California Legislature

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on
Natural Resources and Water

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OVERSIGHT HEARING

Science and Policy Update on Ocean Acidification – the "Evil Twin" of Climate Change

Purpose of Hearing

This hearing is the first in the Legislature to focus exclusively on the ocean acidification issue and its potential to affect waters and the marine environment offshore of the California coast. The Committee's intent is that legislators, staff, and the public will focus on marine aspects of climate change just as they currently focus on the land-based effects of climate change. While we are awaiting the release of the white paper from the West Coast Ocean Acidification and Hypoxia Science Panel in less than a month, it is not too early to consider the research, monitoring, and funding needs of the scientific community and the state agencies that are leading California's work on the marine impacts of climate change. These changes are expected to affect fisheries, shellfish, plant communities, and other marine resources. A major public education effort will also be required.

This hearing comes at a time when issues in the news have raised broader concerns over the health of marine environments along California, Oregon and Washington's coasts. While not all events can be ascribed to ocean acidification or climate change, per se, they do demonstrate what happens when marine ecosystems are disrupted. In some of these cases, the underlying causes – such as warmer surface temperatures – are predicted to occur in the future as a result of climate change and ocean acidification. For example:

- Currently, Dungeness crab and rock crab fisheries off most of California remain closed due to neurotoxin contamination from an algal bloom. While it is unclear what exactly caused the algal bloom, the unusually high temperatures in the ocean waters were a factor. By one estimate the value of the commercial crab fishery is up to $95 million per year.
- A warm pocket of water (called "The Blob") that persisted off California's coast for the last couple years contributed to the unusually warm, dry winters.
- Along the Pacific Northwest, widespread die-off of oyster and scallop populations in 2014 was due to colder, more acidic waters welling up from depths.
- Along much of the West Coast, massive deaths of sea stars over the last couple years may be due to a link between warming ocean waters and a disease.

Introduction

Since the beginning of the industrial revolution, human activities have dramatically increased the concentration of carbon dioxide in the atmosphere and current carbon dioxide levels are higher than they have been in over 650,000 years. Carbon dioxide and other pollutants in the atmosphere are having a wide range of impacts on the world, including rising temperatures, melting ice sheets, rising sea levels, changing precipitation patterns, and more frequent and intense droughts. All of these effects will have serious consequences for California.

Each year oceans are estimated to absorb approximately 25 percent of all carbon dioxide released through human activities. This service provided by the oceans has benefited us by slowing the accumulation of carbon dioxide in the atmosphere. However, this benefit has come at a cost: oceans are becoming increasingly more acidic. While most media coverage of the effects of climate change on the world's oceans typically focuses on sea level rise, less conspicuous changes to ocean chemistry are occurring that have the potential to alter ocean ecosystems, disrupt food webs, and profoundly impact human societies directly or indirectly linked to oceans.

Ocean acidification: how does it occur?

When carbon dioxide from the atmosphere is absorbed by seawater, a set of chemical changes occur that are collectively referred to as ocean acidification. Some of the carbon dioxide (CO_2) will remain as a dissolved gas in seawater. Some CO_2 molecules react with water molecules (H_2O) to form carbonic acid (H_2CO_3), the same acid found in carbonated beverages. Carbonic acid then breaks apart into a hydrogen ion (H^+) and a bicarbonate ion (HCO_3^-). As the concentration of hydrogen ions increases, the seawater becomes more acidic and that is measured as a decrease in pH. Furthermore, some hydrogen ions subsequently react with carbonate (CO_3^{2-}), thereby reducing the amount of carbonate in the seawater. This reduction in carbonate in oceans can be very disruptive to many organisms (as described below). In summary, the increased levels of carbon dioxide in the atmosphere results in *increases* in dissolved carbon dioxide concentrations, hydrogen ions, and bicarbonate ions along with *decreases* in carbonate concentration and pH.

It should be noted that the term "ocean acidification" does not suggest oceans are categorized as "acid" on the pH scale (i.e., $pH < 7$). Rather, it is a relative term that describes the lowering of ocean pH, similar to the way an increase in temperature from -20°C to -10°C would still be described as "warming."

As a result of human activities, surface ocean waters have decreased by 0.1 pH units. While that may not seem like a large drop, the pH scale is logarithmic and that change corresponds to a 30 percent increase in acidity. Predictions based on business-as-usual carbon dioxide emission scenarios indicate that by the end of the century the surface waters of the ocean could be nearly 150 percent more acidic, resulting in a pH that the oceans have not experienced in more than 20 million years.

Impacts of ocean acidification on marine life

Ocean acidification is expected to impact ocean animals and plants to varying degrees. Some organisms may benefit from the additional carbon dioxide in the ocean. Photosynthetic algae and sea grasses may grow faster and larger because they require carbon dioxide to live just like plants on land. However, studies have shown ocean acidification generally has a large and negative impact on survival, growth, and reproduction of many marine organisms. This is particularly true with organisms that produce shells or skeletons, including oysters, clams, sea urchins, starfish, corals, and many types of plankton. These marine organisms produce calcium carbonate shells or skeletons using carbonate from the seawater. As stated in the section above, when ocean pH decreases, the availability of these essential building blocks is reduced. Mussels and oysters, for example, are expected to grow slower and have smaller shells.

Corals, which use calcium carbonate to form coral reefs, are particularly vulnerable to ocean acidification. Ocean acidification may slow coral growth and cause existing reefs to break down faster than they can be rebuilt. When the reduction in coral reef formation is combined with other environmental stresses (e.g., rising ocean temperatures), the long-term viability of these ecosystems and the estimated one million species that depend on coral reef habitat is severely threatened.

Even organisms that do not have shells can still be affected by ocean acidification. Fish are able to adjust their internal pH to compensate for more acidic conditions in their surrounding water. However, these adjustments place greater stress on their systems, potentially reducing survivability. Also, more acidic water can disrupt the physiological tools some fish use to sense their surroundings, making them more vulnerable to predators.

The effects of ocean acidification may have broader implications than the ability to produce shells or the survival of individual species. Each species exists within a complex web of other species and those interactions may be altered by ocean acidification. For example, as oceans become more acidic, the availability of essential nutrients may be affected, causing ripple effects throughout the food web.

In addition to the negative impacts on marine life, there is new evidence that ocean acidification is exacerbating global warming. As oceans become more acidic, emission of a biogenic sulfur compound called dimethylsulphide (DMS) may decrease. This is important because DMS is the largest natural source of atmospheric sulfur. Higher levels of sulfur can have a dampening effect on global temperatures by reducing the amount of solar energy that reaches the Earth's surface through the role of sulfur in the formation of atmospheric particles and cloud formation. While research in this field is ongoing, these results underscore how interrelated many aspects of climate change are.

Potential socio-economic impacts of ocean acidification

Ocean acidification poses a threat to many of the benefits human societies receive from marine ecosystems. Fish and shellfish industries are likely to be hit hard by reduced fishery sizes. This will be particularly harmful for island nations, coastal communities, and parts of the developing world where people depend on the ocean for both economic and dietary needs. Furthermore, some ecosystems provide several benefits to nearby communities. Coral reefs, for example, bring tourism income, protect shorelines from erosion, and provide habitat for fish. Also, marine ecosystems also provide enormous cultural value to many communities.