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Editorial

Famines, food insecurity and coral reef 'Ponzi' fisheries

This editorial concerns the joint issue of human numbers and failure of food supply, and focuses on the fact that coral reefs, if fished less intensively and destructively, can support much more biomass (food) than they do now. It starts with correcting some misconceptions about the supply of food globally, before focussing on some reasons why reefs cannot do what they are being asked to do. It also tries to show that failing to admit to some clear points is leading to a worsening situation.

1. Malthus and famines – is there famine now?

It has become fashionable to claim that Malthus' predictions of mass famine have been wrong. After all, it has been argued, the world population today is 7 billion, and is likely to rise to least 9 billion within a human generation. Two examples: at one end of the spectrum we have a journalist best left unnamed who said: "...Malthus was wrong as he failed to foresee the great boom in agriculture and technology." At the other end we read in the President's Foreword to a Royal Society report (no less!) which says: "But despite devastating regional famines, prognostications of mass starvation have not been fulfilled, even though the population has risen around sixfold since Malthus's time" (Rees, 2009). It is not clear why the President of such an august body (which must contain an ecologist or two who could have been consulted) thinks 'devastating regional famines' are not 'mass starvation', and nor does it say why the two things are different anyway – they would be identical for the people in an affected region.

Therefore, when is famine not a famine? What is mass starvation, if different? Table 1 grimly lists several defined famines, detailing locations, dates and estimated numbers of those who died. This simply tries to illustrate what numbers of deaths constitute 'famine' in conventional terms. It does not enumerate those who had lives blighted by food shortages and which resulted in devastating consequences for human health and society, and it does not attribute any one particular cause to each case. Such situations persist in many countries today, with chronic undernourishment affecting almost one billion people worldwide (FAO, 2012), and many political wars are underlain by resources shortages too. Coastal people in the tropics are amongst the vulnerable.

Present day data on food shortages and on deaths that arise from this are available, though difficult to measure. A decade ago, Black et al., (2003) asked in The Lancet: "Why and where are 10 million children dying each year?" Two years later in the same journal these co-authors report on World Health Organisation estimates of the causes of death in children (Bryce et al., 2005), stating: "Under-nutrition is an underlying cause of 53% of all deaths in children younger than age 5 years" (Fig. 1). Worldwide means mostly the poorer countries, and the expected diseases are all there: malaria, measles and so on. More than half of the deaths are exacerbated or caused by malnutrition; well-fed infants do not die from these infections nearly as readily as starving ones do. From this, deaths of approximately five and a half million infants under five years of age are at least exacerbated by food shortage every year.

If "six countries account for 50% of worldwide deaths in children younger than 5 years, and 42 countries for 90%." (Black et al., 2003), then this is surely an on-going global famine, annually much larger than those recorded in Table 1. Perhaps some people avoid calling this a 'famine' firstly, because it is not geographically constrained, but happens all around the world, though mainly in warm countries. Secondly, it is not bounded by time: it occurs continuously. If such immense mortality caused by food shortage is not viewed as Malthusian it can only be because of bureaucratic or semantic nit-picking. In this sense, Malthus was surely right. And of course the above figures relate only to the deaths of under fives – I have not found figures for all people, or older people, or for people on tropical coasts specifically, which is what I turn to later.

A simple oversight is common here too. The argument has commonly been made that the situation cannot be that bad or else the human population would not be increasing so fast. But measured population increase is a net figure – the result after mortality is deducted from the gross increase, which is much larger. This masks the problem in many people's minds (Sheppard, 2003).

2. Food from the sea

What has this sorry story got to do with this marine science journal? Most readers of this journal are concerned about degradation of various marine habitats. We know, better than anyone else perhaps, that marine ecosystems are key to supporting large numbers of people. They supply 'ecosystem services', food being a central but not the only one. Take coral reefs: this major habitat provides 99 benefits to mankind in nine major categories (Angulo-Valdés and Hatcher, 2010), nutrition, commercial, monetary and others. One problem continually wrestled with is that when we try to increase one 'ecosystem service' we can inadvertently cause deterioration in another. In the process of supplying these services, the ecosystems become degraded by over-use.

Dependency on protein from the sea is almost total for a huge number of people, with many more being partially dependent. Further, approximately 3 billion people live within 100 miles (160 km) of the sea, a number that could double in a decade as a result of

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Table 1
Some statistics of some defined or declared 'famine' in terms of number of deaths. From Wikipedia. See http://en.wikipedia.org/wiki/List_of_famines for a much longer list.

1947	USSR	1–1.5 million
1958	Ethiopia	100,000
1959–1961	China	15–43 million
1968	Biafra	10,000 per day
1968–1972	Sahel	1 million
1972–1973	Ethiopia	60,000
1974	Bangladesh	1 million
1983–1985	Eritrea–Ethiopia	400,000
1991–1992	Somalia	300,000
1996–1997	North Korea	300,000–800,000
1998	Sudan	70,000
1998–2004	Congo	3.8 million

human migration towards coastal zones (Economist, 2014). (This is aside from issues of non-sustainable industrial fishing in pelagic and deeper water.) That the present system of marine and fisheries 'management' is failing in a global sense, is not questioned, except perhaps by some fishing industries whose entrenched interests necessitate political lobbying at the highest level to retain the *status quo*. The evidence for this is clear (Fig. 2). Pitcher and Cheung (2013) discuss the decline in the status of global fish stocks. The combination of dependency on a resource, together with its inability to provide that same resource with current pressures is not a happy one.

3. Hubris, and 'managing' marine ecosystems

There have been many workshops, papers and fora discussing how to encourage a paradigm shift towards a different approach to obtaining food from the sea. Almost everyone recognises that it is needed. These workshops and committees address different proposed solutions, from protecting natural resources and biodiversity to increasingly intensive ocean farming. All may be needed. But it is unfortunate that increasing some products of an ecosystem such as productivity can diminish others that underpin ocean resilience and, ultimately, the flow of ecosystem goods and services. Thus focusing on increasing production may simply set up a greater problem in the near future. Some of the proposed solutions are much the same as what has been done before, only pursued more intensively. "Marine Spatial Planning' is one of the ideas growing in popularity. Some approaches advocate leaving some areas as un-exploited, replenishment reservoirs. Progress in one obvious option, that of creating properly protected areas to permit greater juvenile supply, is lagging badly behind need, but is slowly gaining acceptance with formation of large ones (Toonen et al., 2013) Other suggestions advocate simply farming the sea on a more industrial scale, as happens on land. We do lack a coherent, workable, and acceptable mechanism to increase marine food production that will both work in the short term yet maintain into the future both a high diversity and the myriad other 'services' the biosphere provides. Different countries of course are considering different approaches, but alarmingly, too many are still dithering, postponing or avoiding any rational decisions. Sometimes this is because their food-support ecosystems have deteriorated so much that there seems nothing they can do.

Several steps might be possible. The first, in my view, is to recognise our commonly fraudulent use of the word "manage" when it comes to marine ecosystems. Managing a coral reef? Managing a seagrass bed? This is pure hubris. We do not manage those habitats; all we could manage might be human activities that would damage or destroy them. People with the label "Manager" dislike this point, but this comment generates favourable comments from thoughtful scientists.

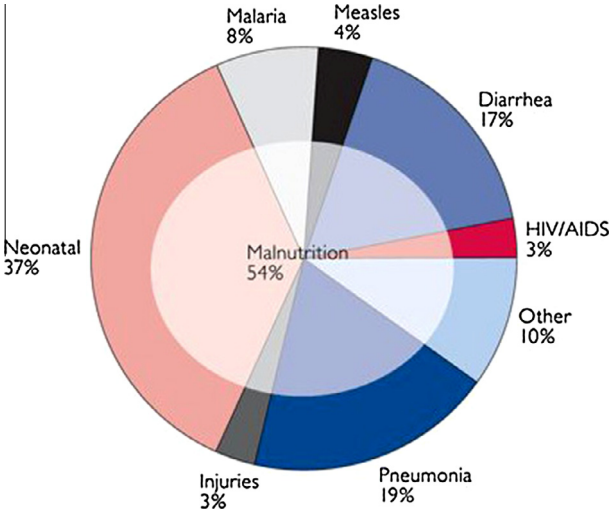

Fig. 1. Major causes of death in children under five in developing countries and the contribution of malnutrition. *Source*: Adapted from Bryce et al. (2005).

A second step is to openly talk about population pressures. Today, at many international fora it is frowned upon to even mention population numbers, family planning issues, and related subjects. Alternatively, they are quietly ignored. Mora (2014) discusses this problem in depth.

A third step, seemingly trivial but probably very important, is to recognise that language must be used correctly. In some countries and industries deliberate misuse of language has led to many ecological problems. Some personal favourites of word misuse are:

- "Reclaim": the word used when sea is turned into land. It may have been a breeding ground for marine food species. Commonly the fill material is taken from adjacent, equally valuable shallow areas.
- "Borrow pit": the areas dredged to get landfill material. To borrow means you will give it back!
- "Ground improvement": I have seen this used for flattening a coral reef, for foundations.
- "Worthless swamp": a mangrove stand, believed to be fit for nothing except construction.

In many places the shallow, highly productive sea is priced more highly when it is no longer sea, and terminology of this kind can convey incorrect messages to a senior manager or politician.

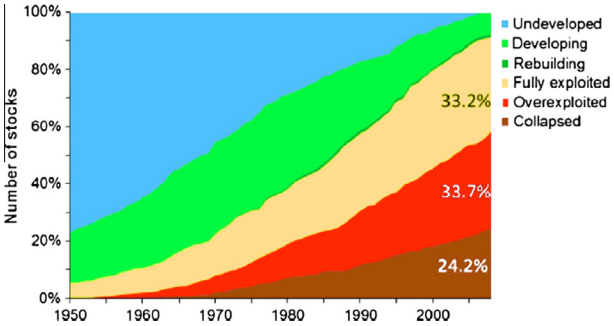

Fig. 2. History of the status of world fish stocks from the FAO catch database 1950–2008, using a catch-only algorithm. Collapsed and overfished populations comprise almost 60% of world's fisheries. The proportion of developing stocks is decreasing and the fraction of rebuilding stocks is constant and small (about 1%), both signals that, in converse, might be a beacon of hope. From Pitcher and Cheung (2013).

4. The Ponzi effect and reef fishing

Tropical seas are one important example of the global overfishing problem. As noted above, uncounted numbers of people depend on protein from reefs, and in many countries coastal populations are rising faster even than the national averages. But first, who or what was Ponzi?

A Ponzi scam is a well known scheme of financial fraud, named after its infamous practitioner, made famous again recently by a gentleman now residing in a US jail for perpetrating the world's largest (so far) financial scam. In essence, the operator takes money from investors by offering a very high rate of return. The promised high return is paid to that investor using the capital given by a later investor similarly attracted by the promised high return. Thus, the second investor's capital is not invested, but is used to pay the high interest promised to the first investor. That first investor thinks his large payment is interest on his money – but it is not. And so it goes on, in pyramid-like fashion. It can work for a while, but in a finite world it has to topple eventually. The total amount of capital may never build up, but is used to pay the supposed interest to earlier investors. In simplest form there is no interest at all, just capital being used. Pauly (2010) first alluded to this.

What are the parallels with reef fishing and what has a Ponzi scheme got to do with reef fisheries? Reef fish are the capital in question. We may picture a person with a canoe, fishing for his or her family – an idyllic picture (but which reader would really like to swap places permanently?). That scenario would have been sustainable; the surplus fish produced on a healthy reef will replenish what he catches. But then he buys an engine, to make life easier (who would blame him?) but he then needs to catch more fish to pay for it so no longer is he eating all his catch but catching more to sell. In the village, many fishermen are doing the same. Then, he gets a bigger boat, so he can catch more fish to sell, but now has even bigger boat payments to make. So he catches more fish. And so it goes on. The 'capital' is the fish stock, and there comes a point when natural replenishment cannot keep up. The story keeps going: a businessman or a group buy a freezer plant, which needs more capital (fish) still. You can see how the sustainable picture evolves into one that is not. This may be economic development for the people, or for some, but is not sustainable, and links back to malnutrition discussed earlier.

Any reef fisheries can be easily 'sustained' at a very depleted level of course. But fisheries should ideally be managed for sustainable high yield, without collapsing the breeding stock. But almost nowhere in the world does this appear to be the case (Pauly, 2010). In pelagic waters, tuna and other fish are in decline, while for reefs, the term 'sustainable coral reef fishing' has been considered by many an oxymoron (Pauly et al., 2002). The term 'sustainable' sometimes has been morphed to 'sustainable growth' which, with respect to fisheries and probably most other areas of marine exploitation, is nonsensical. In other words, "We still need to invent sustainability..." (Pauly et al., 2002; Pauly, 2010) with respect to reef fishing. Examples of this can be seen in the Viewpoint by Fenner (2014, this issue).

One factor exacerbating an already problematic situation is that it is the bigger fish that fetch the most money, yet it is the larger, older adults of many species that produce exponentially more eggs. Most fisheries management regimes tell people to throw back the smallest fish rather than the biggest, yet the reverse is what they should be doing if they want to keep up the supply of juveniles in these cases. More large breeding fishes would allow people to live of the yield (the interest) instead of stock (the capital). Such a scenario can be followed all the way to industrial scale fishing.

There is another reason why reef fish stocks collapse. From parallels with whaling, economics suggests that the best economic way to profit from whaling would be to catch them all now and sell them, and then invest the money into something else – this was concluded 30 years ago (Clark, 1973, 2006).

We know from the work of Graham and McClanahan (2013), Graham et al. (2013), Friedlander and DeMartini (2002) and others that unfished reefs have many more large breeding fish than do over-exploited reefs. Collapse of reef fisheries in particular seems to happen remarkably easily. Of about 20–30 sites studied by these researchers and their colleagues, a few have reef fish biomass estimated around 7 tonnes per hectare or more. Most sites have less than 1 tonne per hectare and only very few have biomass somewhere between the two. This could indicate some sampling bias, but the weight of evidence suggests that the slide from high to very low biomass happens very quickly. This 'exploitation gap', which is clearly identified in the publications of Graham, Friedlander and colleagues, could tell us that relatively little fishing is needed to collapse a high biomass system to one that is very depleted. If it turns out to be a real phenomenon then this will be a very important factor.

Other factors exacerbate this. Coral reefs may be destroyed very easily; their ability to adapt to multiple stresses is poor (Ateweberhan et al., 2013). Fishing from the world's reefs already far exceeds sustainability. It already would require several more Great Barrier Reef equivalents to support present sustainable yields (Newton et al., 2007), for example. Few reefs have avoided degradation when being heavily exploited, and those that continue to produce sustainable high harvests have done so perhaps because of tribal laws that have limited fishing inside the chief's reserves, or because they were too remote or too hazardous for the technology of the day (Pauly, 2010). Given the massive depletion of fish stocks on the coral reefs fringing all dozen or so Indian Ocean coral reef countries measured so far (Graham and McClanahan, 2013), 'sustainability' seems to be a flawed concept.

Notwithstanding desires and aspiration for sustainability, unless or until a sustainable system of high production from reef fisheries is invented (or managed), the only precautionary way to 'manage' reef fisheries at present, given the Ponzi-like way such fishing operates, is to prohibit it in biologically significant sized areas. These, it must be hoped, will maintain a suitable 'seed stock'. Several small no-take fishing areas in a dozen Indian Ocean countries sometimes do have greater fish stocks than surrounding fished areas, but the differences are often only modest, and the reefs may fall far short of their full potential (Graham and McClanahan, 2013).

Cynics might ask: "you suggest feeding more people by stopping them from fishing?!" The answer actually is "yes", if done in a carefully planned way. In several Philippines examples, strict protection of even modest sized reefs from fishing has resulted, after just 3–4 years, in a several-fold increase in fish yield and commensurate increase in incomes. Marine Spatial Planning is one answer here. MSP is in its ascendency, and I hope that proper recognition is made of the facts that (a) this issue is urgent, and that (b) you can only keep taking high production year after year if you do not eat into the capital. The problem is that the yields, especially from overfished reef, is not big enough to satisfy immediate needs, and so people are obliged to dip into the capital. Measures to protect the 'capital' cannot be the only answer though: traditional attempts to better regulate each element of the process (gears used, size selection, effort, temporal planning, etc.) are clearly needed also.

But you cannot stem a rising tide of starving people, so even this is insufficient. Most of all, much better recognition of the double problems by people in authority is needed, namely of the existing food shortage caused by over-extraction, and of the burgeoning human populations that drive it. This is indeed a difficult if not intractable issue that, unfortunately, is not in the hands of simple science!

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