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Synthesis, part of a Special Feature on The Privilege to Fish

Fishful Thinking: Rhetoric, Reality, and the Sea Before Us

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ABSTRACT. Fisheries science and management have been shrouded in controversy and rhetoric for over 125 yrs. Human reliance on fish through history (and even prehistory) has impacted the sea and its resources. Global impacts are manifest today in threatened food security and vulnerable marine ecosystems. Growing consumer demand and subsidized industrial fisheries exacerbate ecosystem degradation, climate change, global inequities, and local poverty. Ten commonly advocated fisheries management solutions, if implemented alone, cannot remedy a history of intense fishing and serial stock depletions. Fisheries policy strategies evaluated along five performance modalities (ecological, economic, social, ethical, and institutional) suggest that composite management strategies, such as ecosystem-based management and historically based restoration, can do better. A scientifically motivated solution to the fisheries problem can be found in the restorable elements of past ecosystems, if some of our present ideology, practices, and tastes can be relinquished for this historical imperative. Food and social security can be enhanced using a composite strategy that targets traditional food sources and implements customary management practices. Without binding laws, however, instituting such an ethically motivated goal for fisheries policy can easily be compromised by global market pressures. In a restored and productive ecosystem, fishing is clearly the privilege of a few. The realities of imminent global food insecurity, however, may dictate a strategy to deliberately fish down the food web, if the basic human right to food is to be preserved for all.

Key Words: *back-to-the-future; ecological ethics; ecosystem restoration; fisheries management; fishing down the food web; food security; policy goals; the sea ahead; trade-offs*

INTRODUCTION

Fisheries science and management (Pitcher et al. 1998) are ensnared within a 125-year-old controversy (Sims and Southward 2006) over the status (Hilborn et al. 2003) and impacts (Pauly et al. 1998*a*, 2005) of the fishing enterprise. Some regard fisheries as largely successful (e.g., Beddington et al. 2007, Hilborn 2007*a*,*c*,*d*), with only "minor" ecosystem impacts (Sibert et al. 2006). Other scientists report serious problems with modern commercial fisheries: inadequate data (Watson and Pauly 2001, Pauly 2007), poor compliance (Pitcher et al. 2008, 2009*a*,*b*), inappropriate incentives (Hilborn et al. 2004, Grafton et al. 2006, Hilborn 2007*b*, Rosenberg 2009), incomplete valuation (Sumaila 2005, 2007, Lam and Sumaila 2008), failed management (Walters 2007), vague policy goals (Pauly et al. 2003, Pitcher and Ainsworth 2008), dysfunctional institutions (Hanna 1998, Hilborn et al. 2005*a*, Acheson 2006), and ineffective governance (Sutinen and Soboil 2003, Kooiman et al. 2005, Crowder et al. 2006, Grafton et al. 2007, Jentoft 2007, Bromley 2008, Lam and Pauly 2010). A surging human population and widening socioeconomic disparity, both among and within nations, raises the specter of global food security shortfalls and unsustainable exploitation of natural resources. Modern consumer demand, heavy industrialization, international markets, and government subsidies exacerbate global inequities that challenge our ability to govern complex fishery systems (Garcia and Charles 2008).

Less fish brings plenty of advice on how to improve fisheries (e.g., Francis et al. 2007, Roberts 2007) despite sparse diagnostic data. More beguiling management strategies tend to be utopian, narrow, and prescriptive, rather than practical, holistic, and adaptive. They generally take this form: "If only we could do "*x*," then all will be well with fisheries;" but merely wishing for something like "*x*," however

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attractive, does not make it so. This "fishful thinking" reflects an aging chestnut in philosophy, known alternatively as "Hume's Guillotine" (Hume 1740) or the "Naturalistic Fallacy" (Moore 1903), which states that you cannot get an "is" from an "ought," an old adage that has generated vast commentary in philosophy but is likely unknown in fisheries science. Indeed, the fisheries literature is full of authors "fishfully" moving from "oughts" to "ises", with simple management "cures" and policy "prescriptions": in truth, the reality of modern fisheries as complex, dynamic, and coupled human-and-natural systems (Liu et al. 2007*a*,*b*) is missed by such well-intended, but misguided rhetoric.

FISHFUL THINKING: FALLACIES OF SIMPLE SOLUTIONS TO A COMPLEX PROBLEM

Despite authors who have recently emphasized that the complexities of fisheries management cannot be solved by "panaceas" (Ostrom 2007) or "technical fixes" (Degnbol et al. 2006), simple solutions and fallacious arguments are still promulgated. It might be thought that simple versions of these arguments are but "straw men" (logical fallacies where irrelevant topics are presented to divert attention from the original issue), propped up so that they may be easily knocked down; however, presenting and refuting a weakened form of another's arguments is valid and not a straw-man argument. Here, we describe ten common "if-only" fishery palliatives that can fall foul of Hume's Guillotine. For each case, we present the basic "weak" form of the panacea or technical fix, refute this weaker proposition, then follow with a "strong," more nuanced view of the augmented management strategy. The summary below, although thorough, is not intended to be definitive, but rather to illustrate the streams of management alternatives currently flowing into the fisheries literature and policy debates. Only by discarding fallacious arguments can we better explore viable policy options that can begin to address the real complexity of modern fisheries and societal challenges.

Privatization of resources

Currently in vogue and the topic analyzed by this Special Feature is the fisheries economists' nirvana: "If only we could privatize fishery resources, then all will be well with fisheries" (Grafton et al. 2006, Beddington et al. 2007, Costello et al. 2008). This trend toward privatization of fishery resources (Neher 1996, Hannesson 1998, 2005) arose from economists extending the legal concept of property rights to public-trust natural resources (for critiques, see Bromley 2005, 2008, 2009), where fishermen are given "ownership rights" or individual transferable quotas (ITQs) to harvest exclusively an allocation of a nation's fishery resources. The theory of ITQs (Grafton 1996, Arnason 1998) is that a market will be set up in which harvest rights can be traded (Christy 1997), giving fishermen not only "ownership" but also a financial incentive to manage the fishery resources wisely, thus ensuring long-term sustainability (Fujita et al. 1998). Proponents of ITQs argue this will reduce conflict over scarce resources, end the race for fish, and fund management, enforcement, and research, free of public subsidy (Grafton et al. 2006). But, in practice, many legal issues about what is actually owned and how remain unresolved (Eythórsson 2000, Macinko and Bromley 2002, 2004, Libecap 2008, Wyman 2008). And with highly valuable resources, even ITQs do not eliminate cheating and illegal fishing: a classic example is the destruction of the Chilean squat lobster fishery under ITQs (Castilla et al. 2007).

Fundamentally, ITQs and allied "free-market" approaches (Jennings 2007) suffer from the "ownership-promotes-stewardship" fallacy (Bromley 2008, 2009). As assigned catch shares of the total allowable catch (TAC), ITQs are not property rights but rather dedicated access privileges (Macinko and Bromley 2002, 2004, Fujita and Bonzon 2005, Hilborn 2007*a*) and thus only limit entry and access to fishery resources. Moreover, ITQs suffer from social justice issues (Schreiber 2001, Lam and Pauly 2010) in the initial allocation of harvest quotas and subsequent concentration of quotas to large-scale fishing enterprises, which can be exacerbated by leasing (Pinkerton and Edwards 2009). Iceland, an early ITQ adopter, has witnessed improved economic efficiency and reduced fleet size but suffers the social costs of increasing overall fishing capacity, concentrating quotas into larger firms, marginalizing small communities, and escalating conflicts within small-scale fisheries and crew (Jennings 1999, Eythórsson 2000, Alcock 2002, Coastal Communities News 2002). With appropriate TACs, better enforcement and monitoring, and an ecosystem-based approach, the track record of ITQs suggests that they can improve fisheries management, but not always (Chu 2008, Branch 2009): indeed, early ITQ proponents (Hilborn et al. 2005b) admitted that “[r]ights-based management is not a silver bullet, and is probably not appropriate for all fisheries.” An analysis by Clark et al. (2010: 209) states that “[t]he ‘optimists’ maintain that there are no effective limits to privatization and that the decades old fear that privatization could, in some cases, lead to resource extinction are of theoretical interest only. We argue that these fears are, regrettably, not baseless and that there are definite limits to socially desirable privatization.” And so the debate over incentive-based vs. regulatory-based management approaches continues (Gibbs 2009).

Total Economic Valuation (TEV)

Separate from market transactions is the need to capture the non-market value of fishery resources (Sumaila 2005): “If only we could capture the total economic value (TEV) of ecosystem services and future generations, then all will be well with fisheries.” Only by valuing the market and non-market benefits that aquatic resources contribute to society (National Research Council of the National Academies 2004) will resilient marine ecosystems (Levin et al. 1998) be sustained with healthy and productive fish stocks. Provisioning, regulating, cultural, and supporting global ecosystem services (Daily et al. 1997, Millennium Ecosystem Assessment 2005) have been valued at US$33 trillion per year (Costanza et al. 1997). But placing financial value on ecosystem services through market-based instruments (Brown et al. 2007) may not bode well for nature or the poor, without appropriate scientific understanding, legal frameworks, and market mechanisms. Environmental markets with the goal of preserving or restoring ecosystem services may actually accelerate their degradation (Palmer and Filoso 2009) and exacerbate global wealth disparities. Although TEV endows the ecosystem that supports the standing fish biomass with value beyond its marketable landed catch value, including option, existence, and bequest values, it is based on individual preferences aggregated for society and so does not value public goods with societal considerations of ecological sustainability or social equity (Dasgupta and Mäler 2004). Intergenerational equity foregoes rewards to present generations to benefit future generations, who would value future resources more, and so discount less than present generations (Sumaila 2004, Sumaila and Walters 2005). In the case of Newfoundland cod, which suffered chronic overfishing and a notorious collapse in the early 1990s (Rose 2007), intergenerational discounting would have rendered uneconomic the actual harvest profile of the healthy cod stocks present in 1985, favoring a more conservative, sustainable long-term strategy, whereas conventional discounting, with the discount rate set to market interest, advocated heavy fishing (Ainsworth and Sumaila 2005).

In theory, TEV captures the non-market value of fishery resources, but in practice, as ecosystem goods and services become scarcer and more valuable, they are prone to conversion to market values that may compromise the basic needs of the poor while creating opportunities for the rich. Consider the dilemma faced by an artisanal fisherman living in poverty: should he curb his fishing pressure and think of the ecosystem or future generations when he needs to feed his family today? Or in wealthy nations, how will individuals and societies shift to value the future or non-consumptive uses when the global economy is driven by financial incentives based on resources and commodities valued in today’s market? George Sugihara and colleagues (May et al. 2008) have proposed a futures market in fisheries (Dalton 2005, 2006) with an “Ocean Resource Exchange” trading in two types of derivatives: futures contracts for a percentage of a fisherman’s catch at an agreed price at a specified future time and one for trading fish quotas today. With global society still reeling from the financial collapse of December 2008, such ventures are less than alluring, but even apart from a more risk-averse mentality, this would be riddled with uncertainty and create a perverse incentive for venture capitalists to reduce the supply of fish being traded to raise their future stock value. To date, most simulations of application of pure economic goals for fisheries result in the rapid destruction of biodiversity and resources (e.g., Ainsworth et al. 2008a), and moreover, all known real-world examples overwhelmingly support this conclusion. Lam and Sumaila (2008) have proposed a socioeconomic framework for fisheries valuation and analysis that attempts to capture, in addition to the financial, the ecological, social, and cultural value of fish, as well as be practical for management and policy. Meanwhile, traditional Pacific Northwest indigenous societies have a seven-generational, holistic perspective, based on their beliefs in reincarnation and that all ecosystem elements are relatives (Trosper 2009).

Laissez-faire

A common rallying call from fishermen is “If only commercial fishermen were allowed to manage their own fishing, free from governmental interference, then all will be well with fisheries.” This laissez-faire strategy presumes that fishermen can influence the market to favor the most efficient allocation of fishery resources and evolve sustainable fisheries. For example, it was argued that the Newfoundland cod collapse (McCay and Finlayson 1995) might have been averted if fishermen were allowed to self-regulate using their inshore fishermen’s knowledge, all but ignored by the Canadian fishery agency responsible (Matthews 1995). This argument has been extended to letting the industry, under protection against new licenses, reduce fishing effort by financing buybacks of licenses, treated as fully transferable catch rights (Martell et al. 2008). However, private-interest groups with political power, such as commercial fishermen, often influence fisheries management and policy decisions against conservation (Rosenberg 2007), creating perverse economic incentives (Lam and Pauly 2010), notably subsidies (Munro and Sumaila 2002, Clark et al. 2005, Sumaila et al. 2007), which enable fishing enterprises to fish when it would be otherwise uneconomical if costs and benefits were strictly market determined or “internalized.” Fishermen, behaving rationally from the perspective of their private interests, can also collectively destroy a resource if the financial benefits of extracting the resource today exceed the value, to the fishermen, of maintaining a healthy stock tomorrow (Clark 1973, Clark et al. 2010). So the laissez-faire strategy in fisheries management is a two-edged sword, as both governmental interference or favoritism and fishermen’s financial incentives can collapse a stock.

Selective fishing technology

Another utopian, industry-driven solution is “If only we could improve fishing technology, then all will be well with fisheries.” Fishing gear selected for regulated species, sizes, and ages (Kennelly and Broadhurst 2002, Kennelly 2007) and no damage to benthic habitats (as caused by trawling and dredging) can reduce harm of overfishing to stocks and ecosystems caused by fisheries discards, unwanted by-catch, and collateral damage to habitats. But fishing technology has evolved over millennia to increase fish catch and the number of target species caught (Pitcher 2001), to travel greater distances to new habitats (Roberts 2007) and greater depths (Morato et al. 2006). Enhanced refrigeration (Roberts 2007) and other preservation methods (Sivertsvik et al. 2002) can also store caught fish for longer periods. The effect has been serial depletion of species and fished areas (e.g., Berkes et al. 2006, Branch et al. 2006), while fishermen benefit from globalization of markets (Pauly and Maclean 2003). So, even if selective fishing technology and harvest quota regulations are in place, improved fishing technology alone is unlikely to address conservation issues. The motivation of fishermen to enhance fishing technology is to increase profits from fish caught by catching and storing fish more efficiently and effectively. Poor compliance will continue to be an issue in by-catch reduction unless management creates incentives to encourage the uptake of selective fishing technology into fishing practices. Alternative rewards that can compete with economic incentives of fishermen to discard by-catch might be the adoption of improved fishing gear design that can make the fishing enterprise more efficient economically, while conserving fish.

Marine Protected Areas (MPAs)

An alternative to selective fishing technology is to ban fishing selectively: “If only we could set up extensive marine protected areas (Ballantine 1997, Lubchenco et al. 2003, Roberts et al. 2005), then all will be well with fisheries (Roberts et al. 2001).” Marine protected areas (MPAs) are protected areas of the ocean where human activities are restricted, typically to achieve conservation objectives, such as preserving marine biodiversity (Sumaila and Charles 2002, Bohnsack et al. 2004). “No-take” marine reserves are MPAs permanently closed to all fishing and other extractive uses (Ballantine 1997), whereas zones of integrated ocean management are MPAs that regulate uses within a zoned area or network of zones (Lubchenco et al. 2003). Marine protected areas serve as ecological “insurance policies” or “hedges” against scientific uncertainty, as in stock assessments (Lauck et al. 1998). They are not the panacea originally envisaged (Pauly et al. 2002, Norse et al. 2003) but are useful ecosystem-based management tools for marine conservation and sustainable fisheries. By protecting against ecological risks, MPAs can encourage growth in depleted species, restore fish habitats, provide protected source and/or settlement zones for larvae, and create spill-over areas, enhancing recruitment and fishing activity at their boundaries. Although trophic cascades may result from higher population densities inside the MPA, studies suggest greater benefits from larger MPAs and for MPA networks that take advantage of oceanographic linkages (e.g., Roberts 2001, 2005, Russ 2002, Gell and Roberts 2003, Wood and Dragicevic 2007).

Despite their vaunted advantages, MPAs have not been hugely successful, being too few and too small and ecological recovery and implementation too slow, in arresting the decline of marine ecosystems (see, e.g., Agardy et al. 2003, Caddy and Seijo 2005, Jones 2007, Ballentine and Langlois 2008). As of 31 December 2006, only 0.65% of the world's oceans and 1.6% of the marine areas under national jurisdiction were nominally protected, with 0.08% and 0.2% no-take (Wood 2007, Wood et al. 2008). Attempts to establish MPAs have exposed complexity in several dimensions that policy makers must negotiate with affected communities: ecological (Allison et al. 1998, Guénette et al. 1998), socioeconomic (Sumaila and Charles 2002), and sociopolitical (Guénette et al. 2000, Mascia 2003, Agardy 2005). Effective selection, design, and management of MPAs require both local community and centralized government authority, with scientific and socioeconomic objectives clearly identified, combined with "best-practice" reference points (Sainsbury and Sumaila 2003) and enforceable management priorities (Jones 2002, 2007). An analysis of compliance of the top 53 fishing nations with the MPA provisions of the United Nations' "Code of Conduct for Responsible Fisheries" (Pitcher et al. 2009*b*) awarded only 15% "good," and over 80% "fail" grades.

Single-species stock assessment

A less drastic governmental intervention than MPAs, conventional single-species management strategies hold the implicit belief that "If only we could get stock assessments right, then all will be well with fisheries" (e.g., Beverton and Holt 1957, Walters and Maguire 1996, Punt et al. 2008). Quantitative fishery scientists generally prescribe complex models with real-time data acquisition of fish population dynamics data to monitor stock responses to varying environmental and fishing pressures (e.g., Sainsbury 1998, Walters and Martell 2004). By "confronting" (Ludwig et al. 1993) all sources of uncertainty with Bayesian models (e.g., Punt and Hilborn 1997) and statistical decision analysis (e.g., Peterman et al. 1998), it is implied that rigorous modeling (Schnute and Richards 1994) will give reasonably accurate snapshots of fish biomass. Appropriate harvest allocations can then be set at sustainable yields (Rosenberg et al. 1993) for successful management within the fishing industry (Hilborn 2007 *a*,*c*,*d*). However, single-species fisheries science neglects complex multi-species and human interactions (Mace 2001), such that stock assessment analyses, although quantitative, often miss critical factors in the real fisheries dynamics. And although sophisticated single-species, density-dependent population dynamic models are used routinely in fisheries assessments, they are data intensive and parameter rich, yet the overwhelming majority of the world's fisheries are data poor. Two robust solutions to these limitations are to use multi-species or ecosystem models, predictions of which can and often do differ from single-species assessments (e.g., Walters et al. 2005), and to approximate yield estimates from life-history parameters (e.g., Forrest et al. 2008). But often the institutional hurdle of implementing the TAC estimated from such models, however sophisticated, proves infeasible.

Ecosystem-based management (EBM)

Going beyond conventional single-species approaches, "If only we could apply ecosystem-based management (Food and Agriculture Organization (FAO) 2003*a*, Pikitch et al. 2004, McLeod et al. 2005), then all will be well with fisheries." Ecosystem-based management (EBM) focuses on ecosystem links (Larkin 1996) to preserve the structural integrity, healthy functioning, and resilient processes of marine ecosystems and strives to achieve regional cooperation in their management (Sherman 1995). More comprehensive than single-species or sectoral management, from both scientific and governance perspectives (Sissenwine and Mace 2003, Ruckelshaus et al. 2008), EBM is a holistic approach that considers the integrated human–natural ecosystem (Grumbine 1994, 1997, Maguire et al. 1995, Mangel et al. 1996, Mooney 1998, Carpenter and Gunderson 2001, Liu et al. 2007*a*,*b*) to sustain vital services to humans (Browman and Stergiou, 2004, 2005, Rosenberg and McLeod 2005). Closely allied to EBM is the Ecosystem Approach to Management (EAM, FAO

2003*b*), which differs only in its emphasis on retaining as much of the single-species approach as possible. This EAM has been recently extended to examine the human context and dimensions involved in its full implementation (De Young et al. 2008).

Despite highly optimistic claims by its proponents, we know of no cases where applying EBM has yielded its expected benefits. Implementing the FAO stock-specific “traffic-light” reference points approach to EAM will be problematic without proven, simple-to-measure EBM indicators (Caddy and Mahon 1995, Collie and Gislason 2001), a task more difficult than envisaged, especially in data-poor fisheries (Link 2005). Even in data-rich fisheries, complex multi-species interactions with multiple stakeholders in EBM (Leslie et al. 2008) can inadvertently heighten the exploitation of resources managed by multiple agencies with diffusely coordinated mandates. In Norway, EBM has even been used to argue for raising quotas for minke whales to offset their fish consumption (High North Alliance News 2004). If institutions can be designed flexibly to manage complex social–ecological systems, incorporating broad yet effective participatory and inter-governmental decision-making strategies, EBM might lead to adaptive management that is robust in the face of scientific uncertainty (Francis et al. 2007, Hofmann and Gaines 2008, Levin and Lubchenco 2008, Palumbi et al. 2008). But, based on the practical framework of Ward et al. (2002), evaluation of the status of EBM implementation in the 33 top fishing nations revealed dismal results: no country scored a “good” grade, only four were within acceptable range, and 18 had “fail” grades (Pitcher et al. 2008). At its best, EBM does have the potential to succeed as a composite management strategy, if it incorporates some of the other policy instruments discussed here.

Community-based management (CBM)

Alternatively, devolving some government authority to civil society, “If only local communities (see Pinkerton and Weinstein 1995) and fishermen (Haggan et al. 2007) could co-manage (Jentoft 1989, Jentoft and McCay 1995, Wilson et al. 2003) their resources, then all will be well with fisheries.” If local stakeholders and coastal communities participate or share authority in managing local resources, according to social scientists (Harris 1998, Jentoft 1998, Newell and Ommer 1999), there would be less overfishing by fishermen employing local ecological knowledge (LEK) in their harvesting strategies.

Co-management can empower local resource users and encourage conservation of the natural resources on which they depend for food and livelihood (Berkes 2004). Successful community-based management of fishery resources has evolved in Asia and the Pacific Islands (Ruddle 1998*a*,*b*,*c*, Johannes 2002, Ruddle and Segi 2006), Alaska (Kellert et al. 2000), British Columbia (Pinkerton 1999*a*), and the Maine lobster fishery (Acheson and Gardner 2005), but for a counterexample in Fiji, see Dulvy and Polunin (2004). If traditional socioeconomic systems governed by customary practices and laws (Trosper 2009) are allowed to determine fishery management plans and policies (Pinkerton 1999*b*), some of the environmental damage of large-scale, industrial, mixed-stock fisheries can be avoided. But local CBM lacks a global perspective and ecosystem-scale knowledge to set management and conservation goals (Weber and Iudicello 2005). Although the “rationale for community management is often compelling and convincing,” in a lucid review of five community resource management schemes worldwide, Kellert et al. (2000) concluded that “serious deficiencies are widely evident.” Community management does not necessarily produce its often-claimed benefits of more equitable distributions of power, economic returns, reduced conflict, use of traditional ecological knowledge, protection of biodiversity, food security, and sustainable use. In two North American examples (Kellert et al. 2000), key factors in achieving a higher level of success included: strong financial investment, robust local infrastructure, targeted public education, and strong legal support.

Traditional ecological knowledge (TEK)

An increasingly popular strategy, but fraught with cultural hurdles, is “If only we could incorporate traditional ecological knowledge (Kurien 1998, Berkes et al. 2000, Pierotti and Wildcat 2000, Folke 2004, Manseau et al. 2005, Menzies 2006, Berkes 2008) and indigenous peoples’ cultural wisdom of the natural world (Snyder et al. 2003, Garabaldi and Turner 2004, Lam and Gonzalez-Plaza 2006), then all will be well with fisheries.” A contribution in this Special Feature of Haida integrated marine planning (Jones et al. 2010) highlights British

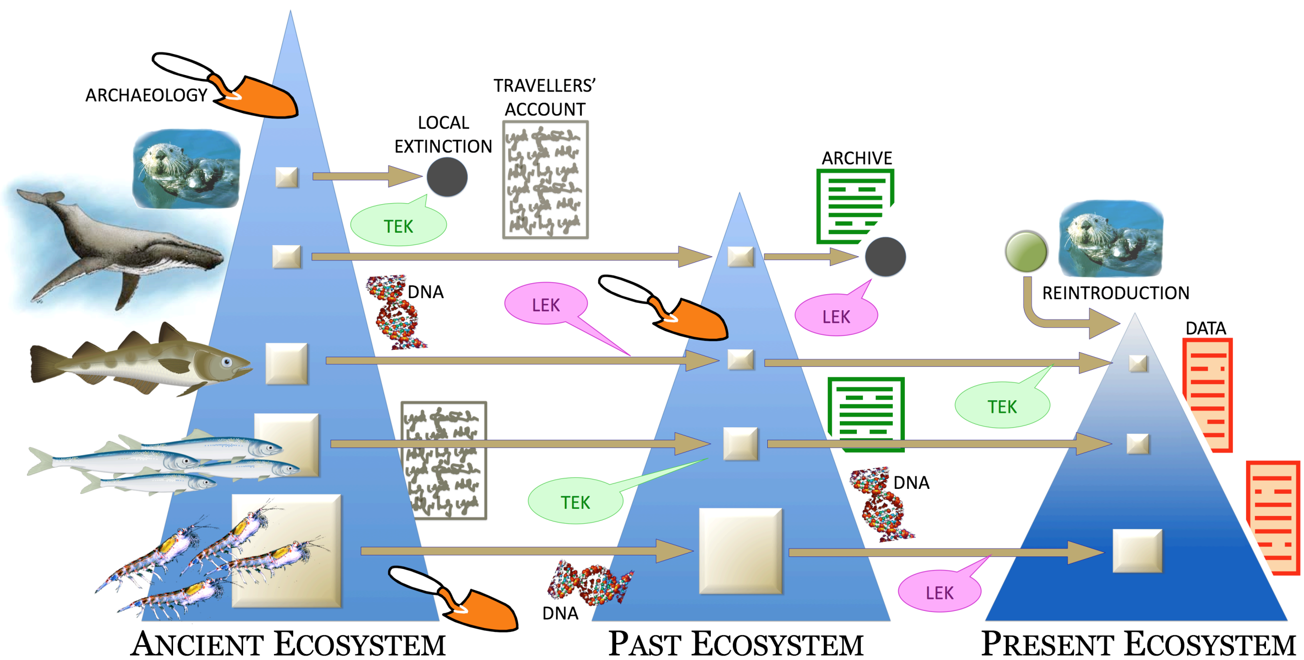
Columbia First Nations' perspectives on TEK in marine conservation (Drew 2005) and stewardship (Power and Chapin 2009). The benefits of incorporating TEK and LEK in fisheries management (Pierotti and Wildcat 1999, Haggan et al. 2007) and governance (Ruddle 1998*b*, Pinkerton 1999*a*, Jones 2000, Mackinson 2001, Johannes 2002) can be profound, but the more diverse and numerous the stakeholders, the more challenging and complex the management and governance (Pauly et al. 1998*b*). Lack of cross-cultural understanding often arises from differing cultural values of natural resources (Kirsch 2001, Lucas 2004), and cognitive models of nature can vary greatly with culture (Bang et al. 2007). Education in diverse ways of knowing may be one remedy, but is a slow process (Lam 2008). Although published persuasive examples of indigenous sustainable husbandry of resources are limited (e.g., Johnsen 2001, 2009, Deur and Turner 2005, Langdon 2007, Berkes 2008, Trosper 2009), they do challenge interpretations of archaeological evidence and analysis based on human foraging theory (Alvard 1993, Krech 2000, Alroy 2001, Ambrose 2001, Winterhalder and Smith 2002, Gillespie 2008).

Historically based restoration

In a simple sense, ecological restoration could also be characterized as a naturalistic fallacy: "If only we could go back to the way things were." But from a more realistic and complex perspective, this strategy is a composite of many of the previously discussed instruments. Lessons from history teach us that, rather than sustain fisheries, we have serially depleted, with ratchet-like increases in technological ingenuity, previously inaccessible resources (Pauly et al. 1998*a*, Pitcher 2001, Ainsworth et al. 2008*b*). Marine ecosystems have been fundamentally altered by overfishing, over millennia in some cases, and greatly accelerated in the past 50 years (Jackson et al. 2001, Pitcher 2001, Roberts 2007). Compelling evidence has been assembled from diverse locations and ecosystems (e.g., coral reefs: Pandolfi et al. 2003; large pelagic predatory fish: Myers and Worm 2003, but see Sibert et al. 2006; deep sea fisheries: Morato et al. 2006; seamounts: Pitcher et al. 2010). Informal data gathered from local fishermen typically support the contention that many fished ecosystems have been severely degraded (e.g., Sea of Cortez: Lozano-Montes et al. 2008, Saenz-Arroyo 2005*a*,*b*; Papua, Indonesia: Ainsworth et al. 2008a). Fishery managers often say that drastically altered systems, such as in Newfoundland, the Gulf of Thailand, or the South China Sea (Cheung and Pitcher 2008), are "still productive." Although this may be true in terms of fishery food products, degraded ecosystems comprise less valuable and desirable food species, are less biodiverse, and are less buffered against change. Ecosystems may unexpectedly become so degraded from fishing as to shunt energy into non-fish organisms (e.g., jellyfish and the "microbial loop"). And some ecosystems may never recover. We can avoid critical thresholds or "tipping points" (Marten 2005, Lenton et al. 2008, United Nations Environment Programme 2009) by first recognizing that ecosystems today are generally in degraded states compared with ancient ecosystems (Jackson and Hobbs 2009), and then proactively altering policy objectives.

To design an effective restoration strategy and policy goal, the history of a fishery must be understood (Costanza et al. 2007, Roberts 2007, Starkey et al. 2008). Reconstruction of past ecosystem states has been recognized in policy analyses as one hopeful way forward (e.g., in the United Kingdom, Royal Commission on Environmental Pollution 2004), a pragmatic but widely misunderstood restoration goal. Reconstruction of the past is confounded by local fish population extinctions, climate fluctuations, and human technological adaptations. Despite these considerable uncertainties, holistic ecosystem models, such as mass-balance and agent-based frameworks, can provide approximate quantitative snapshots of historical ecosystems. Figure 1 depicts this schematically for sample ecosystems, using archaeology, travellers' accounts, archival records, LEK and TEK, and scientific data, including rich information from DNA diversity analyses (see also Heymans and Pitcher 2004, Ainsworth et al. 2008*a*, *c*). "Back-to-the-Future" (Pitcher 2005) is a rigorous historical and holistic approach unlike other policy options: it is based on a profound historical and bioeconomic imperative for management. With a multi-disciplinary, semi-quantitative ecosystem evaluation framework (Pitcher 2005), this policy tool for the restoration ecology of the oceans can characterize marine ecosystems and evaluate the status of threats to biodiversity, sustainability, and ecosystem functioning. It has led to a practical restoration agenda based on achievable EBM employing the concept of optimal restorable biomass (Pitcher 2008, Pitcher and

Fig. 1. Holistic ecosystem models, such as mass-balance and agent-based frameworks, can provide approximate quantitative snapshots of historical ecosystems (triangles) and the biomass trajectories of organisms within them (boxes and arrows), based on archaeology, travellers' accounts, archival records, traditional (TEK) and local (LEK) ecological knowledge, and scientific data, including rich information from DNA diversity analyses.

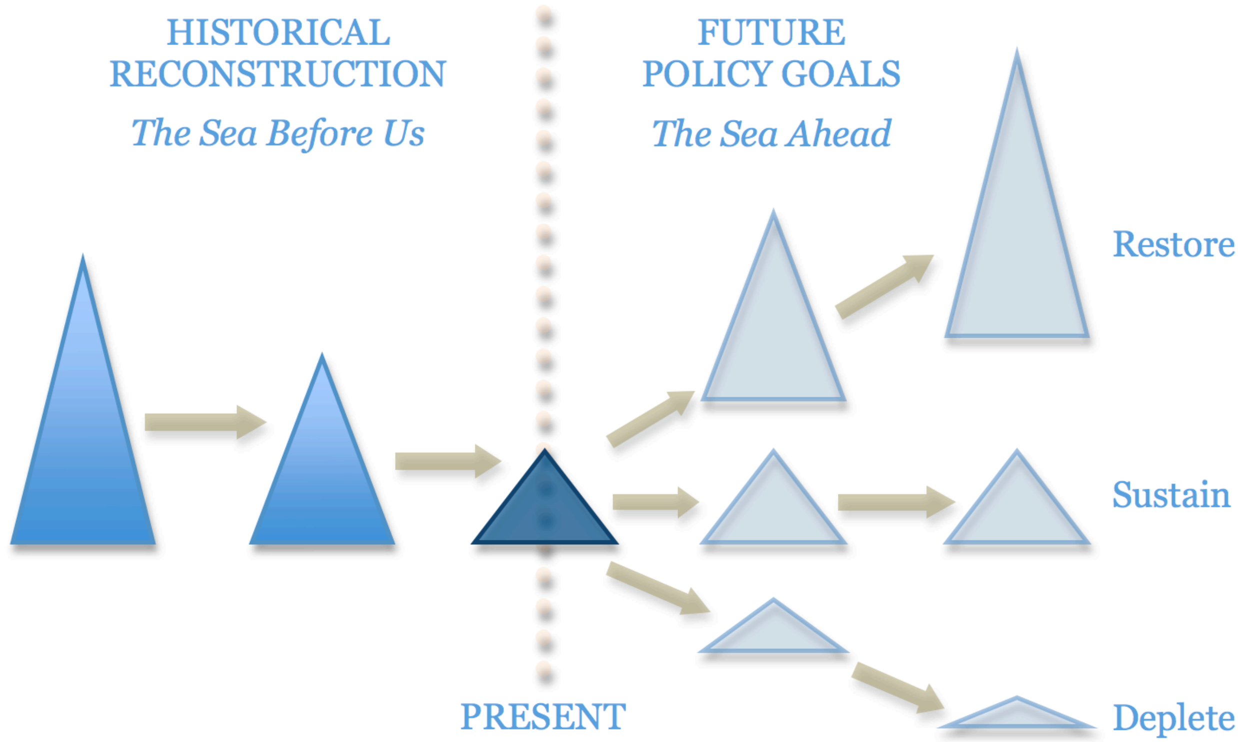


Ainsworth 2008). Fisher-led techniques in bycatch reduction may improve food security through a resilient fishing strategy "across the food web" (Pitcher and Ainsworth 2010). Management policy goals must aim to restore functioning, viable, and robust ecosystems and fish populations, not just sustain the biomass of depleted stocks (Pitcher and Pauly 1998). Historical reconstruction ("The Sea Before Us") and ecological restoration ("The Sea Ahead") are mandatory, in our view (Fig. 2), to rebuilding fisheries with bioeconomic and socially acceptable optima.

DISCUSSION

A fundamental flaw with all this "fishful thinking" is the widespread absence of well-defined, achievable targets for fisheries management. Long-term policy goals are an essential component of the FAO's "Code of Conduct for Responsible Fisheries" (FAO 1995), a comprehensive but voluntary set of management rules that nations should address to sustain their fisheries. Compliance, unfortunately, is poor, as evaluated with a rapid appraisal technique ("Rapfish," Pitcher and Preikshot 2001). Most jurisdictions have not defined policy goals to track their progress in fisheries management: of 53 fishing nations (representing over 95% of the world's catch), 18 failed completely, and only 24 scored "good" on this criterion (Pitcher et al. 2009*a*,*b*). Without specifying policy goals, any or all of the above fisheries management solutions, even if well-implemented, will go awry. Policy goals are visions of what a society desires for its future; they must reflect two aspects of fisheries not yet discussed in the context of the ten management strategies above, namely ecological ethics and governance institutions.

Fig. 2. Management policy goals today should aim to restore functioning, viable and robust future ecosystems (faint triangles), informed by historical reconstructions of ancient and past ecosystems (Figure 1), The Sea Before Us, to not deplete or merely sustain, but restore future fisheries, The Sea Ahead.



Ecological ethics: trophic trade-offs and food security

The urgent global need for human food may soon override any desire for sustainable management. Already, starvation is a reality in many parts of the developing world and the growing food shortage suggests a future in which demand for protein will only intensify. Many forecast a looming food-production gap as the human population escalates and major food-production processes become seriously constrained, both on land and in the sea. In fisheries, estimates of the gap between food demand and production range in the order of 30 million tonnes yearly of protein over the next 20 years (Delgado et al. 2003, FAO 2004). Whereas fishing down the trophic levels in marine food webs has been identified as a perverse symptom of overfishing, causing the serial depletion of predatory fish (Pauly et al. 1998*a*, Christensen et al. 2003), some have argued that we may have to do this deliberately to mitigate the problem of global hunger, especially amid concerns regarding the sustainability of terrestrial agriculture. Economic pressures and market values for increasingly scarce protein will surely exacerbate such tendencies. Intentionally fishing down the food web might well provide more food as biological production increases roughly ten-fold for each decrease in trophic level (Pauly and Christensen 1995).

Today's global fisheries operate at an average trophic level of about 3.3, so reducing this to 2.3 would theoretically increase the world's food harvest ten-fold. This prediction is an optimistic upper bound, however, as changes to food webs are unpredictable, and some organisms, known to bloom in trophic cascades (e.g., jellyfish and toxic phytoplankton), cannot be easily harvested or eaten by humans. More complex ecosystem analyses have estimated the amount of krill (planktonic euphausiids) that can be harvested sustainably from the world's oceans to provide easily assimilable protein for human consumption: e.g., using ecosystem modeling to minimize risks to biodiversity, trophic needs of krill predators, and sustainable benefits to existing fisheries, preliminary estimates suggest this precautionary krill harvest could give three times the protein of present fishery yields (Pitcher 2008). This raises an ethical question: under the exigencies of food security, would harvesting this planktonic resource, albeit in a precautionary manner, transform the privilege to fish into a basic human right to food?

Food-security issues have intensified where fisheries markets have opened up from global trade and industrial capacity. Forage fish, i.e., small and medium-sized pelagic fish eaten by larger fish, seabirds, and marine mammals, are increasingly caught for non-food purposes: as reduction to fishmeal, feed for poultry and carnivorous fish in aquaculture, and fish oil used in the food industry (Watson et al. 2006). As schooling fish, forage fish are easy to capture, requiring less fuel and reducing costs by nearly 40% (Watson et al. 2006). Their reduction to fishmeal and fish oil, however, has augmented market demand, causing prices to go up, just as their direct consumption for food has gone down (Alder et al. 2008); indeed, industrial uses of forage fish products compete with traditional human consumption of these lower trophic-level fish, especially in developing nations (Alder and Pauly 2006). Although Europeans may cope with eating less herring and sprats, Indonesians, Indians, and Africans suffer when sardines are turned into fishmeal for export, rather than marketed locally as food. This use of forage fish has thus become a privilege of the wealthy, over a right of the poor.

Pressure on forage and traditional fishes can easily compromise conservationist, not just human ethics. For example, in salmon aquaculture (Power 2008), the risk to wild salmon of farmed escapees and sea lice infestation aside, the ratio by weight of wild forage fish fed to farmed salmon produced is 3.16, whereas for the ten most commonly farmed types of fish and shell fish, this ratio ranges from 0.75 for carp to a staggering 5.16 for marine finfish (Naylor et al. 2000). Considerations of global food security should restrain this type of aquaculture, given the inefficiency of protein conversion from low-trophic-level forage fish to high-trophic-level predatory fish, such as salmon, whose marine trophic level is analogous to that of lions in terrestrial webs (Morton and Volpe 2002). But the main consumers of farmed finfish live in affluent countries, who no longer have a taste for forage fish, whereas poor citizens in developing countries, having little influence on global markets, lose their forage fish to eat. The complex interplay between the ethical and ecological dimensions in fisheries is highlighted also in the destruction by fishermen, living in poverty and close to starvation, of many traditional fish stocks, including the "chambo" (a herbivorous pelagic tilapia), the national fish of Malawi. These stock depletions occurred despite management rights being devolved to local fishing communities in Lake Malawi and the Philippines (Pitcher 2006). Such overfishing is clearly unsustainable, as starving people forced to "eat the seed corn" are unable to discount their present food needs to save the fish for next year's bounty. With such dire circumstances increasingly common, fishing to eat "in extremis" must be viewed as a right, not a privilege.

Thus, the unavoidable ethical imperative for fishery scientists, from both the natural and social sciences (Ommer et al. 2008), is to find viable ways to mitigate such trophic trade-offs between immediate local food needs and long-term global food security: indeed, our simplistic dichotomy between the right and privilege to fish is not so much a choice as a trade-off between present and future valuing, with local and global impacts. The policy solutions to the global fisheries problem, contextualized to local needs, will require all of the complex tools of fisheries science described above. Options may entail steering both fishermen and consumers away from today's ecologically costly and heavily subsidized fishing practices to find other fish in the sea to fish and eat (Hall 2007, Halweil and Nierenberg 2008). Fishing lower down in the food web is an option that addresses both the privilege to fish for livelihood and the right to fish for food. A robust and quantitative evaluation of the trade-offs is needed to choose among complex policy options, if they are to be representative and transparent as policy goals themselves, rather than some accidental outcome (the world has had enough accidental outcomes in fisheries). With political will and societal awareness, fishing and eating lower down in the food web may become economically viable, ecologically sustainable, and socially just, both as a right and privilege.

Governance institutions: managing people and fish

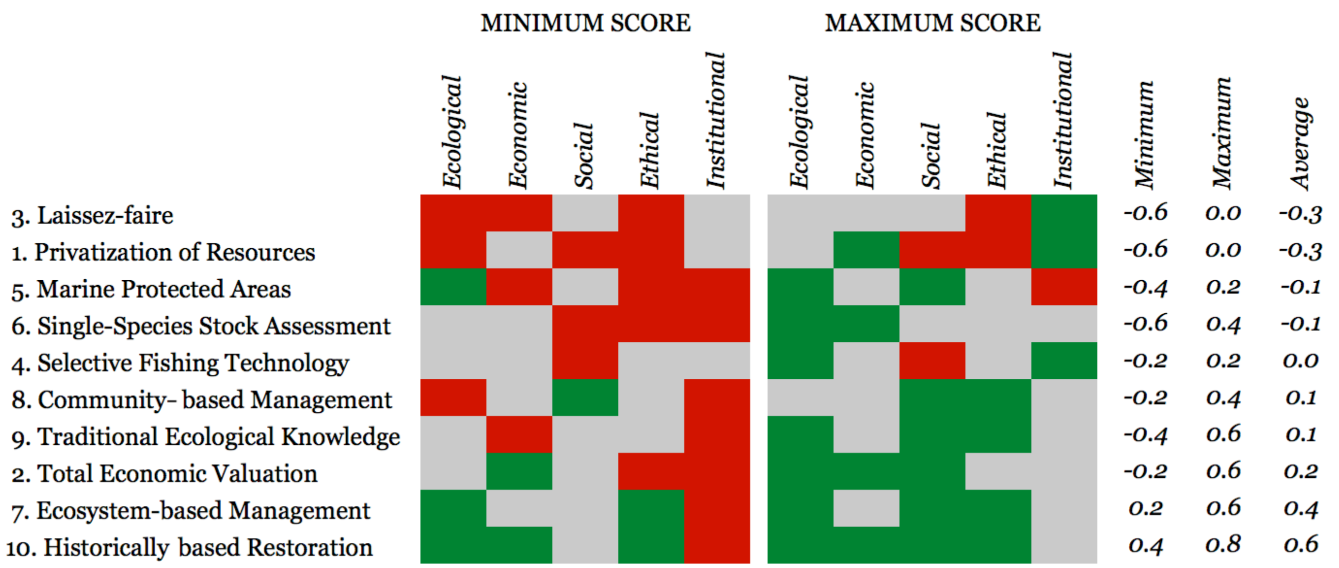
Also missing in the simple solutions to fisheries management is adequate integration of the complex human dimension with the natural system (Berkes and Folke 1998, Carpenter and Gunderson 2001, Gunderson and Holling 2002, Berkes et al. 2003, Liu et al. 2007*a,b*, Garcia and Charles 2008). Fisheries management is widely acknowledged to be about managing humans, not fish (Ludwig et al. 1993, Pitcher et al. 1998, Hilborn 2007*d*), but the human dimensions of fisheries management (De Young et al. 2008) present formidable challenges. The interplay of diverse human interests, values, and preferences with respect to fishery resources (Lam and Sumaila 2008) is a global challenge that cannot be “solved” (Jentoft and Chuenpagdee 2009); it is instead exacerbated by an ever-growing, mobile, and technologically sophisticated human population competing for yet scarcer resources (Lam and Pauly, *in press*). Management of sustainable and responsible fisheries is both constrained and enabled by governance (Ostrom 1990, Kooiman 2003, Kooiman et al. 2005, Acheson 2006, Jentoft 2007, Agnew et al. 2009), that is, the “formal...mores which determine how resources or an environment are utilized” (Juda 1999: 90; see also Juda and Hennessey 2001). To sustain large marine ecosystems, an ecosystem approach must consider not only the natural system, via the productivity of the ecosystem, fish and fisheries, and pollution and ecosystem health, but also its human dimensions, namely the socioeconomic conditions and governance (Sherman 1995).

Research of social institutions needed for sustainable natural resource management (Ostrom 1990, 2007, 2009, Young 2002) and responsible fisheries governance (Sissenwine and Mace 2003) is clear: the fisheries problem can only be addressed with effective, incentive-based management instruments and a long-term, achievable policy goal. Understanding of sustainable fishery systems (Charles 2001) to design appropriate incentives and institutional structures to manage human behavior vis-à-vis fishery resources is emerging (e.g., Fujita et al. 1998, Hanna 1998, 2006, Hilborn et al. 2004, 2005a, Acheson 2006, Jentoft 2007, Grafton et al. 2007, De Young et al. 2008, Chuenpagdee and Jentoft 2009, Lam and Pauly 2010). Social incentives and governance institutions must be designed to account for not only economic sustainability of the fishing industry, but also ecological sustainability with appropriate conservation measures, while accounting for the conflicting interests and behaviors of resource users, managers, and politicians (Acheson 2006). Private incentives must be aligned along societal objectives, regulated and enforced to promote compliance by accounting for the scale and costs of fishery conservation (Wilson 2007) in management plans and policy goals. Despite this growing awareness of the complex human dimension in fisheries, ocean governance is in crisis, still marred by “conceptual confusion, spurious economics, and political indifference” (Bromley 2008: 7, 2009).

CONCLUSIONS

Transparent definition of achievable and restorative policy goals requires an evaluation framework that can assess singular and composite management strategies along multiple variables. Figure 3 displays the ten common management strategies, scored along five performance variables or modalities: ecological, economic and social viability, ethical status, and ease of institutional implementation. The pattern of scores, color coded for positive (green), neutral (gray), and negative (red) outcomes, provides a policy footprint for each management strategy. The “minimum” scores rate the weak or “panacea” scenarios, with performance assessed along each modality, then averaged; the “maximum” scores capture the nuances and enhancements of each management solution. The range between these two sets of scores expresses two sources of uncertainty, in our scoring and the outcomes of the strategy. Average scores estimate the aggregate performance of the management strategies across all modalities. Policy scores reflect our assessments based on the literature reviewed and combined experiences in, among other things, evaluating the quality of global fisheries management (Pitcher et al. 2009*a,b*, Mora et al. 2009) and designing a socioeconomic framework for fisheries valuation and analysis (Lam and Sumaila 2008). Clearly, objective criteria need to be standardized before the proposed policy

Fig. 3. Composite policy performance ratings illustrating the trade-offs inherent in ten common fishery management strategies. The overall average performance of the management strategy rows increases from top to bottom; the numbers correspond to their order of discussion in the text. The pattern of scores, color-coded for positive (green, +1), neutral (grey, 0), and negative (red, -1) outcomes, provides a policy footprint for each strategy. Minimum and maximum scores were assigned by the authors for the weak ‘panacea’ and more nuanced descriptions, respectively, by synthesizing published accounts cited in the text and our individual experiences. The range between these scores expresses our estimate of the uncertainty in the strategy, while the average score is our best estimate for the performance of each management strategy, aggregated across all modalities. Columns correspond to assessments along five policy performance modalities: Ecological, Economic and Social scores are based on sustainability criteria that measure viability (Pitcher and Preikshot 2001); Ethical scores are informed by an interdisciplinary ethical analysis for fisheries (Pitcher and Power 2000; Coward et al. 2000); and Institutional scores relate to data and infrastructure required to implement an institutional framework (Ostrom 2005) capable of delivering this management strategy.



evaluation framework can be rigorously applied, but Fig. 3 offers an informed methodological approach for making tough policy decisions by transparently conveying the perceived strengths and weaknesses of each management strategy. By our performance criteria and assessments, laissez-faire, privatization, MPAs, and conventional stock assessment are all, perhaps surprisingly to some, in the lower half of performance for the ten management strategies. The two best strategies, ecosystem-based management and historically based restoration, are inherently composite, being broad in space and deep in time, respectively, and thus better able to capture the complex human dimension of fisheries.

Aspects of all ten fisheries management strategies will likely need to be implemented, but none alone is sufficient to avert the growing global fisheries and looming food crises. The historical imperative tells us what happened in the past and helps us decide what we want for the future, by informing how we design socioeconomic incentives and policy goals today. Human demands and impacts on the sea are intensifying with global population growth, industrialization, and climate change. By examining historical ecosystems and customary practices and norms, by returning to traditional food sources and community-based management, by considering judicious use of plankton resources in an ecosystem-based context, and by the selective and efficient use of technology, we may intentionally shift global society to a more desirable future. With scientific insight, powered by political will and consumer awareness, we can rebuild fisheries ethically, addressing the basic human right to food while leaving biodiverse marine ecosystems largely intact. “Fishful thinking” can easily degrade to “wishful fishing,” but by widening our analytical nets, we can avoid getting caught by Hume’s Guillotine and assess future trade-offs with composite fisheries management tools, effective institutions, and well-defined policy goals—and perhaps, even restore “fishful ecosystems.”

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol15/iss2/art12/responses/

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