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The shifting baselines syndrome: perception, deception, and the future of our oceans

INTRODUCTION

Humans consider the surroundings of their youth as natural and, as they age, recognize the changes to their environment as unnatural. Children repeat the errors of their parents. Thus, as each new generation collectively adopts this perverse perspective, we lose track of the inexorable degradation of native ecosystems. Pauly (1995) coined the term "shifting baselines syndrome" to describe this phenomenon in relation to the problem of fisheries, for which baselines for so-called "pristine" populations are established by managers that ignore the impacts of earlier fishing that had already greatly reduced fish abundance and size. Consequently, expectations change as we shift to eating smaller and smaller fish and invertebrates at progressively lower trophic levels – the phenomenon now commonly referred to as "fishing down the food web" (Pauly *et al.*, 1998). The gradual accommodation of loss applies to a host of other ecological and cultural resources. Pollan (2008) writes on "the tangible material formerly known as food" and notes that many modern food systems would be unrecognizable to people only a few decades ago. Similarly, we are in the process of destroying many indigenous cultures through a combination of genocide and assimilation. We lose one of the 7000 languages remaining on Earth every two weeks (Wilford, 2007). The "future of the past" (Stille, 2002) is grim indeed.

It is not sycophantic to say that the idea of shifting baselines was revolutionary for the field of ecology, for which our limited understanding of patterns of distribution and abundance, food webs, and community structure are based on the assumption that what we can observe today is all that matters (Jackson, 1997, 2006). The folly of this

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"arrogance of the present" has been clear to historical ecologists since at least the 1980s (Cronon, 1983). No rational person would deny the once fantastically great abundance of bison in North America before European contact (Isenberg, 2000) simply because there are no ecological survey data from the fifteenth century. But in effect this is what most marine ecologists have done until very recently for the former extraordinary abundance of large animals in coastal seas around the world (Jackson, 1997, 2001; Jackson *et al.*, 2001). This is the problem of shifting baselines.

SYMPTOMS

There are three requisite symptoms of the shifting baselines syndrome: change, time, and amnesia. Sáenz-Arroyo *et al.* (2005) captured the complete spirit of shifting baselines after interviewing three generations of Mexican fishers and finding that, compared to young fishers, older fishers named five times as many species and four times as many fishing sites as being once productive but now depleted. Very few young fishers appreciated that large species had ever been common or that nearshore sites had been productive.

Oceanic whitetip sharks (*Carcharhinus longimanus*) were described as the most common pelagic shark in the Gulf of Mexico in the 1950s. Today, scientific papers refer to them as "rare" or dismiss the species entirely because oceanic whitetip sharks in the region have declined by more than 99% and so has their human memory (Baum and Myers, 2004). Fishers off of Canada's east coast, once the center of the cod industry, now fish for formerly discarded hagfish and sea cucumbers (CanWest, 2008), and in Oregon fishers are trading in their salmon fishing gear for gear to catch prawns because the salmon are nearly gone (Yardley, 2008). The "Euro series" spear gun has been introduced in North America to hunt smaller fish. Recently, an east coast US fisherman in his twenties accosted a fisheries manager and told him he was angry at lowered Atlantic bluefin tuna (*Thunnus thynnus*) quotas because there were more tuna out there than he had ever seen. "Well, you're not very old," responded the manager (Woodard, 2008). In fact, Western Atlantic bluefin tuna are critically endangered (Safina and Klinger, 2008; Safina and Hardt, this volume).

Similarly radical shifts are occurring because of global warming as formerly tropical and subtropical species migrate into higher latitudes (Cheung *et al.*, 2009). England's National Marine Aquarium at Plymouth used to have a Mediterranean tank. Today, as temperature and other factors of the North Atlantic have changed, so should the tank's name since so many Mediterranean species are now found off of Plymouth's coast (Mitchell, 2009).

OPTIMISM IS INVERSELY RELATED TO DATA QUALITY

Our optimism or pessimism about our predicament varies as a function of the age and quality of our data. Since baselines for what is natural are reset with every new generation, younger people are allowed to be more hopeful than older people. The gray whale, for instance, is considered an icon of success of the US Endangered Species Act. Gray whale numbers have rebounded from near extinction to 22 000 whales today – a truly great achievement of conservation. But new research using DNA to reconstruct former gray whale abundance suggests that the gray whale population before whaling was more likely 96 000 animals, or three to five times greater than today's estimates (Alter *et al.*, 2007). Humpback whales in the Northern Pacific also have rebounded from 1400 individuals in 1966, after more than a century of whaling, to 20 000 animals today, giving conservationists cause for celebration (Calambokidis *et al.*, 2008). But we have little idea of the actual abundance of humpbacks before whaling. The recovery of the bald eagle tells a similar story. Conservation efforts brought bald eagles back from the brink –417 nesting pairs were reported in the United States in 1967. Today there are more than 10 000 nesting pairs, causing them to be removed from the federal list of endangered and threatened species (Fahrenthold, 2007). However, the recovery baseline for bald eagles was not the population estimated in 1782, when the United States adopted the bird as its national symbol and when as many as 100 000 nesting pairs (ten times the current population) lived in the continental United States (excluding Alaska, USFWS, 1999). No one is suggesting a goal of 200 000 eagles living in the contiguous United States, but it is important to recognize that the baseline has shifted.

Whales and eagles are great success stories for the likely survival of the species. But there is a darker side to shifting baselines, which manifests itself in misplaced confidence based on far more modest successes, as exemplified by the situation of Caribbean green turtles (*Chelonia mydas*), which were vividly described in the documents of the Columbus voyages and most subsequent explorations (Jackson, 1997). Native Americans heavily exploited green turtles long before

Columbus and had already hunted them to near local extinction in places like Jamaica and the Bahamas (Carlson and Keegan, 2004; Fitzpatrick, Keegan and Sealey, 2008; Hardt, 2008). But prehistoric depletion of green turtles is trivial when compared to European slaughter that systematically exploited green turtles for their meat and eggs (Jackson, 1997; McClenachan *et al.*, 2006). As a result, green turtles were reduced to less than 1% of their abundance in the sixteenth century and 20% of nesting beaches were entirely eliminated – with nesting populations at half of the remaining beaches perilously close to extinction. An alarming implication for management is that all the examples of local nesting beach recovery are from baselines of less than 40 years duration whereas all longer time series exhibit dramatic decline (McClenachan *et al.*, 2006).

The globally endangered goliath grouper (*Epinephelus itajara*) in Florida provides another even more disturbing example because dramatic decreases in this highly prized fish occurred much more recently and are well documented historically (McClenachan, 2009b). Recent protection resulted in substantial increases in grouper to some 30% of the 1990 baseline of "virgin biomass," which has been used by sports fishers to declare success and urge the reopening of the fishery. However, analysis of historical photographs and newspaper accounts clearly demonstrate dramatic decreases in goliath grouper abundance and size since the beginning of the twentieth century, strongly suggesting that the recent increases do not represent a significant recovery for the survival of the species.

ANECDOTES AND HISTORICAL DATA

Occasionally, we have rigorous, long-term quantitative catch data for commercially important species like cod and herring to confirm shifting baselines and show that our perception of what is "natural" is skewed (Lotze and Milewski, 2004; Rosenberg *et al.*, 2005; Roberts, 2007; McClenachan, 2009a, 2009b). But, far more often, most of the changes occurred before we were there to see them or could record relevant numbers. In these circumstances, we need to exploit geological, archeological, and historical data in addition to more modern ecological records to reconstruct what used to be in the sea (Jackson, 2001; Jackson *et al.*, 2001; Pandolfi *et al.*, 2003; Lotze *et al.*, 2006, Jackson and McClenachan, 2009).

Many of these historical data are qualitative or semi-quantitative, which is why ecologists tended to ignore them. But there is an enormous wealth of historical data if we know how to use them; and confidence in reconstructions of past conditions greatly increases when different kinds of primary data and proxies are in general agreement. Most importantly, failure to incorporate historical information into scientific assessments because the data are imprecise risks ignoring the obvious. As Daniel Pauly (1995) famously said, the anecdotes are the data. Insistence on traditional quantitative population data represents a kind of false "precisionism" that ignores reality and generality (*sensu* Levins, 1968), and we do so at our peril. The oceans used to be dominated ecologically by lots of very large animals that are impossible to study with modern quantitative ecological methods because they are ecologically or biologically extinct (Jackson *et al.*, 2001; Lotze and Worm, 2009).

The sheer multitude of historical observations easily overcomes the issues of subjectivity and quantitative rigor. The data for Caribbean green turtles discussed previously, for example, come from 163 separate records of observations or hunting of green turtles on or around beaches and gathering of their eggs that were highly prized as food (McClenachan *et al.*, 2006). Those data, combined with data for numbers of turtles harvested or surveyed on particular beaches and at different times, provided the basis for the calculation that there were 91 million large adult green turtles in the tropical western Atlantic before Europeans began to hunt them. Allowing for uncertainties in the data and calculations, we can confidently conclude that there was somewhere between 50 and 150 million green turtles – a biomass that at 200 to 300 kg/turtle approaches the biomass of the human population of the United States today! Most importantly, these uncertainties in historical abundance pale by comparison to the present abundance of green turtles that is less than 300 000 much smaller turtles (Seminoff *et al.*, 2002). Using similar techniques, the abundance of hawksbill turtles exploited for their shells was about 11 000 000 compared to less than 30 000 today (McClenachan *et al.*, 2006) and the abundance of the extinct Caribbean monk sea was between 233 000 to 338 000 (McClenachan and Cooper, 2008).

McClenachan (2009a) used an entirely different approach to determine the decline of sports fish around Key West from the 1950s to the present. Sport fishing logbooks might be sparse but sport fishermen love to be photographed with their catch. Using historical photographs taken in Key West from 1956 to 2007, McClenachan examined the mean individual size and species composition for 13 groups of recreationally caught "trophy" reef fish. Measurements derived from the photographs show that the mean length of trophy fish declined by more than 50% (92 cm to 42 cm), mean weight declined by 90% (19.9 kg to 2.3 kg), and species composition changed from dominance by large groupers and other predatory fishes to small snappers. The average length of sharks also declined by more than 50% over 50 years. Nevertheless, the price for a fishing trip remains the same adjusted for inflation. Thus, consumers are still paying the same for catching much less fish – a remarkable example of shifting baselines in personal expectations.

Finally, when the kinds of historical data illustrated above are lacking, one can simply code historical observations to reflect categories of abundance, (e.g., what was the most abundant species observed, or classification of species as abundant, common, rare, or absent) and statistically compare their rankings or frequency of occurrence (Jackson *et al.*, 2001; Palomares *et al.*, 2006). All of these approaches have been used to document in considerable detail the varyingly precipitous decline of innumerable species in all the major ecosystems of the oceans (Lotze *et al.*, 2006; Jackson, 2008; Pauly *et al.*, 1998; Pauly *et al.*, 2003; Jackson, 2001; Jackson *et al.*, 2001; Myers and Worm, 2003; Lotze and Milewski, 2004; Lotze *et al.*, 2005). The degradation is so great that entire ocean ecosystems are globally endangered, rather than just individual species. By analogy with the criteria for the Red List of endangered species compiled by the International Union for Conservation for Nature, coral reefs and coastal seas are critically endangered, continental shelves are endangered, and open ocean pelagic ecosystems are threatened (Jackson, 2008).

THE ARROGANCE OF PRECISIONISM

The report by Myers and Worm (2003) that globally 90% of large predatory fish were gone because of overfishing attracted lots of attention but also generated bitter disagreement between fisheries scientists and ecologists, such as Ray Hilborn and Boris Worm, which was captured for posterity in the 2009 documentary film "The End of the Line." Nevertheless, the National Research Council report to investigate the ecosystem consequences of fishing acknowledged declines within the range of 65–80%, which is much more than had been acknowledged by fisheries scientists or the fishing industry before Myers and Worm's article appeared (NRC, 2006).

The intensity of this squabble over what turned out to be a relatively small discrepancy in interpretation of the data is symptomatic of the "precisionism" of fisheries managers who tend to forget the limitations of the scientific data and the simplifying assumptions of the models used to calculate truly sustainable catch. A good example is the case of Alaskan pollock (*Theragra chalcogramma*) in the east Bering Sea that have so far sustained one of the largest fisheries in the world that supplies a great proportion of the fish used for frozen breaded fish products that are a staple of the fast food industry. The US National Marine Fisheries Service (NMFS) intensively manages the fishery, providing impressively detailed annual analyses of abundance and stock structure and highly sophisticated models of past and predicted future abundance to provide the basis for setting ecologically responsible quotas for the fishery (Ianelli *et al.*, 2008). But the road to ruin is paved with good intentions and the fishery has been in decline for several years with increasing rumors of population collapse in 2009. Eastern Bering Sea pollock biomass dropped 65% between 2003 and 2008, fishers are traveling greater distances to find fish, and northern fur seals that feed on pollock are in decline (NOAA, 2008).

If the fishery does collapse and has to be shut down to allow stocks to recover, it will cause extreme economic hardship and loss of jobs on the scale of the collapse of Atlantic cod in eastern Canada in 1992 (Walters and Maguire, 1996). How could this happen in 2009? The problem is that the fishery is managed to the margins of what the models say they can catch, based on models that assume we can safely ignore changes in oceanography, climate, and interactions with other species that may have profound effects on reproduction and abundance. Remarkably, the quotas have been reduced by only a small percentage each year, even though the stock of reproductive females has declined steadily and steeply for the past 5 years, because the *model* predicted that the population would recover a few years out (Ianelli *et al.*, 2008), which so far it has not. This policy is equivalent to giving a very large loan to a very large company that is hemorrhaging money on the basis of a revised business strategy that promises increases in profits several years in the future – a very high risk game indeed.

The pollock story may be an extreme case of overconfidence in models, but we don't think so. Perusal of the NMFS website (http://www.nmfs.noaa.gov/) shows that inadequate data are available for a little more than half of the 528 fisheries for which NMFS is responsible, despite the financial resources of the wealthiest economy in the world. Of the remaining 244 stocks, 41 are "subject to overfishing," 42 are "overfished," and 148 are "fully fished" or "not fished to capacity," a category that includes Alaskan pollock. Thus, at best, only 28% of US fisheries are believed to be in good shape and NMFS is managing by wishful thinking. Try to imagine how much worse the situation is in the waters of developing countries whose fish are being overfished by the wealthy nations of Europe, North America, and Australasia (e.g., Kaczynski and Fluharty, 2002).

After several years of pedantic disagreement, Hilborn and Worm assembled a team of fisheries biologists and ecologists to try to resolve their differences (Worm *et al.*, 2009). The authors report: "In 5 of 10 well-studied ecosystems, the average exploitation rate has recently declined and is now at or below the rate predicted to achieve maximum sustainable yield for seven systems." The paper is titled "Rebuilding global fisheries," but "well-studied ecosystems" inevitably refers to the relatively small number of data-rich fisheries that occur within the waters of the wealthy, developed nations that can afford detailed quantitative stock assessments and are best equipped to deal with management. Of the 24 ecosystem models considered in the study, there is one considered from all of Africa, one from all of South America, and zero from Asia (Worm *et al.*, 2009, Fig. 2). Moreover, for the ten fisheries stock assessments examined, none of the data extend further back than the 1970s (Worm *et al.*, 2009, Fig. 3). For all of their impressive quantitative rigor and model building, the authors seem to be grasping for examples of success. For an outsider it seems that, even today, quantitative fisheries management is complicit in fisheries collapses.

If the notion of scientists intentionally resetting baselines seems far-fetched, consider the New England Fisheries Management Council's 2007 stock assessment for monkfish (*Lophius americanus*) in the Northwest Atlantic, which declared that monkfish were not overfished. The 2007 assessment reversed the scientific community's previous understanding about monkfish, which were considered overfished and in great need of rebuilding. There was a perverse reason for the reversal: the new analytic model ("SCALE") for monkfish used to generate the stock assessment was done considering data using a shorter assessment time frame (1980–2006) rather than the previous time frame (1963–2006) when biomass indices from surveys were approximately two times higher than 1980s estimates (NMFS, 2007). Using similar "smoke and mirrors" techniques of analyzing only fish biomass from, say, 2005 onward, we could erase the problem of overfishing around the globe. In fact, this was effectively done with sport fishing records when, in 1996, the International Underwater Spearfishing Association (http://www.iusarecords.com/about.htm) reset world records, creating twentieth century records and a new twenty-first century category, likely because fish were getting smaller.

THE CONFOUNDING ROLE OF THE MEDIA

If some scientists are guilty of clouding the issue with false precision, some media outlets are just as guilty of clouding the issue with misleading imagery that strongly shapes the public's belief about the state of our state of our environment. The most popular movie ever made about fish is "Jaws," not "Empty Oceans, Empty Nets." And although the excellent front-page articles by Ken Weiss (2006) in the *Los Angeles Times* were awarded the Pulitzer Prize, they have not had the same impact as the Emmy-award winning Blue Planet television series that glossed over human impacts. Feature films and commercial television have vastly larger audiences than public television and newspapers.

Successful story telling, which explains the success of "Jaws" and other popular media, thrives on tension. But the media often creates tension between the wrong actors. It has been recognized that the so-called "fair and balanced approach" to science news can be detrimental. As Al Gore pointed out in "An Inconvenient Truth," climate scientists, as represented by their peer-reviewed literature, hold a consensus view on the effects of our carbon emissions while the media continues to report skepticism (Boykoff and Boykoff, 2004; Oreskes, 2004). Similar problems inhibit more realistic discussion of the collapse of fisheries and ocean ecosystems. Likewise, consistently bad news does not make for good entertainment, as is clear from the television shows "E.R.," "Chicago Hope," and "Rescue 911" that portray two-thirds of cardiac resuscitations as successful, whereas in reality rates of recovery after patient resuscitation are closer to 15 percent (Diem *et al.*, 1996). People believe that 70% of CPR patients survive because that is what they see on television, and they believe that the oceans are okay because that is what they see on the Discovery Channel and National Geographic TV.

FUTURE SCENARIOS

Learning about the past is important because it will help us determine our future. We already have glimpses at what could be our "Brave New Ocean" (Jackson, 2001, 2008) – an ocean full of jellyfish, hagfish, and microbes. In the sci-fi novel "The Swarm" (Schätzing, 2006), whales and fish disappear, invasive species foul ships and jellyfish, and toxic blooms takeover. People living near the coast move inland and scientists are the only ones thinking about the big picture. This science-fictional future is painfully close to reality. In Florida, when a red tide comes ashore, the barrier island is now evacuated; the emergency rooms fill up with people with congestive problems and acute asthma (Weiss, 2006). Nobody can live there for weeks if the red tide lasts. This is "Brave New Ocean" and "The Swarm" and it is real. Imagining future scenarios can be very provocative (think Arthur C. Clarke, Aldous Huxley, or H. G. Wells). Schatzing spent several years researching marine issues and the publication of his book led to a large increase in the profile and funding for marine science in Germany where "Der Schwarm" was first published (Worm, 2006). On the other hand, consistently bad news is depressing and causes people to disconnect and give up hope. So we desperately need examples of successful actions that have reversed the seeming inexorable degradation of the oceans.

Overfishing must be stopped immediately and the mandate to rebuild stocks within a 10-year window strictly enforced (Safina *et al.*, 2005). The establishment and enforcement of vastly more and much larger marine protected areas (MPAs) where most wildlife is protected are a good place to start. MPAs work, as evidenced by the increases in fish stocks on George's Bank after large areas were closed to fishing (Rosenberg *et al.*, 2006). They also have welcome unexpected consequences, including the increased resilience of protected coral reef ecosystems to global warming and disease (Knowlton and Jackson, 2008; Sandin *et al.*, 2008). But MPAs represent much less than 1% of the total area of the oceans while most ecologists agree that we need to set aside a third of all habitats and ecosystems as insurance for the future (Wood *et al.*, 2008).

To protect highly migratory species, we need to zone the entire global ocean including the high seas to internationally regulate protection and resource use. Australia has made a dramatic beginning by rezoning to protect one third of all habitats and ecosystems along the entire 2000 km long Great Barrier Reef, a distance similar to the Pacific coastline of the USA from Seattle to San Diego (Pandolfi *et al.*, 2005). The United States has followed by setting aside vast areas of the Pacific within the exclusive economic zones surrounding the Hawaiian Archipelago and the Pacific Trust Territories. These are areas surrounding wealthy nations where relatively few people are affected. The much harder challenge is to extend protection to the waters of developing nations that cannot afford to simply shut down the livelihoods of their starving poor, and to the high seas that have been traditionally open to plunder by anyone with the resources to do so. Or we can do nothing and wait for catastrophe to knock, as it surely will. The choices are ours.

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