Troubled waters

Dr Alejandro Frid communicates the science of overfishing and climate change widely in the hope that a better informed public might steer governments towards policies that value intergenerational justice

How will your latest research inform policy to address the problem of overfishing?

Our work supports the notion that species with similar diets and positions in the food web do not necessarily play the same ecological roles. If species differences in anti-predator behaviour are predictable on the basis of life history characteristics, as our results suggest, then fishery scientists might improve their ability to predict how fishery exploitation of top predators alters food webs that contain different combinations of mesopredators, which are smaller predators at risk of being eaten by larger predators. In turn, these predictions may help managers set better informed goals for the conservation or restoration of top predatory fishes.

Can you explain the repercussions of cascade effects on marine resources?

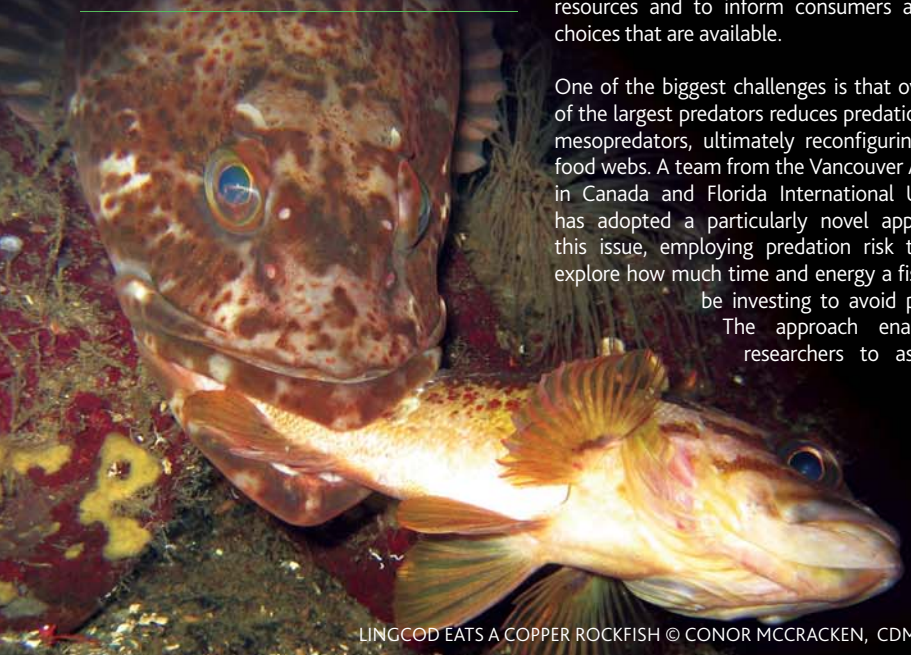
Our work highlights that, despite occupying similar positions in the food web, rockfishes have stronger anti-predator responses and are less likely to feed in the presence of large lingcod than kelp greenling or other mesopredators with shorter life spans and earlier maturity. Fisheries that deplete large lingcod could potentially allow all reef mesopredators to increase their feeding rates, but these increases are probably greatest for long-lived rockfishes than for other species. These behavioural changes, in

Predator-prey relationships

Over-exploitation of top marine predators is altering marine ecosystems forever. **Vancouver Aquarium** and **Florida International University** are investigating how predation risk impacts trophic cascades to help inform global fisheries management

THE UN HAS predicted that people will have fished the oceans dry by 2050 if global fishing continues unabated. Averting this disaster will require a major change in the world's approach to economic systems and the mitigation of climate change. However, there are some important actions that can be taken to move towards more sustainable fisheries; including establishing no-fishing zones and educating consumers about the kinds of fish they are buying and which fish stocks are more sustainable. All over the world, marine biologists and fisheries experts are investigating the sustainability of fisheries to both protect these resources and to inform consumers about the choices that are available.

One of the biggest challenges is that overfishing of the largest predators reduces predation risk for mesopredators, ultimately reconfiguring marine food webs. A team from the Vancouver Aquarium in Canada and Florida International University has adopted a particularly novel approach to this issue, employing predation risk theory to explore how much time and energy a fish should be investing to avoid predators. The approach enables the researchers to assess the costs and benefits that determine prey behaviour, which in turn influences the reproductive success of individuals over their lifetime. Project Leader Dr Alejandro Frid explains that this application has helped his team to work out how different species of mesopredators respond to the presence of a top predator, helping them to identify if, relative to longer-lived species, mesopredators with shorter life spans and fewer opportunities for reproduction take greater gambles: "We theorised that these fish would maximise return for shorter investment in reproduction by being more reckless feeders in the face of predation risk".



LINGCOD EATS A COPPER ROCKFISH © CONOR MCCRACKEN, CDM IMAGES

EXPERIMENTING ON NATURAL REEFS

To test these hypotheses, the researchers carried out experiments on natural reefs using video cameras to record fish behaviour. The study area was in Howe Sound, which is close to the Aquarium and enabled easy access for the scientists to complete field work throughout the year. The reefs in Howe Sound are home to several fish species, including mesopredators (kelp greenling and rockfishes) and a top predator (lingcod), and serve as an ideal site to test hypotheses about predator-prey interactions. "The location allowed us to trial general ideas about how top predators affect the anti-predator and feeding behaviours of mesopredators," elucidates Frid. Mesopredators were offered a food reward in the form of live shrimps placed a short distance from safe rocky areas. To manipulate predation risk they added in a life-sized model of a predatory fish at different distances from the food reward to see how this would alter mesopredator behaviour.

The footage confirmed that the shortest-lived mesopredators, the kelp greenlings, took the highest risks and the longest-lived mesopredators, the quillback rockfish, were not even tempted to leave the safe haven. The

turn, might affect populations of shrimps or other small species of prey (a cascading effect) and perhaps the competitive balance between different mesopredator species.

Who has helped to inspire your research?

My earliest scientific heroes were Drs George Schaller and Craig Packer – pioneers of the ecology and conservation of large carnivores. Dr Larry Dill, a leading behavioural ecologist, became an inspiration and I was lucky to have him as my doctoral supervisor. This led me to meet Dr Marc Mangel, a theoretician with an uncanny ability to encapsulate just about every aspect of biology into elegant equations. These days I am inspired by scientists like climatologist Dr James Hansen, marine biologist Dr Alexandra Morton, and economist Dr Mark Jaccard, to mention only three, who use evidence-based activism to argue in favour of policies that would mitigate climate change and other threats to humans and biodiversity.

What concerns you the most about the impact humans are having on our planet?

Climate change eclipses all other conservation problems and I often feel that my research is analogous to fiddling while Rome burns. Our changing climate threatens global food security and the low-lying coasts where billions of people live; as these issues worsen, governments are less likely to pay adequate attention to overfishing, deforestation and other impacts of human consumption on biodiversity. Climate change and ocean acidification are likely to diminish any conservation successes by altering ecosystem function and predator-prey relations. As the father of a young daughter, my obligation is to keep my sense of humour and focus on what can be done. That is why I am politically active as a citizen-scientist and spend time communicating the science behind climate change to the public, hoping that an educated public will put more pressure on governments to act.

findings suggest that the life-span of a fish species plays a significant role in their behaviour in front of predators. This means that fish with shorter life spans may be more willing to risk exposure to large predatory fish while feeding. From the researchers' perspective, one of the most important conclusions to draw from their research is that by depleting the top predators, the feeding behaviour of mesopredators will change, potentially impacting on competitiveness between species and on the smaller prey levels. This has major implications for fisheries management around the globe.

EVOLVING THEORIES

Frid has been involved in researching behavioural ecology in marine environments for many years. Before the late 1970s, most theories about predator-prey associations revolved around direct predation, which is now known to be only part of the picture. Subsequent studies highlighted the highly complex nature of this relationship, including how predators spread fear amongst prey populations, which is essential to understanding more about how ecosystems and food webs function. More recently, investigations have looked at these implications, such as how the fear factor affects levels of growth and reproduction in prey species. This includes studies completed by Frid and his colleagues into how predator risk effects impact trophic cascades. Frid also has contributed to a growing body of knowledge that applies predation risk theory to help unravel how human disturbances, such as ecotourism and marine transportation (both commercial and recreational), effect marine species. "Both of these recent research trends have influenced the science that underlies ecosystem management, but the extent to which they will affect policy remains to be seen," clarifies Frid.

He and his partners are now witnessing a new trend based on analysing how global warming impacts the links between predators and prey in marine ecosystems and what this means for oceans policy and fisheries governance: "Most recently, ecologists have turned their attention to how climate change and ocean acidification alter predator-prey relationships via mechanisms that involve changes in species distribution and the physiological states that affect behaviour". He believes that this research will become increasingly significant, and hopes that their work will continue to play an important part in educating both policy makers and the general public.

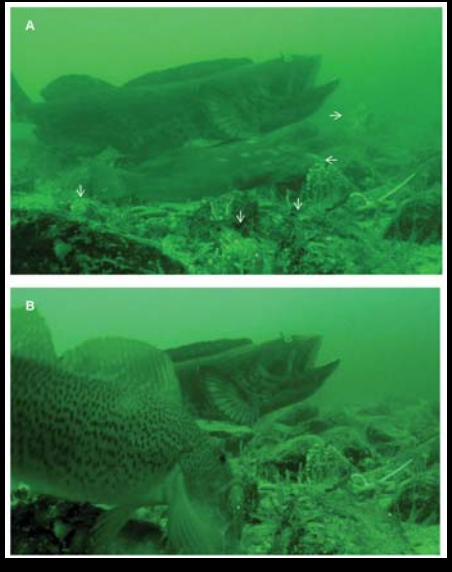


FIGURE 1. Field experiments: In panel A, a male kelp greenling (left-pointing arrow) closely inspects shrimps (vertical arrows) near the lingcod replica (large fish in background), while a copper rockfish (right-pointing arrow) keeps a greater distance. In panel B, a female kelp greenling attacks shrimps.

INTELLIGENCE

APPLYING PREDATION RISK THEORY TO THE RECOVERY OF DEPLETED POPULATIONS OF ROCKFISH AND LINGCOD IN HOWE SOUND

OBJECTIVES

To understand how the overfishing of upper-level predatory fishes, such as adult lingcod, has impacted the population and feeding patterns of mesopredators that, as a result, are becoming the new 'top' predators of over-exploited marine communities

KEY COLLABORATORS

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FUNDING

Natural Sciences and Engineering Research Council of Canada

Florida International University

Howe Sound Research and Conservation Group

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www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0040083

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