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Living Lab Program for Climate Change and Conservation - Final Report

Project title:

Supporting park management under climate change: using an ecosystem model to identify vulnerability, resilience and management options in parks with a marine component

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Research findings

Qualitative discussions with BC Parks staff highlighted that impacts of climate change on seagrass are of particular interest. Within the multi-faceted impacts of climate change, understanding the impacts of ocean warming and marine heatwaves are of greatest concern at the present time. Additionally, managers were interested to focus on impacts over the near term (within ten years), rather than impacts several decades into the future, reflecting timescales over which planning and management decisions are realized. As such, findings are focused on these issues and time horizons. Key findings are as follows:

Impacts of ocean warming

Quantitative modelling approaches revealed the following impacts of ocean warming on the BC Parks network:

- **Ocean warming contributes to seagrass loss** – Within 10 years of increased seawater temperatures (2 °C, 2023) due to climate change, a 5% loss of seagrass in seagrass was observed, on average, 5 locations: Cape Lazo, Hornby & Denman Island, the Sunshine Coast, Saanich Inlet, and Trincomali Channel (Fig. 1). Average seagrass biomass decreased over time, to 15% loss by 2043, and 28.8% loss by 2053, relative to a control simulation representing present day conditions.
- **Ocean warming contributes to the loss of macroalgae** – The negative impact of warming on kelp and other macroalgae was less than that observed for seagrass. There was an average 3% loss across Cape Lazo and Hornby and Denman Islands, but an average 2% gain in biomass across Trincomali Channel, Saanich Inlet and the Sunshine coast after 10 years of warming. However, similar to seagrass, macroalgae biomass decreased with time, with losses across all sites that averaged to a 10% relative decrease by 2043, relative to a control simulation representing present day conditions.
- **The most vulnerable areas (those experiencing the greatest effects from warming) were Saanich Inlet and the Sunshine Coast**, which showed the highest percentage loss of seagrass over time (from 7% loss after 10 years to 40-50% loss over 30 years of warming).

- **Possible refugia within the region (areas experiencing the least impacts from warming) appear to be within the Trincomali Channel**. Here, the response to warming was variable, with initial relative increases in macroalgae and bivalves, and the lowest overall decrease in seagrass (< 10% loss, even after 30 years).
- **Seagrass is the most vulnerable** of the benthic species studied, as described above.
- **Bivalves are the most resilient group** of the benthic organisms studied, with mixed responses in different locations. In Saanich Inlet, bivalves decreased by approximately 30% relative to the control after 10-20 years of warming, but fluctuated and recovered by 2053, indicating some resilience over the longer term. For all other locations, there were either no changes in relative biomass, or increased percent biomass, possibly due to other, connected effects in the ecosystem.

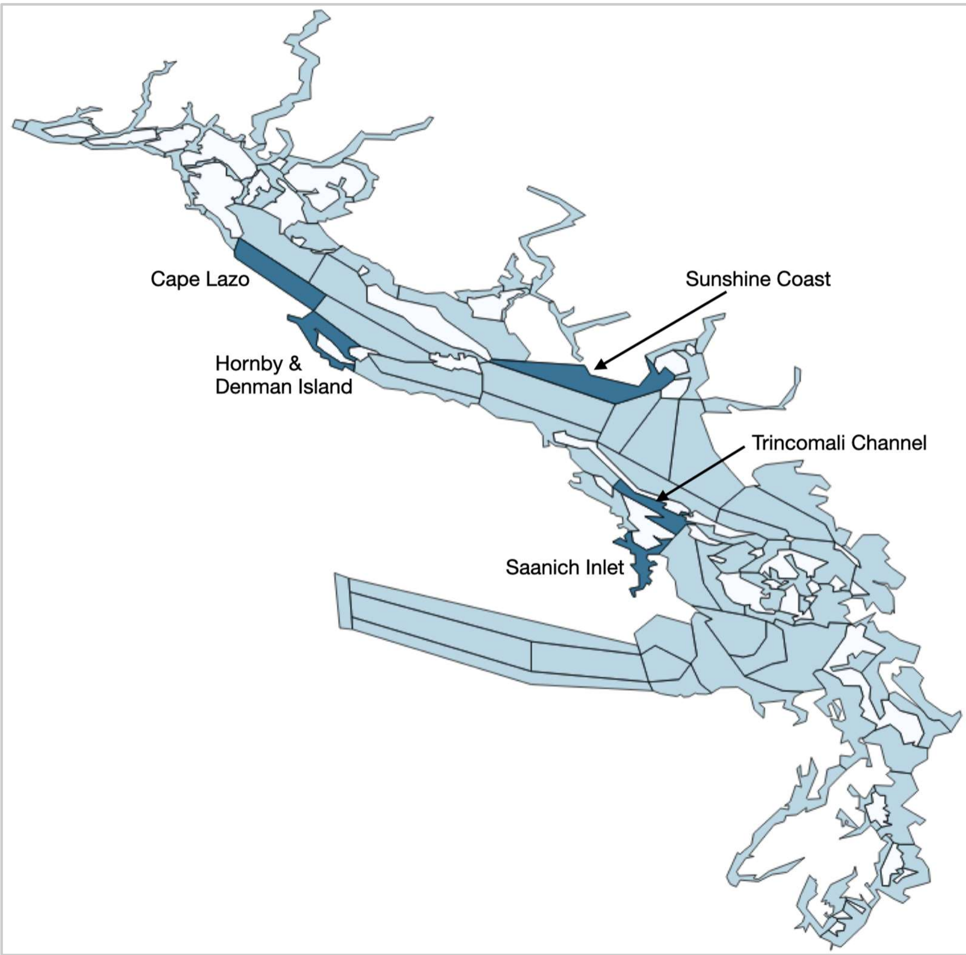

Fig. 1: Map of the Salish Sea Atlantis Model polygons. Dark blue indicated polygons that overlap BC Parks with a marine component. Names displayed correspond to those used in the text.

Impacts of marine heatwaves

The impacts of marine heatwaves in the BC Parks network are variable, with some species and regions being more strongly affected by these extreme events than others. Quantitative modelling approaches revealed the following impacts within 1-10 years of a summer marine heatwave of 10 days duration on the BC Parks network:

- **Declines in seagrass biomass** – There were overall declines in seagrass biomass relative to a control simulation with no heatwave. Seagrass declined by a maximum of 8% up to 10 years after the heatwave, with the largest decline in the Sunshine Coast.
- **Variable impacts on macroalgae** – The impact of heatwaves on macroalgae was variable, with different impacts seen across the Salish Sea region. The following impacts were seen in the modelled results: initial declines in biomass followed by recovery at Trincomali Channel and Saanich Inlet; increased relative biomass by 5% in the Sunshine Coast with no declines, and declines of 2-4% at Hornby & Denman Islands and Cape Lazo.
- **Trincomali Channel is relatively resilient to marine heatwaves** – The maximum declines in seagrass and some benthic grazers in this region were less than 2%. In addition, macroalgae, bivalves, and other benthic species were seen to increase in biomass.
- **Saanich Inlet is vulnerable to marine heatwaves** – This inlet appears to be the most vulnerable region within the Salish Sea, with the largest declines in relative biomass of other benthic species, such as bivalves (-18%), as well as -7% change in seagrass following a simulated heatwave event. Though the Sunshine Coast showed the largest decrease in seagrass, other species were not as negatively impacted in this region.
- **Seagrass was among the most vulnerable groups**, along with benthic grazers.
- **There is limited evidence for resilience to marine heatwaves** among the groups studied. No groups consistently showed resilience across all locations.

The project will continue beyond 22 March in order to further distill the impacts on the BC Parks network, and to provide final outputs for park management. Outputs for park management will be produced with direct input from managers to ensure their utility.

Methods summary

Both qualitative and quantitative approaches were used in this project: (1) semi-structured and open discussion with BC Parks staff to determine climate change priorities and concerns and (2) ecosystem modelling to identify the impacts of climate change on parks with a marine component. The modelling methodology is outlined, in brief, below:

1. Specific climate stressors and scenarios of interest were identified through collaborative discussion with staff involved in the management of BC's provincial parks.
2. Climate scenarios (including marine heatwaves) were then tested in a whole-of-system model called Atlantis. Atlantis is a model that incorporates all features of the marine and coastal environment, including physical conditions, the animals and plants in the system, the food web and habitats, as well as the people and activities that interact with these natural features.
3. Model output was cross-referenced against the map of BC Parks to determine impacts on clusters of connected parks with a marine component.
4. Model output was interrogated to determine the short- and long-term impacts on habitat-forming groups of interest (seagrass and macroalgae).
5. Model output was also interrogated to identify whether there were hotspots of impacts from warming (vulnerable regions), and areas where the impacts from warming remained relatively stable (resilient regions/refugia).

Key outcomes for BC Parks

The results of this project have the following outcomes for BC Parks:

- Seagrass were identified as the most vulnerable benthic species to ocean warming and marine heatwaves, and are therefore a good target for conservation and protection efforts to ensure they have the best chance of survival and recovery from climate change induced impacts.
- Modelling results indicate that benthic species within Saanich Inlet and, to some extent, the Sunshine Coast are the most susceptible to impacts of climate change (ocean warming and marine heatwaves in particular). Managers can expect the flora and fauna within these environments to change as the ocean continues to warm and as the region experiences heatwaves.
- There are some areas within the Salish Sea that are relatively resilient to the impacts of climate change (Tricomali Channel in particular). These areas could be candidates for future protection.

The additional outcomes, listed below, will also be realized following testing of further scenarios of interest to BC Parks:

- A deeper understanding of how the marine component of the BC Park network is impacted by marine heatwaves over the short and long term (i.e., immediately following an extreme weather event and in the period thereafter).
- In addition to the broad regions identified as being vulnerable/resilient, the results will be explored in greater depth to identify parks within the BC Parks network that are particularly vulnerable or resilient to the climate stressors tested in this project. This information will prove useful in making strategic decisions within and beyond park boundaries.

These scenarios, and the outcomes relating to them, represent an extension to this work to ensure the results of this project are fully usable and, where appropriate, actionable by BC Parks.

Relevance to BC Parks management

By mapping areas that are particularly climate-sensitive, this project is helping managers to precisely target their management action towards those areas that are at greatest risk from climate change and other stressors. By understanding vulnerabilities in the park system, it is possible to identify areas that would benefit most from management intervention, as well as those that are comparatively resilient.

The following recommendations emerged from the results of model simulations:

- Management action appears most needed for parks located within or near Saanich Inlet and along the Sunshine Coast, which are particularly vulnerable to climate change.
- Opportunities for climate resilience/refugia exist for BC Parks along and within the Trincomali Channel network.
- Seagrass habitats that are most at risk from ocean warming and marine heatwaves include all areas highlighted within this study, especially when considering the medium-term impacts of these events (5-10 years after).
- While none of the simulations our study indicated that seagrass had resilience to extreme warming events (marine heatwaves), kelp and macroalgae in the Trincomali Channel, Saanich Inlet, and the Sunshine coast showed some resilience to extreme warming events.

The recommendations on the above areas may be refined in-line with additional model runs, if requested, though these simulations extend beyond the scope of this funding, to ensure even more detailed and reliable recommendations for BC Parks.

Upon extended synthesis of results, further recommendations may be identified. We anticipate that all recommendations will enable a regional approach that can be applied by park managers.

Project's challenges/opportunities

Throughout its duration, the project experienced a critical, unanticipated challenge that delayed the onset of the work. This pertained to the time required to calibrate and ensure the smooth-running of ecosystem features within a complex end-to-end model. It took significantly longer to refine the model, fine-tune parameter files and incorporate appropriate data into the Atlantis model than anticipated – all of which are precursors to testing a climate scenario in a model in order to determine the impact on a particular region, habitat or species. As such, the results presented in this report provide a broad overview of the impacts of climate change on the BC Park network. We intend to go beyond the work presented here to provide further, more detailed outcomes on closely connected parks and the ecosystems they protect (see next steps).

Key opportunities relating to this project are as follows:

- **To support the work of BC Parks within park boundaries** – in particular, through management action that could help vulnerable habitats to be more resilient (e.g. for seagrass beds that are climate-stressed, reducing anchorage to reduce the cumulative effect of human impacts on the environment).
- **To provide reference material that informs management beyond park boundaries** – for example, through highlighting areas that are particularly vulnerable and may need additional protection, or highlighting areas that are particularly resilient that could serve useful sites for monitoring the impact of other, non-climate stressors.
- To support park visitor and public understanding through visual interpretation of the project results, highlighting the impact of climate change on the park network.

Conclusions/next steps

A brief synthesis of key findings and next steps is provided below:

- This project revealed areas of vulnerability and, where applicable, resilience to ocean warming and extreme weather events (marine heatwaves). *See key findings for detail*.
- This project also highlighted marine species and groups that are particularly vulnerable within the BC Park network. *See key findings for detail*.
- Recommendations to BC Parks Managers center around highlighting areas of potential management action within the BC Parks network, and areas of potential refuge from warming impacts.
- The next steps in this project include communication of fully analyzed results to BC Parks staff and determination if additional simulations are needed based on feedback received.
- Finally, the outcomes presented in this report will be tailored to park managers in concise digests that can be used to support management action.

We aim to present the outcomes of this project to BC Parks staff within the next month and use this time to provide an opportunity for staff to have their questions answered. This meeting will also provide valuable guidance regarding how managers would like to receive outcomes of this project (whether as short briefings, a detailed report or as visual summaries). These additional materials will follow the production of this formal report.

References and links

[Optional - Provide any other links or information related to the project, including existing blogs, related publications, or other media]

- BC Protected Areas Research Forum presentation (link to slides presented in December 2022).
- Overview of the model used to assess the impacts of climate change on parks with a marine component (link to the Salish Sea Atlantis Model website).