Seas of Trouble

Andrew Park

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“Ad mare usque ad mare” – from sea to sea. So goes the motto emblazoned on Canada’s coat of arms. But with some significant exceptions, Canadians probably don’t see Canada as a maritime nation, or self-identify as maritime people. Nevertheless, Canada has the longest coastline of any sovereign nation, measuring 202,080 or 265,523 kilometers in length, depending on whose estimate you believe. Canada’s Exclusive Economic Zone (EEZ) stretches across 2.9 million square kilometers of the Atlantic, Pacific, and Arctic oceans, an area equivalent to 31% of Canada’s terrestrial land base.

Canada has significant rights and responsibilities in this vast ocean estate. She has the right to explore, do research on, and exploit living and non-living resources *above*, o*n*, and *beneath* the seabed. Her responsibilities include the legal requirements to manage commercial fish stocks and protect species at risk. These rights and responsibilities are jointly governed by the Fisheries Act, the Oceans Act, the Arctic Waters Pollution Prevention Act, and the Species at Risk Act.

In principle, all these levels of legislation provide the basis for a strong, sustainable ocean management regime. In practice, however, our national legislation has all too often been held hostage to political expediency, leading to the collapse of fisheries, the development of incipient “dead zones” on the ocean floor, and the necessity to treat some marine mammals as toxic waste when they die.

Furthermore, the global ocean is suffering multiple environmental pressures from direct and indirect human actions. Because our territorial waters mix with those of the open sea, Canada cannot escape these planetary pressures. The litany of environmental stresses includes ocean warming, ocean acidification, the extermination of many top predators through overfishing, the spread of anoxic dead zones produced by excess nutrients and warming waters, and marine pollution from multiple chemical species and sources. Together, these stresses constitute an existential threat to the health of the oceans, and perhaps, the very survival of some ocean ecosystems. Contemplating the latest research on ocean health, Alex Rogers, the director of the International Programme on the State of the Ocean (IPSO) stated “*The health of the ocean is spiraling downwards far more rapidly than we had thought*".

Like many of the ocean’s significant health problems, media coverage of the crisis is largely invisible, lurking far below the shallow waters of national newspapers and networks. In a very real sense, the ocean’s problems are out of sight and out of mind. And while our diagnosis of environmental issues in the oceans is improving, our ability to propose and implement solutions is imperfect to say the least.

What we do know is that the abuses of the past make the oceans more vulnerable to the environmental challenges that are developing right now. For example, overfishing has disproportionately exterminated large predatory fish, leaving the oceans dramatic depleted compared to the oceans of the past. A human symptom of this historic depletion is "fishing down the food chain", where fishers increasingly exploit first the food fish of the vanished predators, and then the food fish of those food fish, and so on down the line.

But there's more! The wholesale loss of predators combined with warming ocean waters have allowed jellyfish populations to explode in many places, particularly in relatively stagnant, polluted seas such as the Baltic. Ironically, the proliferating jellies may well be suppressing the recovery of exploited fish populations by feeding on larval fish.

Ocean warming is one obvious result of human-induced climate change. But there is a second climate crisis affecting our seas – ocean acidification. During the last 200 years, the oceans have absorbed about half of all emissions from burning fossil fuels, or about 525 billion tons of CO_2 during this period. The additional CO_2 has decreased the pH of ocean waters from about 8.16 in pre-industrial times to about 8.05 today, a drop of about 0.11 pH units. This does not sound like all that much, but bear in mind the pH is expressed on a logarithmic scale. This means that a 1 unit decrease in pH increases hydrogen ion concentrations, and therefore acidity, by a factor of 10. The 0.11 unit decrease in ocean pH has therefore increased relative acidity by about 28%[1].

The current rate of pH decline is unparalleled in the last 55 million years, and perhaps even the last 300 million years [Bijma, 2013 #1505]. By the time atmospheric CO_2 doubles its pre-industrial level, ocean pH is forecast to decline to 7.91, an increase in relative acidity of another 38% over current levels. The global ocean has probably not experienced a pH this low for at least 20 million years.

The potential effects of ocean acidification are extremely disturbing. As calcium solubility increases, calcifying organisms are less able to extract it from seawater and to secrete it into shells. Thinning of shells has already been observed under natural conditions. In Canadian waters, where pH has fallen more than the global average, some crustaceans and arctic mollusks have experienced shell thinning (Centre of Expertise in State of the Ocean Reporting (SOTO) 2012). Calcifiers exposed to elevated CO_2 concentrations in lab experiments experience reductions in calcification of 8% – 83% (Kleypas et al. 2009).

The effects of adding CO_2 to the ocean are taking humanity into unknown ecological territory. There is a definite risk that food chains could be seriously undermined by acidification, or even collapse. Past episodes of severe ocean acidification have been accompanied by mass extinction, and these include the Permian-Triassic extinction, which was the biggest on record to date (Zeebe 2012). The potential economic effects of ocean acidification are also immense.

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[1] We say "relative" acidity here, because strictly speaking, at pH values above 7, solutions are considered alkaline. Therefore, a drop in pH from 8.16 to 8.05 has made the oceans less alkaline (or basic) rather than more acidic. But the term "ocean acidification" has come into general use, even amongst scientists, so I use it here.

Thanks to “fishing down the food chain” (see below), much of the world’s marine food catch consists of calcifiers like shrimp and lobster, while shellfish farming is a multi-billion dollar industry worldwide (Roberts 2012).

Acidification represents a tangible and probable threat to these resources, and in our opinion, is among the most serious threats facing marine ecosystems this century.