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*Bio*logic

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Fishy business

In discussing risk in these columns, I have commented on how it may well be unreasonable to expect the untrained to adopt the scientific method and to carry out evaluations in the manner preferred by those who have acquired a scientific training with considerable effort. This does not suggest that other types of input are of lesser value—non-rational inputs into decision making are important. However, it is interesting to think about something where your own database is defective, to see how you might cope if your customary style of thinking about things fails to help. So this is about risks to fish and domestication of animals in the Neolithic.

In retrospect, no one is surprised that the hunting of bison with rifles on the Great Plains led to their (effective) extinction in a relatively short time. A change in technology had produced an imbalance between cropping and replacement. But when it comes to fishing, we are curiously reluctant to accept that comparable changes in technology (steam power winches, diesel engines in the 1920s, freezer trawlers, acoustic fish finders in the 1950s) have had the same effect on fish stocks—we prefer to invoke what Pauly *et al.*[1] have called 'unspecified environmental change'.

Historically there is ample evidence that fisheries have tended to be unsustainable,[2] and the sustainable examples have generally been in populations where a large part of the population were inaccessible to hunters, since the population kinetics of fish depend critically on massive 'over-production' of fry. In fish, older females are a critical part of the equation; a 12.5 kg red snapper contains the same number of eggs (9.3×10^6) as two hundred and twelve 1.1 kg fish (this column prides itself on providing data with which to astonish people at parties). At particular risk are populations of fish 'trapped' by a specific habitat where a long-lived reserve cannot be protected—this is the population-related danger of cyanide fishing for reef fish (there are others!). There is also good evidence that populations recover rapidly when not fished, but only in the Pacific halibut fishery has this kind of intervention been successful: probably a value-related thing.

The first invocation of a natural event to explain over-fishing was the 1971–72 collapse of anchovy fishing, attributed to El Nino but due to a 'real' catch of 12 million tons rather than the official 8 million. This attribution allowed over-fishing to continue, and this excess contributed in turn to the destruction of cod fishing in New England and Newfoundland—ending, as Pauly *et al.* said, 'fishing traditions reaching back through centuries'.[1] In fact, the expansion of fishing into waters previously unfished has concealed a general fall in ocean yields since the 1980's.

Marine and terrestrial feeding systems differ in an important way. In the marine environment herbivores (the zooplankton) feed on algae, small fishes (sardines) on the zooplankton, and larger fish (cod, tuna) on smaller fish. This is unlike the terrestrial situation (where, for example, wolves are smaller than moose) and the structure has some consequences that are non-intuitive. We are removing the larger long-lived fish at the top of the chain from the marine system. It might be considered that this will remove predators and increase the yield but in fact what happens is that previously suppressed species often expand to fill a niche (good Darwinian stuff) and these are sometimes useful like squid (and jellyfish—if you like it) but may be toxic (blooms). More importantly, the food web is simplified, removing the possibility of allowing predators to switch between prey as their abundance fluctuates in normal cycles. As Pauly points out, this means that environmental variations will impact more strongly on fisheries, making the chicken and egg of intervention versus variation very difficult to resolve.

The destruction of the seabed by trawling also has a powerful effect on the food web, both directly and by making the survival of juvenile fish difficult. Demersal (bottom) fishes, which tend to be long-lived, have diminished faster than the shorter-lived pelagic (open water) fish. Continental shelves (<200 m deep), much of them ice-covered, account for around 7% of the oceans, but are the substrate upon which 90% of the current yield depends. Much of the deep ocean is as productive as the centre of Australia.

What about aquaculture? In practise this is mainly the feeding of carnivores of higher value (salmon) with fish-meal and oil in a number of forms but often derived from herring, sardine or mackerel. It uses much more fish mass than it produces and is a further pressure on resources, although for some fish, more intensive research is producing a better methodology for culture (this is a bit like zoos and the rare animal—an important and valuable activity but not a commercial one).

How might we deal with this in terms of a risk assessment? Is the risk to a sustainable fishing industry or to fish, or to the ocean or to the food webs? Fisheries data is often good but crudely manipulated—in my view there is an interesting contrast with clinical trials where data sets are sometimes less carefully defined and collected than landings, but manipulation is rare. What appear to be essays in sustainability (for example, the establishment of Marine Protected Areas) are really Phase III studies—or possibly Phase II—where a defined population is closely examined to see if it satisfies certain expectations when particular variables are examined. As we know, it is not until large population exposures occur that problems appear. For drugs we can do a risk/benefit analysis with well-defined outcome measures, but how do you do this for oceans?

In general, we have not had to face impacts of the kind that modern technology has presented for oceans on the land, mainly because of the gradual nature of the processes involved and a disregard for the displacements that may have occurred. Domestication of animals has arguably been the most lifestyle-changing human activity over the last 13 000 years (party-wise, do you know why zebras cannot be domesticated despite 200 years of trying—apart from their awful tempers?). Domestication implies breeding in captivity and control of animal food supply: as Diamond has said 'Hannibal's African war elephants were just tamed individuals'.[3] The process has only been applied to 14 of the 148 species that produce individuals weighing >45 kg (the Premier League of horse, cow, sheep, pig and goats, with a First Division including water buffalo and reindeer). When this was done, did we consider the risks to the animals, when sheep were selected for loss of their outer hair or kemp, cattle to be smaller, chickens to be bigger and dogs for a wide variety of functions? Did we consider disease transmission, when measles and tuberculosis came from diseases of cattle, influenza from pigs and ducks and smallpox possibly from cattle (or camels)? Of course not. There were other preoccupations as crops were also domesticated and there was no system of inquiry. The reasons for limitations on the extent of all kinds of domestication have a modern resonance; oak trees are an important source of food for many animals but the production of the bitter (and toxic) compounds produced in acorns is controlled polygenically. This made selection for the non-bitter forms beyond the capability of pre-21st century man (offspring of non-poisonous individuals were often dangerous). This is unlike the position in almonds where a single gene effect allowed effective selection.

So our perceptions change with time, we have been primarily concerned about our species until very recently and not until we are threatened by want (or, perhaps more precisely, absence of something we want) do we start to think on a grand scale. Pigs are important to vast tracts of humanity but pig kidneys (of the genetically modified kind) give rise to more concerns about virus transmission than normal human/pig contact.

The homelands of agriculture (to use Diamond's term) were the places best suited to the domesticable plant and animal species—they are the sites where they were natives (the fertile crescent, China, Mesoamerica, Andes/Amazonia, Sahel, tropical West Africa, Ethiopia, New Guinea and the eastern US). Food production as a human activity arose independently in these nine areas, but they are not now the sites of greatest productivity, due to further changes in crops, the development of farm machinery, climate change and human activity. Importantly, the fact that a plant or animal is native to a place does not mean it will not do better anywhere else (think of the rhododendron).

So if we want to fix an environment to save, which one do we chose? and at what time? How utilitarian are we allowed to be? How much can we consider ourselves to be 'masters of creation'? Whose jobs should be preserved? Answers on a post-card please (and about the zebra).

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