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Errors and omissions:

Later references:

There is an update (2010) of the Greenhouse Gas emissions from Gabriola at:

http://www.nickdoe.ca/pdfs/Webp638.pdf

An update of the whole issue of climate change and its effect on groundwater on Gabriola is due for publication in *SHALE* 23.

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Gabriola warming—a changing climate?

by Justine Pearson

Introduction

At times, the controversy about global warming, with its worldwide scope and centuries-long time-scales, seems remote and all too easy to ignore. However, if only out of self-interest, we might be wise to refocus our perspective and take a moment to consider the potential *local* implications of global warming. What sort of impacts are we likely to see here on the Gulf Islands? Which of the predicted impacts of global warming is most likely to affect our island lifestyle? Are we more vulnerable to some effects than others, and if so, are we prepared for the consequences?

Although we are as likely as anyone in the world to notice changes in our environment due to the predicted global warming, some of these effects will be of less consequence to us than they will be to others—people don't die in the Gulf Islands of heat exhaustion during heat waves for example, nor are they likely to in the future. Sea-level rise may be of concern to some coastal areas, but widespread inundation of large tracts of Gabriola by the sea is not going to happen anytime soon. Although some aspects of climate change are going to cause us grief, anything that brings us more sunny days in summer can't be all bad.

GW—the scientific basis

During the last century, the earth's atmosphere warmed by about 1ºC, with much of the warming occurring since the 1980s. Most scientists believe that this warming was caused primarily by carbon dioxide (CO_2), methane, and other greenhouse gases that were exhausted into the air by human activities.

By far the most authoritative and comprehensive source of information on the global warming phenomenon is the Intergovernmental Panel on Climate Change (IPCC). The IPCC was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. The IPCC has three major working groups:

- Working Group I assesses the scientific basis of global warming—is the climate changing? If so, what is the cause and how will climate change in the future?
- Working Group II assesses the environmental and socio-economic impacts of predicted climate change
- Working Group III formulates possible strategies for responding to climate change.

Working Group I has issued three reports so far. The first in 1990, the second in 1995, and the most recent in 2001. Contributors to the working group's findings include 122 lead authors, 515 contributing authors, and 420 draft-report reviewers. Several hundred more experts and scientists from all over the world participated in the final-report review stage. The working group's conclusions are based on those of several hundred peer-reviewed, published technical papers.

The conclusions of the 2001 report, can be summarized as follows:

- an increasing body of observations indicates that the world is getting warmer and that other changes in the climate are also taking place

- new and stronger evidence indicates that most of the warming observed over the last fifty years is attributable to human activities
- confidence in the ability of models to both explain past climate, and to predict future climate, has increased significantly over the past ten years
- emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate
- global average temperature and sea level are projected to rise under all six IPCC-conceived political and socio-economic scenarios
- human influences will continue to change atmospheric composition throughout the 21st century and climate change will persist for many centuries.

The IPCC presents only broad, large-scale predictions for the effects of global warming, but there are many local studies engaged in generating more specific scenarios for Canada, British Columbia, and even particular biogeographical regions within our province. The models indicate:

- a sea-level rise in the 200–600 mm range (8–24 inches) for coastal British Columbia over the next century. To uncertainties in the climate predictions has to be added local uncertainties resulting from the complex geological processes at work along the coast
- a temperature increase for western North America in the 3–6°C range. This prediction includes an allowance for the cooling effect of projected large increases in sulphate aerosols
- a longer frost-free season
- an increase in frequency and intensity of winter storms
- an indeterminate change in net annual precipitation, but great likelihood that winter precipitation will increase and summer precipitation will decrease
- an intensified hydrologic cycle—more frequent intense precipitation in winter, increased peak stream flows in winter, and increased water usage by plants (evapotranspiration) in summer.

What is particularly unsettling to some is that current climate models are unable to assess the likelihood of a very large, rapid change in climate due to an alteration in the pattern of ocean currents in the Pacific Ocean. Drastic changes in world climate over very short periods of time have been known to occur in the past.

Despite the ample evidence that human activity is causing global warming, some still think that some other agency is responsible for the changes in climate over the last few decades. Though agreement on this may be a logical prerequisite for justifying enforced changes in our fossil-fuel consumption, and supporting implementation of the Kyoto Protocol for example, it is not so for planning for the *consequences* of global warming. So, whether or not you agree that humans are responsible for the change, without any doubt, our climate *is* changing and it is therefore prudent to begin thinking about what it is going to mean to us. The IPCC notes that coastal areas are particularly at risk. Some of the more significant changes and potential consequences for our part of the world are as follows.

Natural resources

Salmon

Temperature has a strong impact on physiology and behaviour of fish, and research has associated warmer years with

reduced spawning success and higher juvenile mortality. Increased surface ocean temperature is very likely to greatly restrict the extent of suitable habitat and displace fish communities further north, and may create difficulties for fish in migrating back to their home rivers. Fraser River sockeye salmon, for example, are particularly sensitive to warming waters because they are at the southern end of their species range. David Welch, Program Head for High Seas Salmon Research at the Pacific Biological Station, Nanaimo, points out that the best of the global climate models indicates that "some species of Pacific salmon might be eliminated from the Pacific Ocean within about forty years". There may be little or nothing that we can do to prevent this from happening.

Shellfish

Raising the temperature of the oceans creates an environment more favourable to plant reproduction and growth. A likely consequence will be the occurrence of toxic algal blooms (red tide) all year round.

Forests

Warmer temperatures and a longer growing season could increase timber supply if forests are well managed. Changes in species distribution are however likely to occur. Generally, existing species will be displaced further north and to higher altitudes, and more exotic species may begin to occupy the niches left as a result. It may be possible and necessary to plant new species or varieties that can tolerate changing conditions.

Reforestation failures are more likely under warmer, drier conditions, as are increased losses to disease, insects, and fire. Forest fires will probably become more frequent and severe, and limited water supply could make them more difficult to control. The threat to life and property from forest fires is perhaps more severe for those living on the Gulf Islands where many homes are surrounded by forest.

Freshwater

Gabriola has a limited freshwater supply that is already sensitive to fluctuating seasonal volume and demand. Sea-level rise will further threaten the quality of well water on Gabriola because many tens of metres below ground, the island's freshwater "floats" on top of the denser saltwater below it, and the interface between the two will rise with sea level. The existing problem of saltwater intrusion will be exacerbated, rendering many wells, especially those at lower elevations and closer to shore, unusable for most purposes. Additionally, the predicted decreased summer precipitation and increased evapotranspiration may lower the water table at a time when seasonal population increase puts the greatest demand on the water-supply system. Summer shortages are very likely to become more sustained and severe.

Sea- and shore-bird populations

Changes in number and variety of birds are almost certain to result from global warming and the changes in attendant parameters such as sea level, water temperature, storm activity, wind patterns, and food sources. For example:

- sandpiper reproductive capacity is predicted to decrease because global-warming-induced changes in direction and strength of upper atmosphere winds along the west coast will make migration more energy consuming for them. This phenomenon may affect many other migratory bird species

- the expansion of eelgrass, an introduced and now important food source for many waterfowl, will be good for some birds—brant geese and great blue herons, for example—but bad for those that forage in muddy and sandy habitats likely to be invaded by the eelgrass
- the foodchain, which goes from phytoplankton (plant plankton) to zooplankton (small shrimplike animals) to small fish, is likely to change with uncertain impacts. For example, the population of Cassin's auklets around Vancouver Island has decreased with higher sea surface temperatures as zooplankton on which their young feed has declined. However, more storms will be beneficial. Mixing the water discourages the growth of smaller phytoplankton (flagellates), which are too small for zooplankton to eat
- terns, mergansers, and cormorants are likely to suffer if fish stocks are reduced by increased water turbidity.

In summary, it is unclear whether there will be an overall increase or decrease in the numbers of sea- and shore-birds around. What is clear is that we will notice a change in the composition of their populations.

Farms and gardens

Warmer nights and a longer growing season may sound like a benefit for farmers and gardeners, and indeed agricultural and horticultural productivity *can* increase dramatically under these conditions. Additionally, CO_2 is often a limiting factor in plant growth, so increasing atmospheric CO_2 levels could also stimulate crop growth and yield. However, the IPCC states that, overall, positive crop responses are expected for temperature increases of a few degrees, but that the response will change beyond that point and become distinctly negative with long-term greater temperature increases.

Even if we were to think only of the short-term benefits, the problem, still, is that these benefits might be mitigated by excessive heat and limited water supply. Farmers and home gardeners will need to continue water conservation practices and to experiment with drought-resistant and warmer-temperature adapted varieties of plants.

Pests and diseases may become more of a problem as milder winters allow more of them to survive, but we may equally likely get a corresponding increase in new and *beneficial* predatory and parasitic insects that help curb the pests. We will probably need to learn to recognize the changes in the ecology of our gardens and learn also not to respond to every new, unfamiliar insect with fear and suspicion.

Health impacts

The impact on human health is likely to be both positive and negative, and it is easy to exaggerate the extent of the likely changes. People currently living to the south of us do not have demonstrably poorer health than we do. Although pessimistic observers have noted that higher CO_2 levels will encourage the growth of ragweed and other "weedy" plants with a subsequent increase in the incidence of allergies, a warmer climate may also encourage people to spend more time on healthy outdoor activities. Potentially more serious for the Gulf Islands with their large deer populations, is the likely spread of Lyme disease. It has made an appearance on Gabriola this year for the first time ever.

Flooding and storms

Inundation of Gulf Island margins as sea level rises is likely to be of some concern in locations of low relief and shallow gradient.

Outlying low-profile islets, such as Snake Island, may eventually be submerged, but on Gabriola there are few areas that are vulnerable other than perhaps the neck of land at Twin Beaches. Generally, of more concern than any modest average increase in sea level, is the frequency of high tides combined with environmental conditions that raise them even higher. These conditions include low atmospheric pressure, which can cause sea-level rises of 300mm (a foot) or more, and wind-driven waves. Storm surges due to a combination of effects are likely to occur more often. The concern over sea level becomes greater over longer time spans than a century. Sea-level rise is likely to persist for many centuries and will eventually be measured in metres rather than millimetres.

There will probably be an increase in tree blow-down in winter and power supply failures may become more frequent.

The El Niño phenomenon has shown a trend of increased frequency, persistence, and intensity for the last hundred years, but climate models do not agree on whether this will continue, or even whether it is associated with global warming.

Final notes

Clearly, global warming is going to have some effect on our Gulf Island environment. It would be interesting to evaluate how the CO_2 production of Gulf Islanders' lifestyles compares to that of other British Columbians and Canadians. For example, how efficient are the ferries we depend on? Do we use more or less fuel per capita than people living on the mainland? Is car, boat, or worse yet, SUV usage higher than average? We westcoasters tend to think of ourselves as an environmentally-friendly lot, but if we are anything like the rest of Canada, then our fossil-fuel consumption and CO_2 production rates are among the highest in the world and certainly something we need to think about. ◊

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Gabriola's greenhouse gases—*by Nick Doe P.Eng.*

So-called "greenhouse" gases (GHGs) receive a lot of attention these days, it being suspected that humans are generating too much of them. The gases—carbon dioxide, methane, and others—are good at trapping heat (low-frequency infrared radiation) that would otherwise be sent out into space. The result?—a warmer atmosphere and a changing climate.

Although some greenhouse gases are better than carbon dioxide (CO_2) at trapping heat, they are present in the atmosphere in only relatively low concentrations. The major player (other than water vapour) is without doubt, CO_2. Carbon dioxide is of course a natural product. It's a by-product of animal metabolism—we exhale it—and all plants absorb CO_2 to make the stuff they are made of. The "problem-carbon" is not "biological" carbon—this recycles with every new generation of plants—but carbon that's being extracted from below the earth's surface. Oil, coal, and natural gas (methane)—so-called fossil fuels—when burnt, all put carbon (as CO_2) into the air that hasn't been there for tens, even hundreds of millions of years. What's Gabriola's contribution to this excess carbon?—here are some statistics.

Let's start with our garbage. Based on RDN figures, we discard about 1500 tonnes of it annually. As landfill, this generates the GHG equivalent of 560 tonnes of carbon in the form of methane, a more potent greenhouse gas than CO_2. [66 kg of CH_4/tonne of garbage]

How about the ferry to Nanaimo? It makes about 5740 round-trips a year, consuming in the process just over one million litres of diesel fuel. That amounts to another 760 tonnes of carbon in the air each year. [0.73 kg of C/litre]

There's electricity of course. Most people can relate to the power used by a 100-watt light bulb. According to BC Hydro's figures, the equivalent of 42 000 such bulbs are burning on Gabriola all the time. [36.4 GWh per year, about 47.1 kWh/day per home] Using BC Hydro's current province-wide generator-mix, supplying this power to Gabriola releases about 1450 tonnes of carbon into the air each year. [40 t/GWh] This figure is relatively modest because most of BC's power is generated with dams, not by burning fossil fuels.

Now comes the biggy. According to ICBC, there are some 3000 registered cars and trucks on Gabriola (0.85 per capita). Let's say on average, each is driven the BC average of 17 500 kilometres per year. Assuming an average fuel consumption of 10 litres per 100 km (8.5 litres for cars, 11.5 litres for trucks), then vehicle users on Gabriola are generating about 3350 tonnes of carbon each year, not including any allowance for boats. [0.67 kg of C/litre]

So, in order of contribution to greenhouse-gas emissions; first, comes our vehicles (3350 tonnes); second, our electrical supply (1450 tonnes); third, the ferry (760 tonnes); and fourth, our garbage (560 tonnes)—all told about 6100 tonnes of carbon. With few air conditioners and mild winters, we inevitably emit less carbon than most other Canadians, but not much less. Based on per-capita averages for CO_2/CH_4 for non-industrial/non-commercial usage, Gabriola's share is 5600 tonnes of carbon (BC average), and 6700 tonnes (Canadian average). And here's a final thought. If *all* Gabriola's electricity were to be generated in natural-gas-fired CCGT plants—no dams—BC Hydro would still be releasing less carbon into the air (3740 tonnes) (46.3 t/GWh at 45% efficiency) than we are *already* releasing with our vehicles and ferry combined (4100 tonnes). ◊