GEOG 3991
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Assignment 2
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10 April 2019

Section A: Critical Reflections

Topic 1: Vulnerability and SIDS

It is vital to discuss the impacts of climate change on Small Island Developing States: "Failing to address concerns wider than climate change, and instead emphasising hazards over vulnerabilities, means that decisions often fail to account for past literature and experience, while not fully addressing root causes of the vulnerabilities to the hazards"(Kelman 2014). We know they are vulnerable, so the focus needs to be on mitigation and adaptation to a changing climate. I appreciate the urgency to implement plans of action in SIDS and understand the devastation that would result from sea level rise and ocean acidification. I connected with the concept of external and internal factors for vulnerability to climate-related disasters: Recreational development projects like golf courses or hotels could result in resource exploitation, much like offshore oil drilling in the Arctic regions. These development plans may exacerbate internal tensions between local populations, such as financial mismanagement of environmental sustainability projects, or concerns for ethnic preservation of specific areas. The focus may be misdirected to the generalities of climate change when it needs to consider the impacts of climate change on residents of these smaller islands. I find it essential to discuss the political debate of developing an area for tourism while thinking about what that tourism would do to the local traditions and cultures of the island natives. For example, if a project causes damage to coral reefs, it will affect the food source and livelihood for residents. Preserving the Earth for future generations is more valuable than the political debate of recreational and tourism development.

Reference:

Kelman, Ilan. (2014, June). "No change from climate change: vulnerability and small island developing states." *The Geographic Journal* 180 (2) Pages 120-129.

<u>Topic 2: Arctic Climate Impact Assessment (in relation to Indigenous communities' cultural and economic impacts)</u>

My Historical Geology course provided valuable connections to Environmental studies. The Arctic Climate Impact Assessment report gives useful insight into this delicate ecosystem. I value how it connects climate change to the Arctic Indigenous lifestyle, adding another dimension of urgency for slowing anthropogenic global warming. It also makes me realize that oil and gas exploration in this area should be restricted: it could potentially destroy an Inuit culture. The Inuit access to the ringed seal is crucial to their survival: "No other species is present on the land or in the waters of Nunavut in the quantities needed to sustain the dietary requirements of the Inuit" (ACIA 2004). According to the ACIA report, Inuit hunters are noticing changes such as thinning sea ice and reduced ring seal numbers. I think it is important to note the Inuit perspective on climate change in the Arctic because they depend on "living resources from land and sea" (ACIA 2004), thus adding a socio-economic dimension. The Inuit depend on the Arctic resources for nutritional, economic, spiritual, and cultural survival. Since the Arctic is warming at a more rapid rate than other global areas, the information presented in this article is a reminder that climate change affects more than land and sea, it affects human culture as well.

Reference:

Hassol, S. J. (2004). Impacts of a warming Arctic: Arctic climate impact assessment, "Arctic Climate Impact Assessment." Retrieved from http://www.amap.no/documents/doc/impacts-of-a-warming-arctic-2004/786

Topic 3: Flora and Fauna: Biodiversity and Protected Areas in Canada

The Government of Canada report on Sector Perspectives of Impacts and Adaptation gives insight into the effects of climate change on the biodiversity of Canadian ecosystems. I feel this is an essential view on how Canada's ecosystems weave together to reveal social, economic, and recreational aspects. If global warming alters a region's growing season, for example, income from agriculture may no longer be possible. I agree with the presented concepts of conservation and sustainability such as "forestry, agriculture, and fisheries" (Pellatt et al. 2014). I can apply this to my town of 100 Mile House, where forestry is the leading economy, followed by agriculture. There is currently an energy plant in Williams Lake BC that uses biomass fuel from the local lumber mill. With a warming climate in the Cariboo region, it may be possible to switch from cattle farming to grains, for example, reducing methane emissions from the copious cattle herds and provide a more sustainable plant-based diet for the local population. The article presents ideas to implement ecological restoration and adaptation, which I think is a priority for a changing climate. I feel that mitigation and adaptation should be the focus rather than plans to extract any more fossil fuels from the Earth's resources.

Reference:

Nantel, P., Pellatt, M. G., Keenleyside, K., Gray, P. A. (2014). Chapter 6: Biodiversity and protected areas. In F. J. Warren & D. S. Lemmen (Eds.), "Canada in a changing climate: Sector perspectives on impacts and adaptation," pages 161-182. Retrieved from the Government of Canada website: http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2014/pdf/Full-Report_Eng.pdf

Section B: Essay

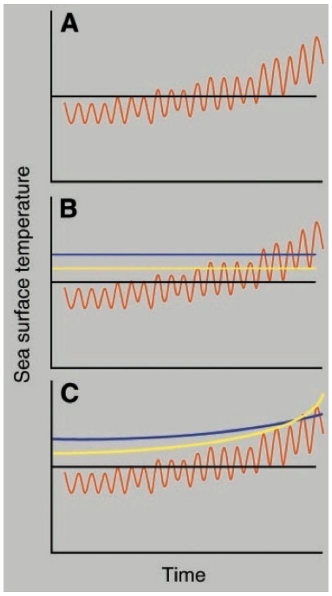
Topic: Ocean Acidification and the potential impacts on shell-forming organisms, specifically, Staghorn corals

Ocean Acidification is another repercussion of excess carbon dioxide: "Since the beginning of the industrial era, the ocean has absorbed some 525 billion tons of CO2 from the atmosphere, presently around 22 million tons per day" (OPT 2018). According to a report by the Ocean Portal Team, ocean water has become 30% more acidic in the past 200 years. This process decreases the number of available carbonate ions that shelled organisms require to build shells and skeletons (OPT 2018). With the increasing rate of climate change, marine ecosystems do not have sufficient time to adapt to a changing pH in the ocean. This paper will focus on the potential impacts of ocean acidification on Staghorn coral, which "play crucial roles in reef-building, and in providing food, shelter and other services to the remarkable array of associated species, a number of which are important to humans" (Turak 2009).

There are approximately 160 species of Staghorn coral, thought to have evolved in the late Paleocene area 55-65 million years ago. "They have dominated reefs for the past 500,000 years" (Turak 2009). However, they are in danger if the ocean remains a dumping ground for atmospheric carbon dioxide. According to the IUCN report, there are three ways in which ocean acidification affects Staghorn coral: "bleaching, acid erosion, and increased disease susceptibility" (Turak 2009). The reason an increase in ocean temperature will cause such a devastating effect is that Staghorn coral and their symbiotic algae, zooxanthellae, live in waters that are within one to two degrees of their warmth tolerance. The algae photosynthesize quickly in a warmer ocean and create toxic oxygen levels within the coral. The coral releases the algae to give it a bleached appearance. Without the algae for an energy source the coral dies. The IUCN reports that if the water returns to an acceptable temperature, the coral will regain their zooxanthellae algae and possibly recover, but: "these colonies still suffer from increased disease susceptibility, reduced growth rates, and reproductive capability" (Turak 2009). Since Staghorn coral is so dominant in reefs when they die, the entire reef can collapse which will affect other organisms that grow in and feed off the reefs: "Globally, 20 percent of coral reefs are already damaged beyond recovery" (Turak 2009). Ocean acidification disturbs the calcification process for Staghorn corals as well. Entire reefs will erode if ocean temperatures continue to rise. The warmer water also breeds disease: "The rapid, large-scale devastating loss of staghorn corals in the Caribbean is due to an unprecedented rise in coral diseases, and this climate change related effect poses a genuine threat to coral biodiversity" (Turak 2009).

The sources of ocean acidification are predominately anthropogenic. Activities such as pollution from agriculture, overfishing, and land development have "been the major drivers of massive and accelerating decreases in abundance of coral reef species, causing widespread changes in reef ecosystems over the past two centuries" (Hughes 2003). For example, a growing world population increases demand in the fish market but depletes the reefs of fish. This depletion, along with increased waste from factories and production alter the equilibrium of the reef ecosystem. Increased ocean temperatures from global warming will exacerbate this imbalance.

Can Staghorn and other corals adapt to ocean acidification? Hughes predicts that there is a coral "bleaching threshold" at an approximate 1°C increase of mean summer maximum temperatures which will "will be chronically exceeded as temperatures rise over the next 50 years, leading to predictions of massive losses of all corals" (Hughes 2003).



"(A) A model is showing a constant coral bleaching threshold, which is likely to be chronically exceeded in the future as oceanic temperatures increase. (**B**) An alternative model that incorporates differences in bleaching thresholds (e.g., among species, depth, and locations), indicated by parallel lines. (**C**) A more realistic scenario where changes in thresholds also occur over time, attributable to acclimation and evolution" (Hughes 2003).

The report also indicates that bleaching is a stress response and may not be adaptive. The ocean warming and acidification rate may be faster than the speed at which Staghorn and other corals can evolve and adapt. Anthropogenic mitigation is required to preserve the Staghorn coral. Marine protected areas are already in place, but models must be put in place to: "reduce pollution, protect food webs, and manage key functional groups (such as reef constructors, herbivores, and bioeroders) as insurance for sustainability" (MacLanahan et al. 2002).

One project that began in 2018 is a Coral Nursery in Sabah Al-Ahmad Sea City, Kuwait, in the Arabian Gulf: "The nursery served as an artificial reef ecosystem" (Nithyanandan 2018). Beginning in 2009, "A mid-water suspended coral PVC nursery was installed at 3.5 m depth for rearing staghorn coral, *Acropora downingi* for transplantation into artificial lagoons in Sabah Al-Ahmad Sea City" (Nithyanandan 2018). The report describes the collecting and gluing of Staghorn coral fragments and nubbins:

"Nubbins showed up to 56% survival and a mean skeletal extension of 10.6–13.4 mm (SD ± 0.8) in 10 months. Transplantation of 116 Acropora downingi colonies was carried out (in June 2014 and June 2015) and monitored colonies (n = 6) attained an average geometric mean diameter (GMD) of 73.6 mm (SD ± 2.91) in one year. The first batch of *A. downingi* transplants (June 2014) showed a survival rate of 43% but the second batch (June 2015) showed 89.5% survival" (Nithyanandan 2018).

The report also acknowledges that the coral farm attracted various species of fish seeking food and shelter, thus indicating success in modelling an artificial reef and enhancing biodiversity (Nithyanandan 2018).

Projects such as the one in the Arabian Gulf are an excellent example of replenishing Staghorn coral colonies and sustain a delicate marine ecosystem. It illuminates the fact that the effects of greenhouse gas emissions can potentially be slowed or repaired, magnifying the urgency with which we need to make a global effort to reduce carbon emissions and slow the effects of climate change.

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