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Responsibility

# Assessing the carbon footprint of aquaculture

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## Pond aquaculture often is carbon dioxide neutral

The carbon footprint for aquaculture products results mainly from the use of manufactured feed and mechanical aeration. Because aquaculture ponds sequester carbon, they can be carbon dioxide-neutral.

The carbon dioxide concentration of the earth's atmosphere was thought to be about 280 ppm at the beginning of the industrial revolution in the mid-1700s. Increasing use of fossil fuels since the onset of the revolution increased the carbon dioxide concentration in the atmosphere to 316 ppm in 1960 and 394 ppm in 2010. In Mauna Loa, Hawaii, USA, the reference site for measuring atmospheric carbon dioxide concentrations, the first reading above 400 ppm was recorded in May.

Clouds, water vapor, carbon dioxide, methane and nitrous oxide retain heat radiated by the earth, causing the planet's temperature to be considerably greater than it would be otherwise. This natural greenhouse effect is exacerbated by increases in concentrations of greenhouse gases in the atmosphere from air pollution – especially combustion of fossil fuels.

Carbon dioxide is the major greenhouse gas resulting from human activities. The observed increase in average global surface temperature of 0.78 degrees-C during the past century is highly publicized as the result of greater atmospheric carbon dioxide concentration. Of course, not all scientists entirely agree with this conclusion.

## Global warming concerns

Global warming and associated climate change are blamed for the melting of polar ice and thermal expansion of the oceans, causing rising sea levels, extreme weather, expansion of subtropical deserts and adverse effects on ecosystems. Atmospheric carbon dioxide concentrations are predicted to continue to increase and have more serious effects in the future on ecosystems and humans.

Moreover, a higher carbon dioxide concentration in the atmosphere results in more carbon dioxide in the oceans, causing ocean pH to decline and increasing the solubility of the carbonate minerals that form the shells of many marine organisms. This does not bode well for many species, including molluscan bivalves of aquaculture importance.

## Global response

The alarm over global warming has resulted in efforts to lessen carbon emissions through energy conservation, greater use of fossil fuels with lower carbon emissions, switching from fossil fuels to biofuels and development of alternative solar, wind and water energy resources. There also are efforts to increase carbon sequestration – removal of carbon dioxide from the atmosphere by incorporating it into organic matter or carbonate minerals through no-till farming, reforestation, landfilling, underground or deep ocean injection, and chemical precipitation.

Governments are developing carbon "cap and trade" programs in which a company is allotted an amount of carbon emissions, and if it does not use all of its allotment, it can sell or trade the remainder. Carbon exchanges – similar to stock markets – have been established to facilitate such programs. Carbon emission taxes also are imposed in some countries.

There is an increasing demand by consumers for products to bear a label revealing their carbon footprint. The carbon footprint is an estimate of the total carbon emissions that result from the production, use and disposal of a product. Carbon footprints also can be evaluated for humanity, countries, individuals and services.

## Energy use in food production

The Food and Agriculture Organization (FAO) of the United Nations recently estimated end use energy for the world food system (Table 1) in which carbon dioxide emissions mirrored fuel use closely. Expressed as carbon dioxide equivalents, annual emissions from the greenhouse gases carbon dioxide, methane, nitrous oxide and fluorinated hydrocarbons used as refrigerants were estimated at 216 to 270 million metric tons (MT) for capture fisheries and 212 to 220 million MT for aquaculture. Total greenhouse gas emissions from human activities presently total about 40,000 million MT annually.

## Boyd, FAO estimates of end energy, Table 1

| End Use | Energy Use (E.J.) |
|---|---|
| Plant crops | 12.8 |
| Livestock | 5.1 |
| Fisheries and aquaculture | 2.4 |
| Processing and distribution | 40.9 |
| Retail, preparation and cooking | 33.8 |
| Total | 95.0 |

Table 1. FAO estimates of end energy use in the world food system in 2008.

Fisheries and aquaculture are minor players, each reflecting about 0.5 percent of total global carbon emissions. This leads one to wonder if concerns communicated by environmental non-governmental organizations about carbon dioxide emissions from aquaculture are justifiable.

Of course, energy conservation in aquaculture is wise because it avoids wasteful use of fossil fuels and electricity generated mainly from fossil fuels. Moreover, energy conservation reduces aquaculture production costs – the major incentive for adoption of energy use reduction practices by producers. Of course, reduction in fossil fuel use also lessens carbon dioxide emissions.

## Aquatic species footprint

The carbon footprints of individual species from capture fisheries and aquaculture have been reported to range 1-3 kg carbon dioxide/kg meat and 2-7 kg carbon dioxide/kg meat, respectively (Table 2). The greater carbon footprint for aquaculture products results mainly from the use of feed and mechanical aeration.

## Boyd, Carbon dioxide emissions, Table 2

| Meat | Emissions (kg carbon dioxide/kg meat) |
|---|---|
| Beef | 12-16 |
| Pork | 4-8 |
| Chicken | 3-4 |
| Wild-caught fish (cod, saithe, haddock, herring, mackerel) | 1-3 |
| Aquacultured fish (shrimp, tilapia, channel catfish, salmon, blue crab) | 2-7 (median = 4) |

Table 2. Carbon dioxide emissions for selected meat products.

In carbon footprints for farmed species, the production and transportation of feed ingredients and manufacturing of pelleted diets and their transport to farms contribute 50 to 60 percent of the carbon footprint. Aeration may contribute another 20 to 25 percent of the footprint. Of course, products from aquaculture systems that do not employ feed or aeration probably have carbon footprints similar to those of products from capture fisheries.

It is interesting to note that aquaculture species compare favorably to chicken and pork with respect to carbon footprint (Table 2). Beef has a much higher carbon footprint than do aquaculture species. Extrapolation of the carbon footprint of the few aquaculture species for which data are available to all aquaculture production provides an estimate of about 200 million MT of carbon dioxide equivalent – about the same as the FAO estimate made by a different method of counting.

One point is overlooked in the computation above – aquaculture ponds sequester carbon. Data collected by researchers at Auburn University suggested that global sequestration of carbon dioxide by aquaculture ponds is about 60.5 million MT annually. When subtracted from the 200-million MT estimate of gross carbon dioxide emissions, this provides a net emission of about 140 million MT or 0.35 percent of global emissions. Because a major component of aquaculture carbon dioxide emissions results from feed ingredient production and feed manufacturing, pond aquaculture often is carbon dioxide neutral or results in net carbon dioxide sequestration at the farm level.

# Perspectives

There is no doubt a basis for concern over excessive use of fossil fuels because the proven reserves of most are adequate for only 50 to 100 years at current global use rates. However, aquaculture is such a minor player in global carbon emissions that the efforts by environmental groups to alert the public regarding the carbon footprint of aquaculture could be better used in promoting the development of alternative energy sources. Humanity is facing a very serious conundrum with respect to its energy future. This issue is much more serious than most people – including the scientific community – seem to realize.

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