Fish guts explain marine carbon cycle mystery

Research published today reveals the major influence of fish on maintaining the delicate pH balance of our oceans, vital for the health of coral reefs and other marine life.

The discovery, made by a team of scientists from the UK, US and Canada, could help solve a mystery that has puzzled marine chemists for decades. Published today (16 January 2009) in *Science*, the study provides new insights into the marine carbon cycle, which is undergoing rapid change as a result of global CO2 emissions.

Until now, scientists have believed that the oceans' calcium carbonate, which dissolves to make seawater alkaline, came from the external 'skeletons' of microscopic marine plankton. This study estimates that three to 15 per cent of marine calcium carbonate is in fact produced by fish in their intestines and then excreted. This is a conservative estimate and the team believes it has the potential to be three times higher.

Fish are therefore responsible for contributing a major but previously unrecognised portion of the inorganic carbon that maintains the ocean's acidity balance. The researchers predict that future increases in sea temperature and rising CO2 will cause fish to produce even more calcium carbonate.

To reach these results, the team created two independent computer models which for the first time estimated the total mass of fish in the ocean. They found there are between 812 and 2050 million tonnes (between 812 billion and 2050 billion kilos) of bony fish in the ocean. They then used lab research to establish that these fish produce around 110 million tonnes (110 billion kilos) of calcium carbonate per year.

Calcium carbonate is a white, chalky material that helps control the delicate acidity balance, or pH, of sea water. pH balance is vital for the health of marine ecosystems, including coral reefs, and important in controlling how easily the ocean will absorb and buffer future increases in atmospheric CO2.

This calcium carbonate is being produced by bony fish, a group that includes 90% of marine fish species but not sharks or rays. These fish continuously drink seawater to avoid dehydration. This exposes them to an excess of ingested calcium, which they precipitate into calcium carbonate crystals in the gut. The fish then simply excrete these unwanted chalky solids, sometimes called 'gut rocks', in a process that is separate from digestion and production of faeces.

The study reveals that carbonates excreted by fish are chemically quite different from those produced by plankton. This helps explain a phenomenon that has perplexed oceanographers: the sea becomes more alkaline at much shallower depths than expected. The carbonates produced by microscopic plankton should not be responsible for this alkalinity change, because they sink to much deeper depths intact, often becoming locked up in sediments and rocks for millions of years. In contrast, fish excrete more soluble forms of calcium carbonate that are likely to completely dissolve at much shallower depths (e.g. 500 to 1,000 metres).

Lead author Dr Rod Wilson of the University of Exeter (UK) said: "Our most conservative estimates suggest three to 15 per cent of the oceans' carbonates come from fish, but this range could be up to three times higher. We also know that fish carbonates differ considerably from those produced by plankton. Together, these findings may help answer a long-standing puzzle facing marine chemists, but they also reveal limitations to our current understanding of the marine carbon cycle."

And what about the future? The researchers predict that the combination of increases in sea temperature and rising CO2 expected over this century will cause fish to produce even more calcium carbonate. This is for two reasons. Firstly, higher temperatures stimulate overall metabolism in fish, which drives all their biological processes to run faster. Secondly, increasing CO2 in their blood directly stimulates carbonate production by the gut specifically.

Dr Rod Wilson continues: "We have really only just scratched the surface of knowing the chemistry and fate of fish carbonates. Given current concerns about the acidification of our seas through global CO2 emissions, it is more important than ever that we understand how the pH balance of the sea is normally maintained. Because of the impact of global climate change, fish are likely to have an even bigger influence on the chemistry of our oceans in future. So, it is vitally important that we build on this research to help fully understand these processes and how this will affect some of our most precious marine ecosystems."

Source : University of Exeter