Why some fish can't go with the flow

March 7 2014, by Dominique Roche

Changing waves and currents can keep fish on the move. Credit: Jordan Casey

Have you ever been snorkelling or scuba diving on a windy day when there are lots of waves? Did you notice how much that flow of water against your body affected your ability to swim and control your movements underwater? Well, fish feel the same way!

Water flow, in waves and currents, plays a huge role in determining whether fish can survive in freshwater or marine habitats. Some species, such as tuna or salmon, are designed for high speed swimming, and thrive in fast flowing water.

Others, such as pufferfish, are not so well equipped to handle the challenges of living in high flow environments, and prefer the peace and calm of sheltered lagoons.

But even good swimmers have their limits. For example, high rates of water discharge from hydroelectric dams can hinder the upstream movements of fish – think of North American salmon or Macquarie perch in Australia.

Not all individual fish are affected the same, of course. Bigger, stronger adults are generally more capable of fighting against strong currents, but smaller, younger fish will be less likely to make it. This has obvious consequences for the age structure and survival of fish populations in the long run.

Waves, coastlines and coral reefs

On the Australian coastline, waves created by winds are a major physical force that fish have to contend with.

Some fish species are "rovers" without a fixed home range, and constantly swim over large areas in search of food or mates. Examples include species of surgeonfish and parrotfish. Since they do not need to defend a territory, these fish can take advantage of waves to help them move around, much like surfers do.

In contrast, many other species, such as damselfish, have small territories that they defend vigorously against unwelcome intruders to protect their food and other resources. To do this, they constantly have to swim against the water flow to avoid being swept away.

Colleagues and I have found that fish spend a lot more energy when they have to swim against big waves compared to a regular, steady current at the same average speed. This makes sense: humans also burn a lot more energy during interval training (when constantly changing between a sprint and a jog) compared to running at a constant speed.

Many fish species regularly face these challenges, especially on Australia's Great Barrier Reef.

Coral reefs are shallow habitats because corals need light to photosynthesise and produce their food. Because of their proximity to the surface, coral reefs are often very wavy habitats. This poses a real challenge for the estimated 25% of marine species found on coral reefs, 4,000 of which are fish.

Climate change

Researchers are increasingly concerned that accelerating changes in weather patterns are affecting fish and other aquatic organisms. Rivers, lakes and coastal habitats are ecologically, socially and economically important places, so it's worth investing the time to research the impacts of climate change on these areas.

In addition to warming temperatures and acidified oceans, sea surface levels, and thus tidal amplitudes, are also predicted to rise as a consequence of climate change.

Already, these trends in weather are being documented. Storms are also increasing in frequency and intensity in ocean basins around the globe, according to the chapter on Ocean Change in the International Panel on Climate Change's report last year. With higher winds and larger tides come bigger waves.

How disturbances from waves affect the movements of predators and prey likely depends on their relative size. Credit: Jordan Casey

Waves, tides and currents are an everyday part of life for fish living in fast-flowing waters, but new extremes in wind speed and wave height may push some species over the edge.

What can fish do?

If waves are costly for some fish, then why don't they move to calmer locations? Fish can swim, after all. And some won't even have to swim very far to reach calmer waters. Water velocity can vary across very small scales on coral reefs.

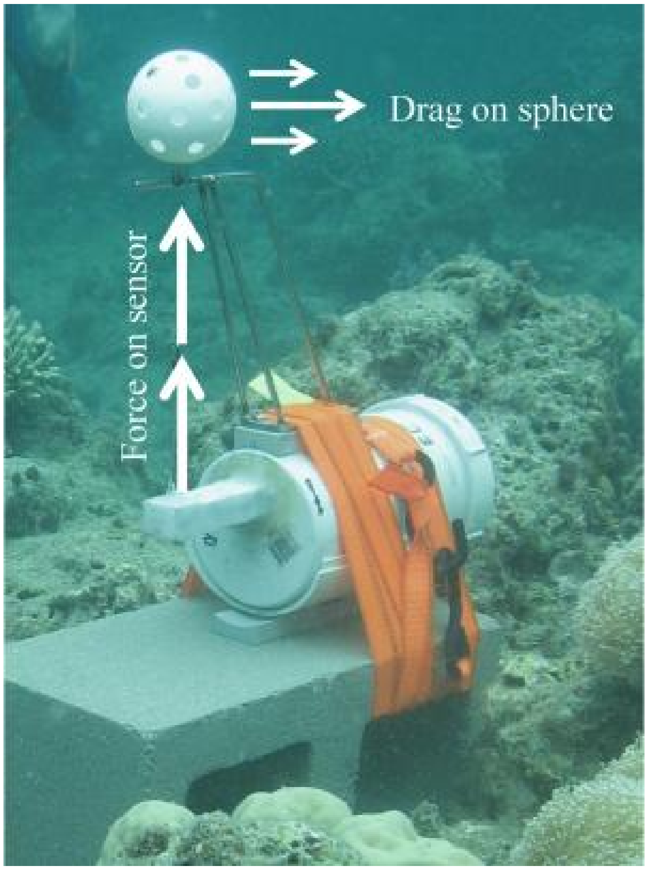
A new underwater instrument was developed at James Cook University to measure wave forces on the sea floor.

A study from January this year using this device showed that water speeds decrease dramatically the deeper you go on coral reefs at Lizard Island. On a windy day, the water flow speed at 9m below the surface is about one quarter of the flow speed at 3m depth.

But there are many reasons why fish might not move to calmer reefs or go deeper to avoid waves:

- sunlight is reduced with increasing water depth, so the shallowest, and waviest, part of the reef, where corals receive the most sunlight, is also the most productive and best habitat for fish
- waves near the surface mix the water and carry the nutrients and plankton that feed fish
- good places to live are at premium on coral reefs and species are all vying for space. This means that fish wanting to move will have to compete with already established residents and dislodge them if they want to take over their homes.

What can we do?



The instrument on a sheltered reef location with the guide rod construction and drag-sphere placement. Credit: Jacob L. Johansen, CC BY

Our understanding of how fish deal with waves, let alone adapt to changes in their flow environment, is very limited.

Answers to many important questions remain elusive – what aspects of their shape, physiology and behaviour allow certain species to thrive in their current habitats?

How do waves affect important phenomena like the outcome of predator-prey encounters, competition between individuals, or the survival of small, larval fish on the reef?

How does water flow interact with other stressors like temperature changes, ocean acidification and fishing pressure in shaping our changing marine communities?

Ultimately, more research into these questions will help us understand how fish might respond to expected changes in their flow environment. These answers will be critical to inform marine resource managers and help them identify and target species that are especially sensitive to increases in wave intensity.

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