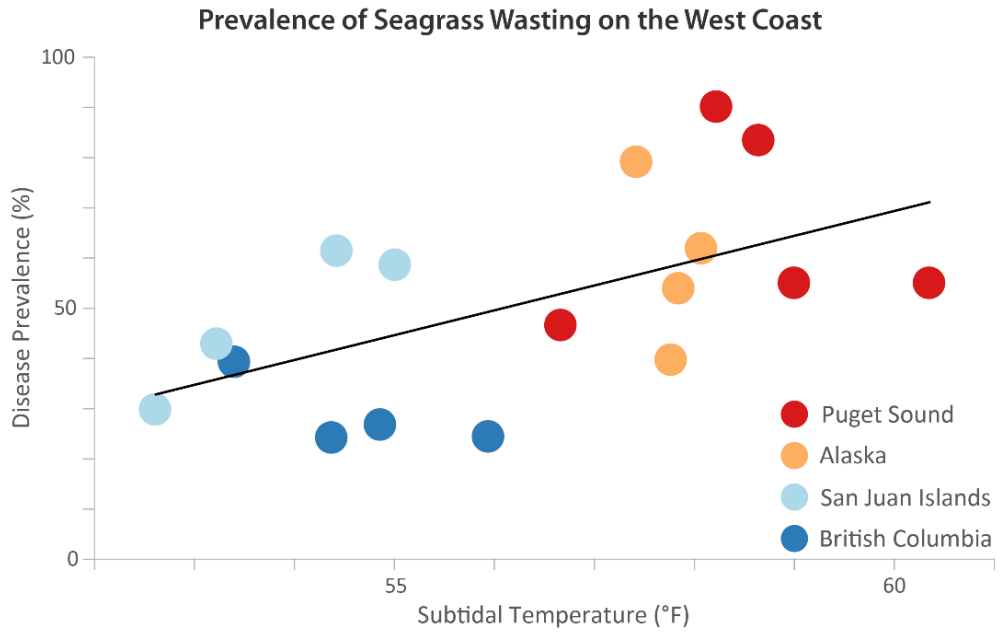

Figure 6: Prevalence of seagrass wasting along the west coast appears to have a temperature dependency. (Graham et al.)

ecology and increases the relevance of our findings well beyond the shores of Calvert Island.

Nearshore Disturbance and Resilience

From infectious diseases and the recovery of predators to a warming climate where the ocean is getting more acidic, Hakai observations are revealing the resilience of nearshore habitats and communities to global change.

In the summer of 2018, Hakai joined an international collaboration, funded by the National Science Foundation, investigating the extent and severity of seagrass wasting disease. The disease has been found among Calvert meadows, but at much lower prevalence than found in warmer, more inhabited areas, like Puget Sound. Early indications are that wasting has a strong correlation with temperature.

A recent publication in *Science Advances* makes use of sea star monitoring from Calvert (and beyond) since 2013. The decimation of the intermediate predator *Pycnopodia*, or sunflower star, along its entire range from Mexico to Alaska is having a cascade of effects across the nearshore. Another publication shows that the absence of *Pycnopodia*, in conjunction with sea otter recovery, is resulting in a denser kelp canopy. Summer 2018 monitoring results suggest that *Pycnopodia* is rebounding in the area, but it is too early to say for certain.

The recovery of predators, like sea otters, can have strong and pervasive effects on nearshore habitats and their communities. Newly reported in *Ecology and Evolution*, the return of sea otters on the Central Coast has revealed a gender bias toward different food sources and the amount of time spent in a given nearshore habitat. Sea otter foraging for diverse prey can cause physical disturbances in many nearshore habitats, and we continue to investigate the resulting ecosystem response.

As these changes happen, we seek to understand the response of the ecosystem and species to the disturbance. We are leveraging our longitudinal time series to see how indicator species (e.g. mussels, macrophytes) across the nearshore are responding through changes in abundance and distribution. Tracking environmental factors is bearing fruit as we're now able to retroactively examine interannual temperature differences and acidification effects on the succession of coralline algae, seaweeds, and invertebrate communities. Continuing these analyses will be a major component of a forthcoming Hakai Coastal Initiative post-doc.

Nearshore Connectivity

Nearshore ecosystems are closely connected via the movement of animals, materials, and nutrients. New research, drawing on Calvert-based observations,

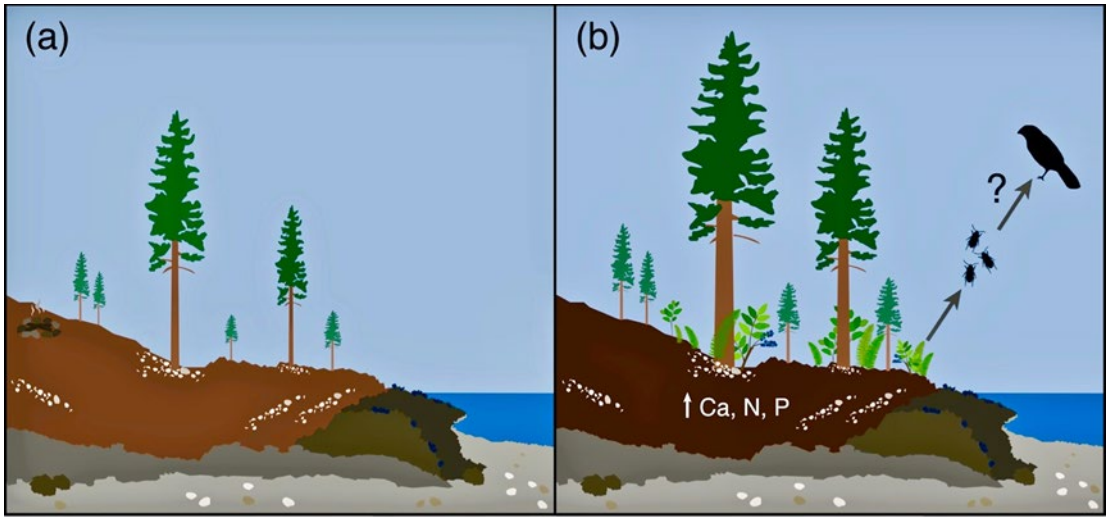

Figure 7: Coastal ecosystems where birds and animals bring shellfish nutrients inland have increased soil nutrients, increased tree height, and greater vegetative diversity. This supports a more diverse community of primary and secondary consumers. (Cox et al.)

demonstrates land-sea connections. A recent review has compiled observations to show that shellfish, in the form of shells and animal droppings, significantly influences soil chemistry and forest productivity/diversity. Similarly, kelp-based material has recently been found as an important building block for eagle nests in some environments.

In the water, nearshore scientists have empirically found enhanced nursery functions of seagrass meadows adjacent to kelp forests. These meadows are also important to the capture and remineralization of both terrestrial and marine-derived carbon since the seagrasses slow water movement and effectively sequester carbon in the sediments. We are also investigating how mussels benefit from using terrestrial nutrients.

These cross-boundary observations of ecological connectivity will soon be augmented by a high-resolution nearshore ocean model developed by Hakai Oceanography. A fine-scale model grid, more closely matching the scale of nearshore observations, was recently developed and implemented. Nearshore scientists are looking forward to using model products to investigate the spatial flow of organisms to describe potential connections between habitats and ocean circulation patterns. Still in refinement, much of the work applying this tool will be conducted in the year ahead.

Lessons Learned, Research Exchanged

Lessons learned and opportunities for sharing methods and findings were abundant this field season. Nearshore technicians were cross-trained in sampling all habitat types throughout the season. Staff built on these skills as they learned from taxonomists on Calvert during the BioBlitz. However, serious and unfortunate field and boating incidents occurred during the season that necessitated an important review of our safety protocols and standard operating procedures. With the improved Intertidal Safety, Boating, and Equipment policies in place we are confident that the Nearshore team will be even more prepared to address potential risks for future field seasons.

In the last six months we have also shared the latest findings. The Nearshore team presented at three conferences (Western Society of Naturalists, Phycological Society of America, and Ecological Society of America). Across British Columbia, we contributed talks and content to the Marine Plan Partnership for the North Pacific Coast, multiple First Nations organizations from Campbell River to Haida Gwaii, and provided training in marine monitoring to the Coastal Guardian Watchmen. In addition to the technical talks and trainings, Nearshore staff were involved in educating BC youth through multiple visits from Central Coast elementary students to Calvert, teaching students in Vancouver schools, and a public seminar through the Vancouver Aquarium about sea star wasting. These efforts to connect to the broader scientific and local

communities are invaluable learning experiences both for Nearshore staff and those they engage with.

Looking Ahead

The last field season was productive for our core sampling programs. This coming year we are looking to find efficiencies in sampling and reductions where possible, while maintaining a high level of quality sampling. We will do this, in part, by consolidating numerous shorter trips into a few longer trips. Current plans estimate that 45 percent fewer days will be allocated to sampling kelp and seagrass habitats and 25 percent fewer days for the rocky intertidal. These surveys are planned for middle to late summer, when historical data shows that productivity will be near, or at, its annual maximum.

With fewer days in the field, Nearshore staff will be freed up to spend more time on data packages that we plan to have ready for public release in 2019. In March we'll take a brief break from data management to conduct our annual field team safety training on Quadra. We have done this the past couple of years and we're looking to build on those trainings, including new protocols instituted at the close of our last field season.

Across the Nearshore team a major focus will be on processing of samples and data analyses. From these analyses come collaborative manuscripts that are in process for many of the aforementioned focal areas, including:

- R. Sanders-Smith and colleagues will soon submit the first results describing the prokaryotic (16S) and eukaryotic (18S) microbial communities associated with seagrass succession and B. Segovia *et al.* will be following with a manuscript detailing the corresponding interannual variability,
- K. Cox and collaborators will soon submit a manuscript describing soft sediment community diversity as related to the shell and gravel composition around Calvert beaches,
- and A. Gehman has been summarizing existing data to determine if sea star diversity contributes to the recovery of sea star populations following the incidence of wasting syndrome.

Also, this will be the last summer of fieldwork for the *Pyropia* project since J. Clark is planning to complete her investigations and write additional papers. Finally, data

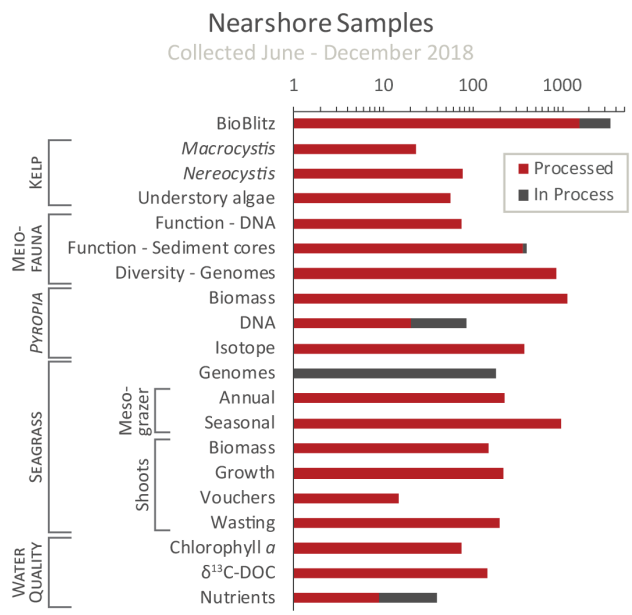

Figure 8: Summary of all Nearshore samples collected over the June–December 2018 period. Note the log scale.

sets are being analyzed with an eye to nearshore connectivity to examine how juvenile fish (B. Millard-Martin *et al.*) and invertebrates (A. Olson *et al.*) are using the diverse habitats of Calvert.

For the upcoming field season, ongoing Nearshore surveys will continue to investigate:

- the role of seagrass and kelp production on fish and invertebrate diversity (collaboration with H. Stewart, M. O'Connor, E. Rubidge, A. Frid),
- the change in kelp productivity in relation to marine heatwaves (collaboration with K. Krumhansl, D. Okamoto, J. Burt *et al.*),
- and the factors that drive distribution of indicator species in the rocky intertidal (work by Nearshore, C. Harley, P. Martone *et al.*).

These focused research initiatives will provide insights to these longstanding, broad-based ecological questions.

Continuing partnerships with Hakai Geospatial, DFO, and the University of Victoria will allow Nearshore to relate ecological relationships of in situ kelp biomass to aerial imagery from Calvert and apply them coastwide. Extrapolations to the whole coast will make use of publicly available Landsat imagery of the region and combine it with high-resolution WorldView-2 satellite data acquired at localized kelp hotspots and ground truthing conducted in conjunction with collaborators. Imagery will also maximize the capabilities of the new

Airborne Coastal Observatory for biomass and biodiversity analyses at these hot spots.

Collaborations and Summary

From the Central Coast to international research programs, research from the Nearshore team has lasting collaborative impact.

Along the Central Coast the Nearshore team has worked to develop relationships with multiple First Nations organizations. Our divers have been collaborating with the Central Coast Indigenous Resource Alliance since 2015; this has resulted in its first publication, led by Frid *et al.* We are also working closely with the Coastal Guardian Watchmen to develop monitoring methodologies in support of the Marine Plan Partnership for the North Pacific Coast (MaPP). In addition, we will soon submit our core monitoring data to these planning efforts.

Working with partners at DFO and Parks Canada, the Nearshore team is scaling up our remote sensing operations (leveraging $55,000 over 2018–2020 in DFO funding) to investigate kelp and seagrass habitats across the coast. Additionally, Hakai data contributes to DFO's provincial estimates of marine mammal populations and seagrass data is being used in the new management plan for British Columbia's Southern Bioregion.

Hakai Nearshore researchers and university affiliates are embedded at all three of the major universities in southern British Columbia. Hakai Coastal Initiative scholars, based out of the University of British Columbia's Institute for the Oceans and Fisheries and Biodiversity Research Centre work closely with Nearshore scientists. These UBC post-docs are leading many of the projects detailed above and are cross-pollinating methods and knowledge from the university to the rest of Hakai. Similarly, Hakai-funded researchers at Simon Fraser University and the University of Victoria are elevating Hakai science through the publication of high profile papers (e.g. Burt *et al.*) and fellowships (K. Cox) with international collaborators through the MarineGEO network.

Our international collaboration with MarineGEO, a Smithsonian-led global network of marine monitoring stations, has facilitated our BioBlitz initiatives and two comparative experimental studies led by M. Whalen and others. Collaboration with MarineGEO is also furthering the establishment of Essential Biological Ocean Variables for seagrass and macroalgal habitats that will allow for improved international comparative analyses.

We are also part of two international marine disease collaborations. A. Gehman is Hakai's representative for the international disease response network, Primary Responders in Marine Emergent Diseases (PRIMED), which has been formed to understand the lasting ecological effects of sea star wasting syndrome while M. Hessing-Lewis leads Hakai's involvement with a new collaboration to study seagrass wasting along the northeast Pacific coast. In all cases Hakai's geospatial capabilities and dedication to long-term studies are an essential asset valued by our international collaborators that will help the scientific community be better prepared for the next marine disease outbreak.

All of this work is done by an extensive and talented Nearshore team composed of nearly 20 Hakai staff and post-docs split between Hakai locations. In addition to the dozen internal Hakai collaborators, Nearshore works with nearly 70 external collaborators from 20 universities across North America who also contribute to research initiatives described in this report. Many projects are led by the post-docs and doctoral candidates from these institutions who are supported by our dedicated field team.

The Nearshore team has been busy—producing data sets that will improve our understanding of biodiversity, resilience, and ecosystem connectivity on the Central and greater BC Coasts. The coming field season will finesse our data pipeline, foster new analyses and publications, and strengthen ongoing collaborations. Our field season will be shorter, but more efficient and focused. We are proud of our accomplishments, pleased to have received recognition from our peers and the media, and excited for the discoveries that lie ahead.

Publications (n = 15)
(Hakai researchers in bold)

Burt, J. Tinker, T., Okamoto, D., Demes, K., Holmes, K., **Salomon, A**. 2018. Sudden collapse of a mesopredator reveals its complementary role in mediating rocky reef regime shifts, *P Roy Soc B*. 285. https://doi.org/10.1098/rspb.2018.0553

Cox, K., Davies, H., Davidson, K., Gerwing, T., **Dudas, S**., Juanes, F. 2019. Shellfish subsidies along the Pacific Coast of North America, *Ecography* [SUBMITTED]

Frid, A., McGreer, M., Gale, K., Rubidge, Em, Blaine, T., Reid, M., **Olson, A**., Hankewich, S., Mason, E., Rolston, D, Tallio, E. 2018. The area-heterogeneity tradeoff applied to spatial protection of rockfish (*Sebastes spp.*), *Aquat Conserv. https://doi.org/10.1111/conl.12589*

Griffiths, G., **Sanders-Smith, R., Hessing-Lewis, M., Olson, A., Wegener Parfrey, L., O'Connor, M.I.** 2019. An experimental test of biotic and abiotic drivers of spatial variation in abundance of the seagrass epiphyte *Smithora naiadum*. *Aquat Bot* [SUBMITTED]

Harvell, D., Montecino-Latorre D., Caldwell, J.M., **Burt, J.M.,** Bosley, K., Keller, A., Heron, S.F., Salomon, A.K., Lee, L., **Pontier O**., Pattengill-Semmens, C., Gaydos, J.K. 2019. Disease epidemic and a marine heat wave are associated with the continental-scale collapse of a pivotal predator (*Pycnopodia spp*), *Science Advances. https://doi.org/10.1126/sciadv.aau7042*

Hind KR, Starko S, Salomon AK, Burt JM, Lemay MA, Martone PT. 2019. Trophic control of coralline species diversity: how barren are urchin barrens?, *P Natl Acad Sci USA* [SUBMITTED]

Hind, K.R., Gabrielson, P.W., Jensen, C., and **Martone, P.T.** 2018. Evolutionary reversals in *Bossiella* (Corallinales, Rhodophyta): First report of a coralline genus with both geniculate and non-geniculate species, *J Phycol*. https://doi.org10.1111/jpy.12788.

Hughes B, Wasson K, Tinker T.M., Williams S, Carswell L.P., Boyer K, Breck M.W., Eby R, Scoles R, Staedler M, Espinoza S, **Hessing-Lewis M**, **Rechsteiner E**, Beheshti K, Grimes T, Becker B, Needles L, Tomoleoni J, Rudebusch J, Hines E, Silliman B.R. 2019. Species recovery and recolonization of past habitats: lessons for science and conservation from sea otters in estuaries, *Conserv Lett* [SUBMITTED]

Lemay, M., Martone, P.T., Hind, K., Lindstrom, S., and L.W. Parfrey. 2018. Alternate life history phases of a marine macroalgal genus have distinct microbial surface communities, *Mol Ecol.* https://doi.org/10.1111/mec.14815.

Lin JD, **Lemay MA, Parfrey LW**. 2018. Diverse bacteria utilize alginate within the microbiome of the giant kelp *Macrocystis pyrifera*, *Front Microbiol.* https://doi.org/10.3389/fmicb.2018.01914

Nahirnick, N., **Reshitnyk, L., Campbell, M., Hessing-Lewis, M.**, Costa, M., Yakimishyn, J., Lee, L. 2019. Mapping with confidence; delineating habitats using Unmanned Aerial Systems (UAS), *Remote Sens Ecol Conserv.* [IN PRESS]

Olson A., Haggarty D, Juanes F, **Hessing-Lewis M**. 2019. Seagrass nursery function enhanced by habitat connectivity, *Ecological Applications* [SUBMITTED]

Prentice, C., Hessing-Lewis, M. Salomon, A., Sanders-Smith, R. 2019. Reduced water motion enhances carbon stocks in temperate eelgrass meadows, *Limnol Oceanogr* [SUBMITTED]

Rechsteiner, E., Watson, J., Tinker, T., Nichol, L., **Morgan Henderson, M.,** McMillan, C., DeRoos, M., Fournier, M., Salomon, A., Honka, L., Darimont, C. 2019. Sex and occupation time influence niche space of a recovering keystone predator, *Ecol Evol* https://doi.org/10.1002/ece3.4953

Rechsteiner, E., Wickham, S., Watson, J. 2019. Predator effects link ecological communities: kelp created by sea otters provides an unexpected subsidy to bald eagles, *Ecosphere* doi.org/10.1002/ecs2.2271

Conferences and Presentations (n = 16)

Clark, J. The case of a missing alga: understanding the decline of a traditionally harvested red alga from BC coasts during "The Blob", Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Poster.

Clark, J. The legacy of the blob: ongoing effects of the pacific warm water anomaly on the traditionally harvested alga*, Pyropia abbottiae.* Phycological Society of America 2018 Annual Meeting, 29 Jul – 02 Aug 2018, Vancouver, BC. Oral.

Cox, K. Integrating 3D habitat models into marine ecosystem assessments. Smithsonian Marine Station Seminar Series. 25 Nov 2018. Fort Pierce, FL. Invited Speaker.

Gehman, A. Sea Star Wasting Disease & How it Impacts BC's Entire Ecosystem, Vancouver Aquarium, 23 Oct 2018, Vancouver, BC. Public Lecture.

Gehman, A., Pontier, O., Kay, S., Harley, C**.** Do kelp subsidies alter grazer-epiphyte interactions in temperate seagrass meadows?, Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Oral.

Gehman, A., Schaeffer O., Harley, C. *Documenting population dynamics of a traditionally harvested seaweed: development of long-term monitoring surveys.* Ecological Society of America 2018 Annual Meeting, 5 – 10 Aug 2018, New Orleans, LA. Oral.

Harley, C.D.G. From keystone predation effects to global change, are we missing the forest for the trees?, 12th International Temperate Reefs Symposium, 6-11 Jan 2019, Hong Kong, CN. Invited Speaker.

Harley, C.D.G. *Species interactions, environmental change, and biodiversity on rocky shores.* University of Aukland. 15 Sep 2018. Aukland, NZ. Invited Speaker.

Hessing-Lewis, M., Monteith, Z., Olson, A., VanMaanen, D. Reshitnyk, L and Sanders-Smith, R. Seasonal trends in seagrass productivity; shoot-level and meadow scale metrics of growth.. Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Poster.

Liggan, L., Documenting population dynamics of a traditionally harvested seaweed: development of long-term monitoring surveys*,* Phycological Society of America 2018 Annual Meeting, 29 Jul – 02 Aug 2018, Vancouver, BC. Oral.

Liggan, L., Staying afloat: Biochemical limitations of buoyancy and the risk of sinking in the bull kelp (*Nereocystis* luetkeana), Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Oral.

Okamoto, D., Pontier, O., Burt, J., Hessing-Lewis, M., Stewart, H., Krumhansl, K. Empirical productivity dynamics in Nereocystis. Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Oral.

Olson, A., Prentice, C., Monteith, Z., Hessing-Lewis. Do kelp subsidies alter grazer-epiphyte interactions in temperate seagrass meadows?. Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Poster.

Reshitnyk, L. Y., Nijland , W., Rubidge, E., Schroeder, S.,**Pontier, O**., Costa, M., **Hessing -Lewis**, M**.** Do kelp subsidies alter grazer-epiphyte interactions in temperate seagrass meadows?. Western Society of Naturalists 2018 Annual Meeting, 8 – 11 Nov 2018, Tacoma, WA. Poster.

Sanders-Smith, R., Trevizan, B., O'Connor, M. Parfrey, L. et al. Successional shifts of Zostera Marina Microbiome. Microbiome Network Symposium, 7-12 Nov 2018, Vancouver, BC. Poster.

Trevizan, B., **Sanders-Smith R.**, Parfrey, L. Diversity Patterns of Microbial Eukaryotes from the Seagrass Epiphytes of Zostera Marina in the Coast of British Columbia, Canada. Microbiome Network Symposium, 7-12 Nov 2018, Vancouver, BC. Poster.

External Media Coverage (n = 70+)

J. Burt – Ecosystem changes resulting from sea star die-off – *Vancouver Sun*, CBC, *Forbes*, e.g. - n = 13

Seagrass Wasting Grant – *Smithsonian Magazine*, *Cornell News*, *Science Daily*, e.g. - n = 5

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