**Changing Seascapes**

**2015 Update and Program Proposal**

Program update 2015

Program funding: May 2015 - December 2018

July 2015: all hands on deck Calvert Station

**Hakai Program Leads:**

**Margot Hessing-Lewis (Hakai), Erin Rechsteiner (Hakai)**

**Overall 3 year Strategic Goal**

This Hakai Research Program aims to quantify the ***causes*** and ***consequences*** of change in British Columbia’s Central Coast nearshore ecosystems, focusing on kelp forests and seagrass habitats. Broadly, it aims to understand the local and regional factors driving future, contemporary, historic and prehistoric change in these coastal ecosystems and the ecological & socio-economic consequences of their dynamics.

**Short-Term 1-2 year Objectives**

1. *Ongoing mapping (2014):* Quantify the regional spatial and temporal dynamics of kelp and seagrass habitats. Document long-term trends in canopy-forming kelp forest and seagrass meadows with complimentary boat-based mapping and remote sensing (World View) and assess drivers of change (**Research Element**: Habitat mapping **Research Lead**: Luba **Researchers**: Keith, Trisalyn, Anne, Wayne, Margot).
2. *Ongoing monitoring 2013 (kelp), 2014 (seagrass), 2015 (soft sediments):* Monitor changes in subtidal and intertidal kelp forest and eelgrass ecosystems, assess the mechanisms driving these changes, and examine the flux of nutrients and species assemblages among these habitats (**Research Element**: Nearshore ecology **Research Leads**: Anne (kelp), Sarah (soft sediments), Margot (seagrass) **Researchers**: Mary, Erin, Brian, Kyle, Kira, Jenn).
3. *Ongoing surveys (2014):* Document seasonal and annual variation in sea otter foraging behavior and habitat-use, assess geomorphic, ecological and behavioral drivers of current range extent and growth rates and predict future rates of range expansion (**Research Element**: Otter Coast **Research Lead**: Erin **Researchers:** Jane, Linda, Trisalyn).
4. *Proposed research (2015):* Assess the contemporary and prehistoric effects of sea otter depletion and recovery on coastal food web structure and productivity using stable isotopes and midden stratigraphies (**Research Element**: Historical Food Webs **Research Lead**: Iain **Researchers**: Jane, Erin, Anne, Margot).

**Synthetic Elements**  
We will synthesize the results of these four research elements by using two interdisciplinary predictive models that build on our empirical datasets to:

* *Ongoing (2014):* Assess context-dependence of ecosystem change across the northeastern Pacific in collaboration with AK, CA partnerships. Additional project components to be proposed Fall 2015
* *Proposed (2015):* Estimate macrophyte contribution to temporal changes in “blue carbon” using contemporary and historical drivers of change. Future research element to be proposed 2017

**Summarized Objectives**

Addressing theses tactical objectives requires bringing together current Hakai research elements (i.e., habitat mapping, macrophyte and sea otter surveys), overlapping Hakai research (i.e. oceanographic monitoring), and building the program with new proposed activities, including field-based measurements, lab-based experimental studies, and new spatial tools to quantify change.

Coastal change in this region is occurring, but the magnitude of change, and the relative weight of the different drivers of change (i.e. sea otter re-colonization, climatic forcing, human influence) has not been quantified. ***Changing Seascapes*** will quantify this change on the Central Coast’s unique regional geography, assess ecological impacts, and place these findings in the context of global change to temperate coastlines.

**Innovation**

This proposal innovates coastal science because it:

1. Asks interdisciplinary questions through the lens of diverse disciplines: geography, ecology, archaeology, and oceanography
2. Uses a combination of new analytical tools (stable isotopes, satellite remote sensing, geospatial analysis) and approaches (monitoring, experiments, and quantitative models)
3. Exploits the unique coastal mosaic of nearshore seagrass and macroalgal habitats only found on BC’s Central Coast within reach of the Hakai Institute’s Calvert Island Field Station
4. Addresses multiple time and space scales of processes simultaneously
5. Tackles the confluence of costal processes that drive change

**Background**

The Central Coast is rich with a mosaic of nearshore habitats including kelp forests, and eelgrass meadows. These ecosystems are among the most productive on our planet, providing a diversity of benefits that coastal communities have relied on economically, socially and culturally for millennia. Together, this abundance of plants and algae buffers the coastline from winter storms, draws-down atmospheric carbon, and provides habitat for diverse assemblages of organisms. Yet, these ecosystems are currently changing rapidly, due to the recovery of predators (i.e. sea otters) and changing ocean climate yielding warmer and more corrosive sea water. Moreover, these current day human-induced changes occur within the backdrop of prehistoric and historic alterations. As a result, there is a need to advance our understanding of how humans alter and benefit from the productivity, biodiversity and resilience of kelp forest and eelgrass ecosystems; to understand the natural history and ecosystems that govern nearshore ecosystems on the Central Coast; and to inform policies that support coastal communities.

**Research Elements that address Objectives 1-4**

*1.* Habitat Mapping*: Long-term Trends and Drivers in Canopy-Forming Kelp Forest and Seagrass Meadows   
(Luba Reshitnyk, Trisalyn Nelson, Keith Holmes, Wayne Jacob, Anne Salomon)*

**Question:** How have canopy forming kelps and seagrass meadows changed through time and what are the primary drivers of this change? **Objective**: Document long-term trends in canopy-forming kelp forest and seagrass meadows with LANDSAT and World View remote sensing and assess the climatic and ecological drivers of change. Use underwater videography, multibeam bathymetry and acoustic data to identify subsurface kelp and seagrass habitats and discern rocky reef from soft sediment areas.  
**Rationale:** Temporal and spatial macrophyte dynamics are likely affected by fluctuations in climate (e.g. temperature, significant wave height and nutrient availability), the cascading effects of sea otter recovery and other human influences including marine harvests. Determining the relative importance of these drivers will allow us to make better predictions about how these foundation species will change under future scenarios of predator recovery and varying climatic conditions. This information will be used to map the spatial dynamics of blue carbon along BC’s Central Coast.  
**Links:** This large-scale habitat mapping will compliment the subtidal monitoring of kelp forest, eelgrass meadows and soft sediment systems, it will also inform the benthic ecology research element in the M2M Program (rocky intertidal projects led by Chris Harley and Patrick Martone).  
**Current Personnel:** Trisalyn Nelson, Luba Reschitnyk, Anne Salomon, Keith Holmes, Wayne Jacob

**New Personnel:** None requested

**Datasets generated:**

* Satellite imagery (Landsat and WorldView) for canopy-forming macrophytes (Keith/Luba)
* Videography and acoustic data for subsurface macrophytes (Luba)
* Bathymetric mapping: multibeam data on depth and substrate hardness (Wayne/Luba)
* Oceanographic data: mapping of oceanographic data across seascape, incorporating remote sensed measure of production (chl), and local physics (Brian)

*2.* Nearshore Benthic Ecology: *Mechanisms Driving Subtidal and Intertidal Ecosystem Dynamics (Anne Salomon, Sarah Dudas, Margot Hessing-Lewis)*

**Question:** How do attached macrophytes change annually (biomass, structure, physiology), how have the associated species assemblages within subtidal and intertidal kelp forest and eelgrass ecosystems changed through time, what top-down and bottom-up factors drive these changes and how does the flux of material between and across ecosystems structure communities and alter ecosystem function? **Objective**: Monitor attached primary producers, associated invertebrate and fish communities and macrophyte drift. Quantify cross-ecosystem flux of macrophyte biomass to explore habitat connectivity and ecological subsidies in the context of otterized seascapes. Use experimental mesocosms and Hakai’s oceanographic program to assess the effects of varying temperature, salinity, and nutrients on macrophyte growth, survival and reproduction.  
**Rationale:** Changes in macrophyte structure have community-wide repercussions, including alterations to associated food webs and production of material exported to other ecosystems. Our aim is to document these changes, focusing on interannual dynamics, as well as the physical and biological drivers of change. Together with the habitat mapping data, this will be used to analyze the trade-offs in ecosystem function associated with changing seascapes as part of the carbon modeling initiative and the coastwide comparison of otter effects.   
**Links:** This in situ habitat monitoring will compliment the broader habitat mapping. Detailed community-level data from surveys will be extrapolated spatially based on larger-scale habitat maps. This research element will be strongly aligned with the benthic ecology research element in the M2M (Microbes to Macrophytes) Program, as well as the other research elements in this Program. Macrophyte data and drift surveys will compliment wrack subsidy component of 100 Islands Program. Contemporary isotopic data of coastal food webs will be linked with ancient isotopic data of similar species found in middens.  
**Current Personnel:** Katy Hind, Jenn Burt, Kira Krumhansl, Angeleen Olson.

**New Personnel:** Carolyn Prentice (potential seagrass Master’s student), Nicole Knight (potential seagrass Master’s student), Hakai summer dive team (n= 4 divers).

**Datasets generated:**

* Kelp forests: annual subtidal surveys and isotopic analyses of producers and associated communities (Anne, CMEC lab)
* Rocky intertidal communities: seasonal surveys of faunal communities (Patrick, Chris, Martone lab)
* Soft substrate intertidal communities: annual surveys of faunal communities (Sarah, Erin)
* Seagrass: annual subtidal surveys of producers and associated communities (Margot, Mary)
* Invertebrate drift surveys: invertebrate drift via tests, shells, winter vs. summer (Erin)
* Quantification of drift macrophyte production & cross-system subsidy flux (100 Islands Program)

*3*. Otter Coast: *The Spatial-temporal Dynamics of Sea Otter Foraging Ecology and Distribution (Erin, Linda, Jane, Trisalyn)*

**Question:** What are the habitat and foraging niches that sea otters occupy seasonally, and how do these change with increasing occupation times? How does sea otter foraging behavior, along with coastal geomorphology and habitat characteristcs, influence population growth rates, and patterns of range expansion in BC?

**Objective**: Document seasonal and annual sea otter foraging behavior, rates of caloric intake, and activity budgets. Assess fine and broad scale habitat use, and corresponding geomorphic, ecological and behavioral drivers of range expansion.

**Rationale:** The effect of sea otters inrecently re-colonized areas vs. long occupied areas (i.e., well established for decades) is expected to be measurable and different. As sea otters deplete available prey in one area, they’re forced to look elsewhere for food. The connectivity, size, and proximity of new candidate habitats to each other and to areas long occupied by sea otters may influence the timing and scale of emigration, and therefore range expansion. We are collecting sea otter foraging, and distribution data, and combining these datasets to predict range expansion. These data are also paired with benthic ecology data, to understand seasonal and longitudinal differences in the ecological effects of sea otter occupation of different habitats.

**Links:** We will integrate this project with a wide range of existing data sets on habitat characteristics (MODIS data on sea surface temperature and productivity, BC shorezone data), as well as DFO’s multi-decadal time series of sea otter population survey data. As well, this project will benefit and be paired with several developing data sets from the remote sensing research and the subtidal monitoring. Sea otter densities and diets will also be integrated with the 100 Islands project to assess the role of sea otter foraging in producing kelp subsidies and associated changes in terrestrial mammal abundance. Finally, results from this project will be compared to the contemporary and ancient kelp forest food web data to investigate evidence of sea otter presence and use by people in ancient times.  
**Current Personnel:** Erin Rechsteiner/Hakai Sea Otter Team, Linda Nichol, Jane Watson, Trisalyn Nelson, Chris Darimont/100 Islands Researchers.

**New Personnel:** A new PhD student supervised by Trisalyn and Linda to work on modeling of range expansion and carrying capacity. Two undergraduate students from VIU to work with Erin and Jane on sea otter links to intertidal mussels and oyster catchers (volunteers).

**Datasets generated:**

* Sea otter diet and foraging behavior: foraging data from seagrass, kelp, and mixed habitats (Erin/Hakai)
* Kelp drift, sea-to land subsidies, and associated invertebrate and mammal abundance (Chris/100 Islands)
* Large scale sea otter habitat use and distribution: seasonal boat surveys (Linda/DFO, Erin/Hakai)
* Fine scale sea otter foraging locations and habitat-use: seasonal shore-based surveys (Erin/Hakai)

*4.* Historical Change in Nearshore Food Webs*: Reconstruction of Ancient Coastal Kelp Forest and Seagrass Structure (Iain McKechnie, Jane Watson, Erin Rechsteiner, Anne Salomon, Margot Hessing-Lewis)*

**Question:** How has the structure and productivity of nearshore coastal food webs changed through deep time? Is there evidence of sea otter depletion reflected in ancient consumer isotopic signatures, size and relative abundance through time, and indicators of old-growth kelp forests?

**Objective:** Assess the contemporary and prehistoric effects of sea otter depletion and recovery on coastal food web structure and productivity using stable isotopes and midden stratigraphies. Model the trajectory of coastal ecosystem productivity through time using carbon as a common currency.   
**Rationale:** We can use pre-otter extirpation records to understand the future of coastal ecosystems, and their recovery trajectory with otter re-introduction. This will allow us to examine the very long term trends in community shifts associated with otters along this seascape. It will also inform modeling of the future of these seascapes under climate scenarios, and determine the possibility for novel communities given dramatic sea change.

**Links:** This project links closely to the contemporary mechanistic understanding of kelp forest and seagrass ecosystem dynamics described above (where contemporary isotope samples will be taken and analyzed). Possible link to Bodkin, Tinker and Estes’s CAMEO grant and joint fall meeting on Quadra and data sharing. **Current Existing Personnel:** Iain McKechnie, Jane Watson, Erin Rechsteiner, Anne Salomon, Margot Hessing-Lewis

*5. Synthetic Research Element: Northeast Pacific; a Margin of Change (Erin, Margot, Anne, Sarah, Trisalyn)*

**Questions:** How does coastline topography and habitat complexity affect broad-scale otter re-colonization parameters (growth, range expansion, carrying capacity)? How does this in turn feedback to alter nearshore coastal food webs? How synchronous are patterns of nearshore change across latitudes (CA to AK)?

**Objective:** Compare otter re-colonization parameters from populations in CA, BC and AK as a function of coastline spatial predictors (e.g., coastline sinuosity, habitat complexity and geomorphology). Compare variation in kelp forest and eelgrass food webs from Alaska through BC to California.

**Rationale:** Large differences in coastline characteristics exist along the Northweast Pacific, with potential to influence sea otter population parameters (i.e. scaling up from research element 3). We hypothesize that the spatial configuration and make-up of the coastline will be an important determinant in observed differences along this coastline. Furthermore, we predict that the Central Coast’s convoluted coastline leads to context specificity, with differences, but also similarities across the key “otterscapes” of the Northeast Pacific.

**Links**: This research element would collaborate with institutions in CA, AK (USCS, USGS and MarineGEO partnerships). This broad-scale research question is intimately linked to the other spatial/habitat Otter Coast research elements.

**Current Personnel:** collaborative work with Margot, Erin, Tim, Brent, Anne, Linda, Sarah, Trisalyn.

*6. Program Next Steps 2017+*

*Proposed Synthetic Research Element: Central Coast Blue Carbon Macrophyte Trajectory (All).*

**Questions:** What is the contribution of marine macrophytes to carbon capture and storage, how has this changed historically, and how do we anticipate this changing in the future under alternative climate change scenarios? What is the economic and social value of this service and can it be used by coastal communities in the global carbon market (UN’s REDD+ program: Reduce Emissions from Deforestation and Degredation)? How does the role of marine macrophytes to “Blue Carbon” compare to its other functional ecosystem roles?

**Objectives:** Quantify macrophyte contribution to “blue carbon” using a temporal approach including modern and historical otter and climate impacts. Quantify the economic and social value of blue carbon and investigate the feasibility of accessing international blue carbon markets. Analyze trade-offs between carbon storage and other uses of macrophyte communities.

**Rationale:** There is growing awareness that kelp forests and seagrass meadows can account for substantial storage of atmospheric carbon. However, these values have not been quantified spatially in BC, nor have they been considered in concert with the temporal change that is evident in these systems. Our goal is to quantify the carbon storage potential of macrophytes on the Central Coast, determine changes associated with future climate change scenarios, and quantify the magnitude in this change through deep time.We also want to consider the trade-offs in the carbon storage role of macrophytes vis-à-vis their other ecosystem services, including provision of habitat, production of material and cultural values.

**Links:** Determination of carbon flux through the system will be considered in collaboration with other Hakai research including oceanography, 100 Islands, M2M and Kwakshua Watershed.

**Current Personnel:** All research leads and some researchers **New Personnel:** 2 post docs to work on blue carbon idea with Trisalyn (spatial-temporal model) and Chris/Anne/Margot (quantifying carbon storage and ecosystem services, drivers of change)

**Research Communications and Collaborations**

1. Hakai technicians Matthew Morgan Henderson and Zach Monteith will be responsible for oversight of shared data and website updates
2. Annual All-Hands overlapping field research time (July) in addition to other field work at Hakai
3. Annual All-Hands Fall Retreat at Hakai Institute South (Quadra Base – October)
   * Student Presentations
   * PI debriefing and future planning
   * Cross-border collaborations

**Links to other Hakai Research Programs**

* Microbes-to-Macrophytes through common program goals and research element overlap
* Oceanography through physical and biological characterization of the study area and study sites
* Changing Landscapes (Duncan McClaren) via historic food web project
* 100 Islands via habitat mapping, stable isotope and macrophyte surveys/cross-system flux
* Sand Ecosystems through soft sediment biodiversity research

**Personnel Summary**

*Research Element Leads:*

Habitat mapping: Luba Reschitnyk (Hakai)

Nearshore benthic ecology: Anne Salomon (SFU), Sarah Dudas (VIU), Margot Hessing-Lewis (Hakai)

Otter Coast: Erin Rechsteiner (Hakai), Jane Watson (VIU), Trisalyn Nelson (UVic), Linda Nichol (DFO)

Historical Food Webs: Iain McKechnie (SFU)

*Researchers and Program Affiliates*

Laura Wegener Parfrey (UBC), Rhea Smith (Hakai), Brian Hunt (UBC)

Patrick Martone (UBC), Chris Harley (UBC), Mary O’Connor (UBC),

Francis Juanes (UVic), Wayne Jacob (Hakai), Keith Holmes (Hakai)

*Current Hakai Scholars:*

Kira Krumhansl (SFU post doc), Jenn Burt (SFU PhD student),

Angeleen Olson (UVic, Masters student)

*Finishing Hakai Scholars:*

Kyle Demes (SFU post doc, Current completion: April 31st 2015, extension requested),

Josh Silberg (SFU Masters Student, Completion: March 31st 2015)