The Ethics and Sustainability of Capture Fisheries and Aquaculture

Mimi E. Lam

Journal of Agricultural and Environmental Ethics

ISSN 1187-7863
Volume 29
Number 1

J Agric Environ Ethics (2016) 29:35-65
DOI 10.1007/s10806-015-9587-2

J Agric Environ Ethics (2016) 29:35–65
DOI 10.1007/s10806-015-9587-2

ARTICLES

The Ethics and Sustainability of Capture Fisheries and Aquaculture

Mimi E. Lam[1,2]

Accepted: 19 November 2015 / Published online: 18 January 2016

Abstract The global seafood industry (capture fisheries and aquaculture) is a vital source of food, income, livelihoods, and culture. Seafood demand is steadily rising due to growth in the global human population, affluence, and per capita consumption. Seafood supply is also growing, despite declining wild fish stocks, with phenomenal advances in aquaculture, that is, the cultivation of aquatic organisms. Aquaculture supplied 42 % of the world's fish in 2012 and is forecast to eclipse capture fisheries production by 2030. The balance between these two seafood production systems has profound implications for global food security, income distribution, and ecological sustainability. Here, a qualitative analysis of the ethics and sustainability of capture fisheries and aquaculture is presented. An innovative practical ethics approach is introduced which adapts the ethical matrix, a conceptual tool for analyzing the wellbeing, autonomy, and justice of different interest groups, and *Rapfish*, a rapid appraisal technique used to evaluate the sustainability of fisheries along six performance modalities, including ethics. Using case studies of global large- and small-scale capture fisheries and generalized carnivorous and omnivorous aquaculture systems, I show that human institutions and social actors interact in complex governance processes to influence seafood ethics and sustainability.

✉ Mimi E. Lam
mimibethlam@gmail.com

1 Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC V6T 1Z4, Canada

2 Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, 2207 Main Mall, Vancouver, BC V6T 1Z4, Canada

Keywords Ethical matrix · Food security · Governance · *Rapfish* · Seafood ethics · Seafood value chain analysis

Introduction

Enough food is produced to feed the world's population, yet 805 million people—roughly one in eight—suffered from chronic hunger between 2012 and 2014 (FAO 2014a): this highlights an ethical crisis within global society. With growing demands on the global food supply from a surging, affluent, yet socio-economically disparate human population, food ethics dilemmas, such as how to combat this distributional inequity, permeate the complex interstices of today's science, technology and society. Issues of food security, that is, access to safe, nutritious, sufficient, and culturally appropriate food (FAO 2001), arise throughout the food value chain. These range from the targets and methods of production, consumer identities and effects, to the consequences of food production on human society, animal welfare, and the environment. As the differential impacts of greenhouse-gas emissions from food production, trade, and consumption are increasingly experienced, food ethics dilemmas will become only more salient.

Food ethics issues blur the distinction between facts and values (Funtowicz and Ravetz 1993; Mepham 2008), forging an inextricable science-society nexus that challenges food policy and governance, whether at the level of the household, producer, market, or government. For the consumer, determining the ethics of buying local, organic, or fair trade food will depend on a multitude of factors specific to the food system and what it interacts with along the food value chain (Economist 2006). Producers act according to their values, which vary with financial and cultural contexts, as well as constraints from governmental regulations and sectoral norms. The global market is not capable of finding equilibria to balance the complex and diverse values brought into the food sector, as shown by the 2008 riots in response to high rice prices. And while government policies regulating the food sector try to prevent harm to society, by minimizing risks to public health and the environment, harm is a normative concept reflecting underlying social judgments of what is good and bad (Lin 2006), which varies with culture and time.

Resolving food ethics dilemmas thus necessitates—*inter alia*—a practical ethics approach to support decision-making in natural resources management, policy, and governance. The ethical implications of food production, distribution, consumption, safety, and health are frequent topics of debate in science, policy, and the media, fuelling public skepticism and concern around issues of human wellbeing, choice, and fairness as they relate to food. Resource access, allocation, and trade decisions can trigger food security or insecurity, as well as ecological sustainability or degradation, so coordinated, normatively guided actions among diverse human institutions, involving civil society, the market, government, and the law, are needed for effective food policies and governance. Unravelling the intricate relationship between food ethics and resource sustainability is critical to achieving a more just and sustainable global society: nowhere is this more salient than in the case of seafood.

The Global Seafood Industry

The global seafood industry, comprising of inland and marine capture fisheries and aquaculture, is a vital source of food, income, livelihoods, and culture. Seafood demand is rising, with growing human population, disposable incomes, and per capita consumption, estimated at 19.2 kg for 2012, consuming 86.3 % of the global fish supply (FAO 2014b). Since the 1960s, the global fish supply grew at an average annual rate of 3.2 %, outpacing the world population growth of 1.6 %. This growth was mostly from aquaculture, that is, the cultivation under controlled conditions of aquatic organisms (e.g., fish, mollusks, crustaceans, and plants). The world aquaculture production volume increased annually by an average of 8.6 % between 1980 and 2012 (FAO 2014b). In 2012, the production of aquatic organisms, excluding plants, totaled 158.0 million tonnes, with 66.6 million tonnes or 42 % coming from aquaculture (FAO 2014b). In 2010, the fish sector was valued at US$ 217.5 billion, with fish providing 10 % of global caloric intake (UNEP 2012), 16.7 % of animal protein, 6.5 % of all protein, and over half of the animal protein and minerals for some of the world's poorest people (FAO 2014b). The fish sector also supports the livelihoods of 10–12 % of the global population and is critical in alleviating poverty for small-scale fishers (UNEP 2012). Seafood is the most highly traded global food commodity, with fishery exports valued at US$ 129.2 billion in 2012 (FAO 2014b; Lam and Pitcher 2012b). Aquaculture is now the fastest growing food sector, projected to supply 60 % of fish by 2020 (FAO 2014b) and to eclipse production from capture fisheries, which has been in stagnation or decline since the 1990s (Pauly et al. 2002; Worm et al. 2009; Pitcher and Cheung 2013; FAO 2014b). Balancing these two seafood production systems has ethical implications for global food security, equity, and ecological sustainability (Lam 2013; Troell et al. 2014). Despite this, seafood ethics have not been well researched compared to terrestrial food systems.

Ethical issues in fisheries (Coward et al. 2000; FAO 2005; Lam and Pauly 2010; Lam and Pitcher 2012a) and aquaculture (Kaiser 2012a, b; Bremer et al. 2012, 2013, 2015; Lam 2013; Troell et al. 2014; Röcklinsberg 2015), both separately and across the seafood value chain, are complex and ill-defined. Growing concern among stakeholders has led to new norms of ethical principles and practice, via governmental laws and regulations, voluntary codes of conduct and trade agreements, and market-based tools (see review in Lam and Pitcher 2012a). Fisheries and aquaculture governance (Kooiman et al. 2005; Bavinck et al. 2013) are evolving to meet ethical standards (Lam and Pauly 2010; Lam and Pitcher 2012a), enshrined legally in the third United Nations (UN) Convention on the Law of the Seas (1982) and in the voluntary guidelines of the precautionary principle (Macdonald 1995), the Food and Agriculture Organization of the UN Code of Conduct for Responsible Fisheries (CCRF; FAO 1995), and small-scale fisheries (FAO 2014c). Compliance to the CCRF's ethical principles, however, is poor, with the majority of fishing nations, comprising 96 % of the world's catch, failing to achieve even a passing score (Pitcher et al. 2008, 2009a, b). Seafood ethics, though in its infancy, has the potential to identify and weigh diverse values and interests, enabling more transparent public decision-making to carve out seafood policies and governance that promote global human wellbeing and ecological sustainability.

Here, an innovative practical ethics approach is introduced that first adapts the ethical matrix (Mepham 2000a, 2008, 2012a, b), a theoretically-based conceptual tool that analyzes the wellbeing, autonomy, and justice of diverse interest groups, which is then operationalized using a *Rapfish*-like approach (Pitcher et al. 2013; Pitcher and Preikshot 2001). *Rapfish* is a semi-quantitative, rapid appraisal technique used to evaluate the sustainability of fisheries along six performance modalities: *Ecological*, *Technological*, *Economic*, *Social*, *Ethical*, and *Institutional*. Updating the ethical matrix of Lam and Pitcher (2012a), itself modified from an FAO analysis (2005), this work analyzes the ethics and sustainability of both capture fisheries and aquaculture. It corroborates the preliminary conclusion of Lam and Pitcher (2012a) that ethical fisheries may also be more sustainable, based on an analysis (Coll et al. 2013) that suggested that fisheries evaluated as being more compliant to the CCRF (Pitcher et al. 2009a) were also more ecologically sustainable. Using global large- and small-scale capture fisheries and generalized carnivorous and omnivorous aquaculture case studies, I argue that a better understanding of the complex interplay among diverse social actors and the human institutions involved in seafood governance (namely, civil society, the market, government, and the law) is needed to foster more ethical and sustainable seafood systems.

Research Methodology

The Ethical Matrix

The ethical matrix (Mepham 2000a, 2008) incorporates basic human interests as the (western) ethical principles of wellbeing, autonomy, and justice applied to different (human, animal, and environmental) interest groups (Table 1). Note that the concept of wellbeing is a contraction of the principles of beneficence and non-maleficence in medical ethics (Beauchamp and Childress 2001). In the original version of Mepham

Table 1 Ethical matrix (adapted from Mepham 2000a, 2008)

Interest group	Ethical principle		
	Wellbeing (consequentialist or utilitarian theory: welfare and health)	Autonomy (rights-based or deontological theory: freedom and choice)	Justice (social contract theory and Rawlsian "justice as fairness")
Producers	Satisfactory income and working conditions	Managerial freedom	Fair trade laws and practices
Consumers	Food safety and quality of life	Democratic and informed choice	Availability of affordable food
Treated organism	Animal welfare	Behavioural freedom	Intrinsic value
Environment	Conservation	Biodiversity	Sustainability

(2000a), the ethical matrix adopts a common morality approach (Mepham 2008), combining the consequentialist (or utilitarian) and rights-based (or deontological) western ethics theoretical traditions, along with Rawls' theory of 'justice as fairness' (Rawls 1971). In light of these ethical principles, the matrix facilitates rational ethical analysis and decision-making of food dilemmas by structuring factual and value-based assessments of the ethical impacts (and their corresponding ethical duties) of proposed actions on different affected groups or stakeholders (Mepham 2000a). Ethical judgment involves different assessors evaluating the impacts on the affected groups and then subjectively weighing the impacts. Designed originally to analyze the ethics of novel agri-food biotechnologies (Mepham 1995, 1996, 2000a, b), the ethical matrix has been adapted for genetically modified (GM) fish (Kaiser 2005; Kaiser et al. 2007; Bremer et al. 2013, 2015), fisheries (Kaiser and Forsberg 2001; FAO 2005; Lam and Pitcher 2012a; Lam 2013), animal production systems (Mepham 2006, 2008), aquaculture (Kaiser 2012a, b; Lam 2013), and agriculture and food security (Mepham 2012a, b). Its adoption, both to outline recommendations for the safety assessment of GM animals under the Codex Alimentarius (FAO/WHO 2004) and to analyze ethical issues in fisheries (FAO 2005), reflects its utility as a public policy decision-making tool to evaluate ethical issues in biotechnology and food regulation. The ethical matrix was evaluated to be 'ethically sound' as a decision-support participatory tool (Kaiser et al. 2007) in both aquaculture and fisheries. It complements the ethical Delphi (Millar et al. 2007), a methodology used to facilitate discussion among diverse experts through a process of anonymous and iterative consultation.

Rapfish

The *Rapfish* methodology is a normative, scalable, and flexible rapid appraisal technique that integrates ecological and human dimensions to evaluate fisheries status in reference to an identified norm or goal (Pitcher et al. 2013, www.rapfish.org). *Rapfish* was developed as a simple-to-use, yet rigorous semi-quantitative and multi-disciplinary tool in fisheries management that empirically ranks the impacts of various attributes on the sustainability of the fishery resource (Pitcher et al. 1998; Pitcher 1999; Pitcher and Preikshot 2001). Users can evaluate fisheries' sustainability status along multiple performance modalities or evaluation fields, viz.: *Ecological*, *Technological*, *Economic*, *Social*, *Ethical* and *Institutional* analyses (see Fig. 1a, updated from Pitcher et al. 2013). Attributes or indicators in each field, such as exploitation status, change in (Δ) catching power, discount rate, social network, adjacency, and governance quality (see boxes in Fig. 1a), are scored from 0 to 10, taking into account uncertainty, then anchored by fixed reference points and weighted by a multidimensional scaling routine to give sustainability values along these evaluation fields. *Rapfish* performance profile kites (Fig. 1b) simultaneously express the multidisciplinary evaluation, making policy tradeoffs explicit, while identifying potential areas of conflict, to facilitate public consultation and policy decisions. Variation in *Rapfish* scoring by diverse stakeholders makes areas of agreement and disagreement transparent, as in the related ethical Delphi (Millar et al. 2007) and Rapid Rural Appraisal techniques (Chambers 1994). It has been applied extensively to both large- and small-scale fisheries (see references in Pitcher

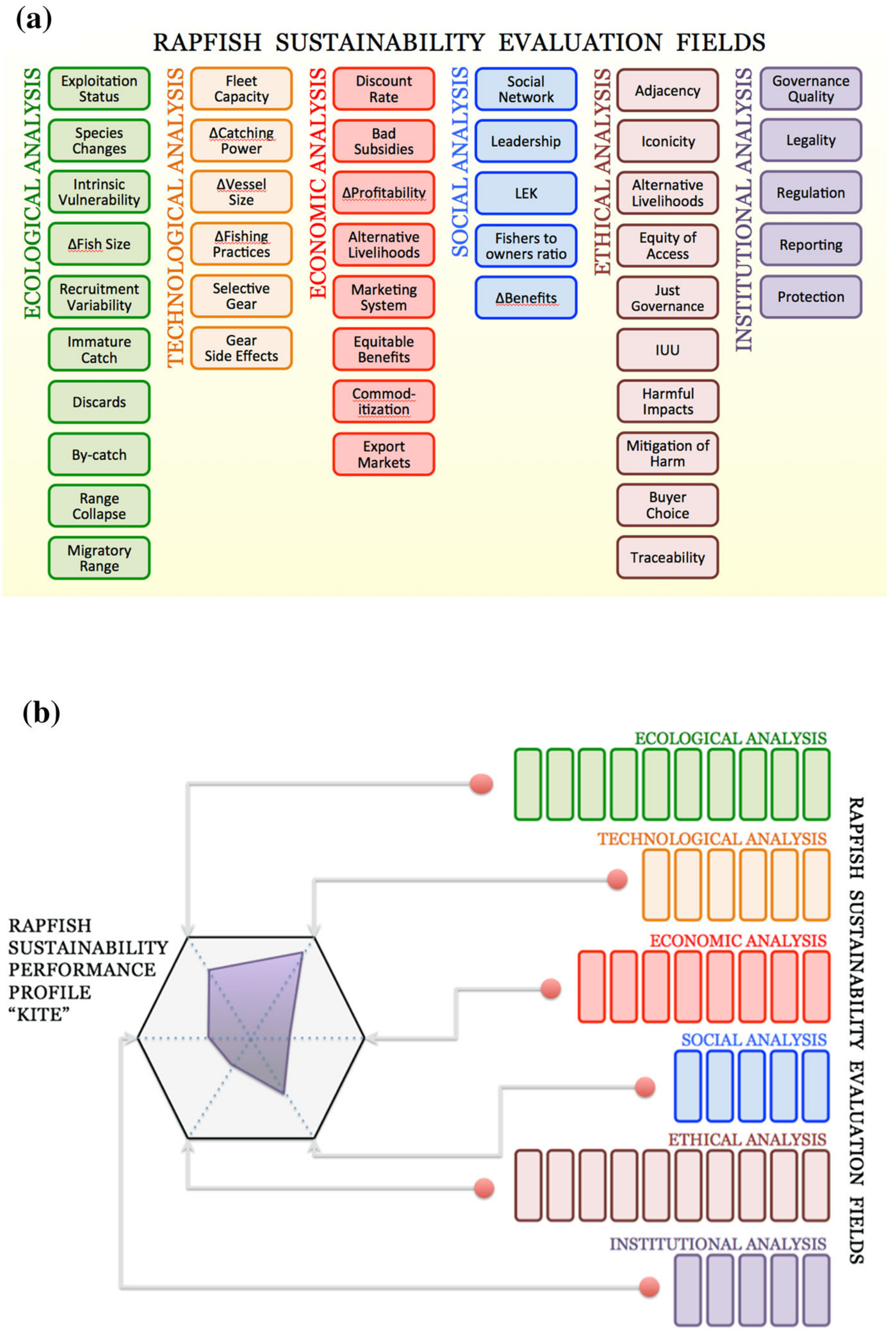


Fig. 1 *Rapfish* methodology (version 3.1, updated from Pitcher et al. 2013; see also www.rapfish.org). **a** Sustainability evaluation fields, **b** sustainability performance profile kite

et al. 2013) and adapted to evaluate compliance with norms other than sustainability, such as the UN FAO CCRF (Pitcher et al. 2008, 2009a) and ecosystem-based fisheries management (Pitcher et al. 2009b).

Merging the Ethical Matrix and *Rapfish* Approaches

This paper introduces an innovative practical ethics approach, first proposed by Lam and Pitcher (2012a), to adapt the ethical matrix, derived from ethical theory, and merge it with the *Rapfish* empirical rapid appraisal technique. The ethical matrix can guide ethical deliberation and judgment by making ethical concerns explicit, whereas *Rapfish* can evaluate semi-quantitatively the relative ethical status of differential impacts on diverse stakeholders. Merging the two approaches yields a powerful theoretically based method for empirical ethical analysis and transparent evaluation of seafood systems to facilitate rational decision-making in policy and governance.

While the original ethical matrix scheme proposed by Mepham (2008) is based on a universal 'common morality' approach incorporating western ethical principles, the participatory approach of Kaiser and colleagues (e.g., Kaiser and Forsberg 2001; Kaiser et al. 2007) allows for flexibility in what ethical principles and affected stakeholders are included. For example, to evaluate preferences for various aquaculture development scenarios in Southeast Asia, Kaiser et al. used a values-based practical ethics approach that was adapted for the cultural values appropriate for the specific country (http://seatglobal.eu). This approach has been culturally adapted to facilitate collaborative governance solutions to the Pacific herring fisheries conflict in Haida Gwaii, Canada. The availability of herring spawn-on-kelp, a traditional food for the Haida, the local indigenous inhabitants, is being jeopardized by the commercial roe herring fishery (Lam 2015b, c). Note that the ethical field of *Rapfish* has also been revised (see Fig. 1a and Table 5) to reflect current understandings of what ethical attributes may enhance the sustainability of the fishery resource. Eventually, as the *Rapfish* ethical field and the combined ethical matrix-*Rapfish* approach are developed synergistically, they will afford complementary ethical analyses for seafood systems, the first focused on fisheries and the latter on the entire integrated seafood value chain, encompassing both capture fisheries and aquaculture.

The cells of the ethical matrix for seafood production systems and value chains (Table 2) are specified with qualitative interpretations of the ethical principles as they apply to different interest groups, with the justice principle evaluated in part with Rawls' 'justice as fairness concept', but utilizing more Sen's realized or comparative justice approach (Sen 2009). The cells will eventually be populated with multiple attributes or indicators of ethical status that can be evaluated semi-quantitatively by the *Rapfish* method. For the qualitative analysis presented here, ethical status is scored as 'good', 'average' or 'poor' in the "Seafood Production Systems" section to illustrate the power of the methodology applied to capture fisheries and aquaculture. This combined ethical matrix-*Rapfish* approach offers a robust method with which to evaluate seafood ethics and sustainability and thus affords a valuable novel practical ethics tool to effect transparent decision-making in seafood policy and governance.

To address increasing public concern over fish welfare and ethics (Röcklinsberg 2015), there is a growing body of research delving into the cognitive and emotional

Table 2 Ethical matrix for seafood production systems and value chains (updated from Lam and Pitcher 2012a)

Interest group	Ethical principle		
	Wellbeing	Autonomy	Justice
Natural system			*Ecosystem*
Ecosystem	Ecosystem integrity: conservation of aquatic habitats, food webs, and biodiversity	Preservation of adaptive capacity and resilience to anthropogenic perturbations (e.g., fisheries, pollution, etc.)	*Productive* stewardship to maintain sustainability *Restorative* mitigation and restoration of damaged ecosystems
Fish populations	Fish stock abundance and genetic conservation	Behavioural freedom: free access to feeding or breeding habitats (limited migration barriers)	*Productive and restorative* precautionary management and policies for sustaining and restoring fish biomass, growth, and reproduction to preserve species, e.g., do not catch juveniles or fecund females
Individual fish	Fish welfare: maintenance of health and minimal induced pain, fear, stress, and suffering	Freedom and flexibility to develop through various life history stages and engage in feeding, anti-predator, mating, social, schooling, and other naturally evolved behaviours for species	Ethically acceptable or humane treatment of exploited fish in sustainable fish production systems, including selective catch and limited discards, bycatch and waste in capture fisheries, and access to food and care and protection from predators in aquaculture systems; killing without suffering; intrinsic value
Human system			*Social*
Society	Healthy economy and environment: minimal environmental and social costs or harms from fishing and aquaculture enterprises	Freedom to information and to express concerns about the governance of resources to ensure it benefits all of society	*Distributive* minimal subsidies with fees collected by management agencies distributed to social or public programs *Retributive* compensation for social or ecological harms
Government agents	Feasible and relatively facile alternative management and policy options to serve the public interest	Freedom to act in good faith and independently, without corruption, bribery, or unequal power relations	*Social* government agents uphold the public trust without being sued, corrupted, or bribed, where decision-makers are liable, transparent, accountable, and invite public participation in debates and governance

Table 2 continued

Interest group	Ethical principle		
	Wellbeing	Autonomy	Justice
Fishers/ aquaculture farmers	Work and social security: satisfactory income and safe working conditions; poverty eradication; health care, educational and other capacity-building opportunities; respect for cultural diversity	Managerial freedom and food sovereignty in fish production systems; freedom to choose alternative livelihoods; empowerment of producers, including women and ethnic minorities; recognition of distinct identities of indigenous communities and cultural rights	*Distributive and retributive* Employment opportunities for fishers/farmers; participation in decision-making; equitable and secure access to and use of resources; fair treatment in entry, use, credit, market, trade, subsidies, regulations, policies, and law; compensation for social inequities and injustices
Consumers	Food security: access to safe, nutritious, affordable, sufficient, and culturally appropriate food	Food sovereignty: freedom to choose desired food through eco-labelled choices of responsibly harvested seafood and culturally appropriate foods, with provenance and biological information	*Distributive* Equitable access to food; no trade barriers; balance low-trophic-level forage fish consumed for food and reduced to fishmeal for high-trophic-level farmed fish production
Other stakeholders	Non-consumptive uses also valued in resource decisions, such as ecological and cultural values of fish species	Freedom to compete for share of and access to aquatic resources; participatory decision-making and collaborative governance	*Distributive and retributive* equitable share of and access to resources for food, income, livelihood, culture, and recreation; dispute resolution for resource conflicts
Future generations	Sustainable flow of aquatic resources for benefit of future generations	Freedom to choose how resources will be utilized (not prejudiced by resource degradation or depletion)	*Retributive* Mitigation and restoration of ecological and social harm caused by seafood systems (e.g., reduction in fossil fuel use and global warming due to fisheries)
Interaction			*Ecosystem and social*
Overall system	Sustainable development: ecological integrity, economic viability and stability of competitive industry with equitable entry and access to resources, livelihoods, and fair trade; food security for society	Resilient human and ecological communities secured through conditional freedom or privilege to fish (fishing rights with societal obligations) of fishers and responsible aquaculture practices	*Productive, restorative, distributive and retributive* ecosystem-based management; historically based restoration; cross-sectoral equity in access, trade, law and taxes; harm compensation

capacities, as well as the moral status of individual fish (see, e.g., Meijboom and Bovenkerk 2013 and references therein). Fish have neuro-architecture analogous to mammals that can process and integrate complex information and organize behaviour in response to environmental stimulation, with cognitive and emotional capacities and behavioural patterns varying between and within fish species (Braithwaite et al. 2013; Andersen et al. in press). Detailed studies into the emotion system in fish indicate that individual fish can exhibit distinct 'personalities' (Kalueff et al. 2012; Martins et al. 2012) and stress coping styles (Braithwaite et al. 2013). Other research suggests that fish are likely sentient beings capable of pain, fear, stress, and suffering, and thus from an ethics perspective, should be given the benefit of the doubt and treated humanely (Sneddon 2006, 2011). This ethical argument has led to a call to expand the "moral circle" to include fish so that they receive moral consideration in their own right to ensure some basic welfare (Lund et al. 2007), such as the five freedoms: freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury or disease; freedom from fear and distress; and freedom to express normal behaviour (Farm Animal Welfare Council 2009). Moral consideration has been discriminated by Bovenkerk and Meijboom (2012, 2013) from moral significance and how fish should be treated based on differing normative theories, as captured in the ethical matrix. For example, animal husbandry systems, such as aquaculture, could be designed with ethical considerations so that animals are treated respectfully and are killed without suffering (painlessly and unknowingly) (Lund and Olsson 2006). With this emerging science and ethics of fish, individual fish now are added in the ethical matrix of Table 2 (updated from Lam and Pitcher 2012a) to the natural system interest groups, along with fish populations and the ecosystem. Note that inclusion of individual fish as an interest group in the ethical matrix does not require that it be included in a given ethical analysis, which will depend on specific cultural values and ethical perspectives, but justification would need to be given as to why it is excluded.

Similarly, future generations have been added as an interest group to the human stakeholders in Table 2 (updated from Lam and Pitcher 2012a) to capture a temporal perspective in the ethical analysis and connect with the sustainability and ecological economics literature. In particular, sustainable development (Brundlandt and World Commission on Environment and Development 1987, p. 16) "meets the needs of the present without compromising the ability of future generations to meet their own needs." Natural resource management recognizes both intergenerational discounting approaches in ethical cost–benefit analyses (Sumaila 2004; Sumaila and Walters 2005) and intergenerational equity and sustainability (Padilla 2002). Cultural property (Kirsch 2001) has been considered as an example of intergenerational valuing of marine resources (Lam and Borch 2011; Lam and Pitcher 2012b), which can help make some of the "invisible losses" of indigenous communities (Turner et al. 2008) more visible. With a greater understanding of resource users' time preferences (Burton 1993) and relative valuations (Sumaila 2007), appropriate incentives can be offered or sanctions imposed by human institutions to appeal to the interests and values of non-cooperators and stakeholders in general. Such temporal-oriented notions are important to consider when evaluating the competing interests in the human exploitation of aquatic resources for seafood, particularly as wild fish stocks decline and aquaculture production places increasing demands on the natural environment, with both short- and long-term sustainability and ethical consequences for the affected human communities and interest groups.

Seafood Production Systems

Capture Fisheries

Growing global demand for seafood commodities (Lam and Pitcher 2012b; Pitcher and Lam 2015) has depleted top predators (Myers and Worm 2003) and functional groups serially through trophic levels (Pauly et al. 2002), while also harvesting the greater primary productivity at lower marine trophic levels, such as forage fish (Pikitch et al. 2014) and krill (Pitcher 2008), with complex and often adverse implications for ecosystem stability and biodiversity. Fisheries governance grounded in both sustainability science and ethics (Lam and Pauly 2010) has the potential to rebuild the generative capacity of marine ecosystems and restore their resilience, as well as to protect human communities and societies that are dependent on fishery resources. Harmful impacts of fisheries may be reduced by internalizing environmental and social costs, eliminating harmful fishing subsidies, gear, and practices, and promoting ecolabelling, standards, and certification (Lam and Pauly 2010; Lam 2012; Lam and Pitcher 2012a). Fisheries management schemes that promote the privatization of fishery resources, such as 'rights-based fishing' (Grafton et al. 2006), have been challenged on ethical grounds, arguing that fishing by private enterprises is a conditional right or 'privilege' with fiduciary responsibilities of marine stewardship and conservation (Lam and Calcari Campbell 2012). An instrumental and ethical harm principle in fisheries has been proposed (Lam 2012), whereby fishers would pay for this 'privilege to fish' through entry and landing fees scaled with fishing capacity, with the policy goal to reduce overcapitalization and overfishing. Fisheries governance also can be enhanced by reducing the vulnerability, insecurity, and poverty among fishers, thereby securing social justice and the basic human rights of fishers, particularly in small-scale, developing-country fisheries (Allison et al. 2011, 2012), as the depletion of local fishery resources could compromise the basic human right to food (Pitcher and Lam 2010).

Capture fisheries, which account for approximately 120 million tonnes of fish annually (Pauly and Zeller 2016; cf. 90 million tonnes in FAO 2014b). They are typically categorized as either large- or small-scale fisheries. Large-scale, industrial fisheries use large specialized vessels, such as trawlers, purse seiners, long liners, and gill netters, with salaried crews. Small-scale, artisanal fisheries, on the other hand, rely on small owner- or family-operated crafts, some non-motorized, operated mostly inshore with more selective, multiple fishing gear technologies. The comparative benefits of large- and small-scale fisheries have been aggregated globally (Pauly 2006; Pauly and Zeller 2016; see Fig. 2), including: annual landings for human consumption; annual catch discarded at sea; annual catch for industrial reduction to fishmeal and oil, etc.; fuel used per tonne of fish for human consumption; number of fishers employed; and government subsidies.

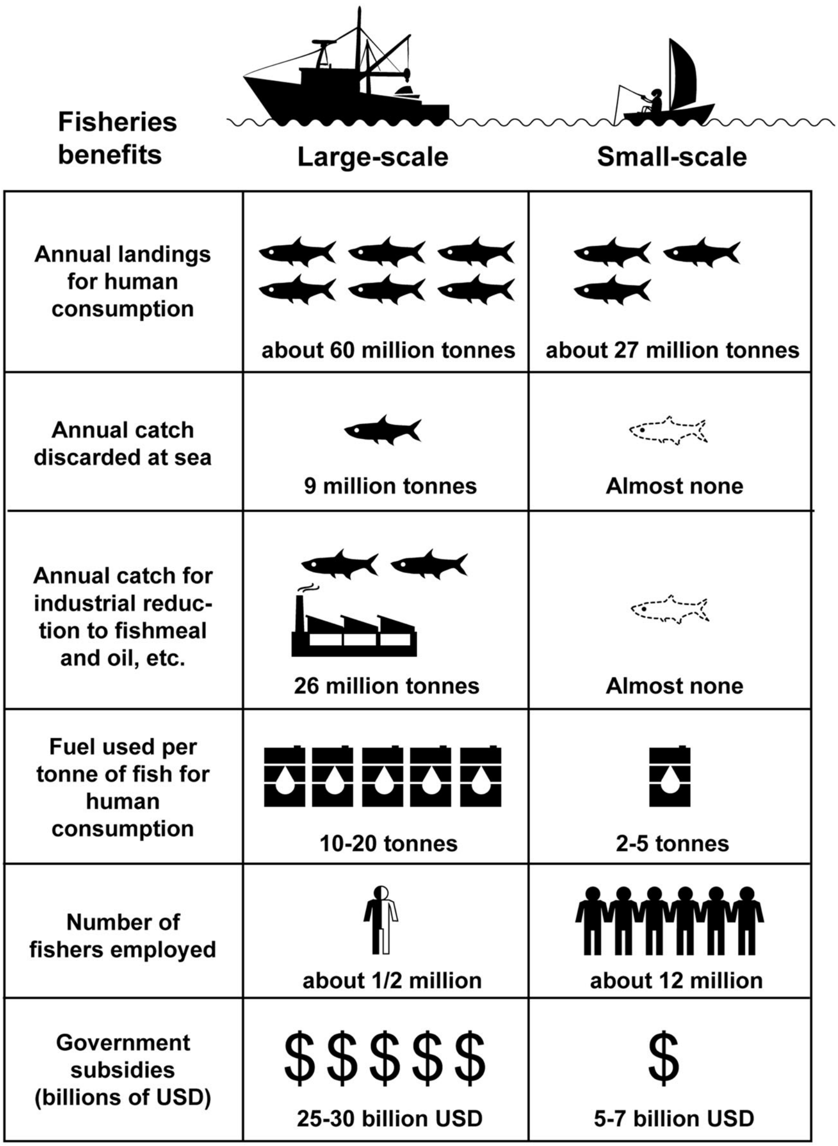


Fig. 2 Schematic illustration of large and small-scale fisheries prevailing in most countries of the world (statistics are global, with reconstructed catches from 2000 to 2010; Pauly and Zeller 2016, reproduced with permission from the authors)

Large-Scale Fisheries

Large-scale fisheries include industrial commercial fishing fleets, which, generally of high volume and profit, have contributed to global overfishing and declining fish stocks (Pauly et al. 2002; Worm et al. 2009; Pitcher 2012; Pitcher and Cheung

Table 3 Comparing the ethics of global large- and small-scale capture fisheries. (Color figure online)

CAPTURE FISHERIES: LARGE-SCALE	Wellbeing	Autonomy	Justice	CAPTURE FISHERIES: SMALL-SCALE	Wellbeing	Autonomy	Justice
Ecosystem	Poor	Poor	Poor	Ecosystem	Average	Average	Poor
Fish Populations	Poor	Average	Poor	Fish Populations	Average	Average	Average
Individual Fish	Poor	Average	Poor	Individual Fish	Average	Average	Average
Society	Average	Average	Poor	Society	Average	Average	Average
Government Agents	Good	Average	Poor	Government Agents	Poor	Average	Poor
Fishers	Average	Average	Poor	Fishers	Poor	Poor	Average
Consumers	Good	Average	Poor	Consumers	Average	Poor	Good
Other Stakeholders	Poor	Average	Poor	Other Stakeholders	Poor	Average	Poor
Future Generations	Poor	Poor	Poor	Future Generations	Average	Average	Average
Overall	Average	Average	Poor	**Overall**	Average	Average	Average

Green	Good
Yellow	Average
Red	Poor

2013). They have caused significant damage to ecosystems (Lam 2012), with the amount varying by gear type (Chuenpagdee et al. 2003). This historical legacy of post-World War II economic expansion of national fishing fleets reflects an era when environmental impacts of fisheries were largely unrecognized and the industry was heavily subsidized (Sumaila et al. 2010). This legacy persists today as a sense of entitlement among fishers, who have 'captured' regulators in many developed countries (Stigler 1971; Lam and Pauly 2010). Industrial-scale fisheries are considered largely unethical (Lam and Pauly 2010), as private fishing enterprises exploit public resources without compensation to the public treasury. To address this missing ethical dimension, 'pay-as-you-fish' policies or extraction fees for fish landed have been proposed (Bromley 2008, 2009), which could be incorporated by adopting a harm principle in fisheries (Lam 2012). Emerging ethical issues around the sustainability of seafood production have led to ethical analyses of fisheries (FAO 2005; Lam and Pitcher 2012a; Lam 2013), which are expanded upon here with qualitative analyses of global large- and small-scale fisheries in Table 3. This comparative ethical analysis will be discussed after an overview of small-scale fisheries.

Small-Scale Fisheries

Small-scale fisheries, which account for approximately 27 million tonnes of catch annually summing catches from artisanal, recreational, and subsistence fisheries (Pauly and Zeller in press). They contribute to global food security, nutrition, poverty alleviation, and livelihoods, vitally in many developing countries. Despite their importance, small-scale fishers and fish workers are often marginalized and not involved in the resource decision-making that affects their livelihoods (Pauly 2006), with ethical implications (Lam 2012). Consequently, small-scale fishers, particularly those that are extremely poor, often contravene or operate outside of government regulations, with many small-scale fisheries catches being illegal (e.g., Hauck 2011), unreported (e.g., Bali Strait sardine fishery; Buchary et al. 2011) or unregulated in open-access regimes or poorly managed community fishing grounds (e.g., Tonle Sap; Evans et al. 2004; Lamberts 2006; Lam 2015a). Problematic elements of small-scale fisheries include: income and asset poverty, vulnerability to climate and other variability, exclusion from decision-making, lack of recognition in planning, limited access to social services and infrastructure, and political marginalization (Béné et al. 2007). Human rights, including economic, social, cultural, political, and civil rights, are critical to achieving sustainable development for small-scale fisheries and the supported fishing communities (Allison et al. 2011, 2012). Wellbeing offers a comprehensive integrating lens, with material, relational, and subjective dimensions by which to examine small-scale fisheries (Weeratunge et al. 2014). In recognition of the vulnerability of small-scale fisheries and their importance to food security and livelihoods, particularly in developing countries, new voluntary guidelines for securing their sustainability have been adopted (FAO 2014c). Securing human rights for fishers to decent standards of living, work, healthcare, and education will require changing existing governance institutions and power structures that determine resource allocation and access. As the world's seafood production comes primarily from regions with weak governance, improved governance is essential to enhancing the contribution of seafood to food security (Smith et al. 2010). Comparative ethical assessments of seafood systems evaluated for the various affected interest groups, as is done in Table 3 and discussed in the next section, will support improved decision-making and governance by making values and potential sources of conflict explicit.

Comparative Ethical Analysis for Large- and Small-Scale Fisheries

Using the updated ethical matrix of Table 2, the preliminary analysis of Lam (2013) has been refined to perform a qualitative ethical analysis that compares the wellbeing, autonomy, and justice of global large- and small-scale fisheries, as presented in Table 3. The rapid appraisal scoring of the cells in this novel ethical matrix-*Rapfish* approach applied to global large- and small-scale fisheries using aggregated literature sources (e.g., Pauly and Zeller 2016, in press). The overall conclusion is that small-scale fisheries are assessed to be more ethical than large-scale fisheries, primarily due to their more selective gear and less ecological damage, greater employment of fishers, and fewer subsidies and fuel consumption. Note that, as the methodology is being refined to include multiple indicators in the cells, disaggregating risks and benefits, and specifying unique ethical impacts. These could then be scored quantitatively, accounting for uncertainty, and robustly, with standardized scoring guidelines for assessors who may have diverse ethical perspectives and value landscapes and judgments. Here, the overall qualitative scores are obtained by averaging the individual scores in each column, where the worse score is used when the average falls evenly between two categories. The refined ethical matrix-*Rapfish* method can yield a kite diagram with semi-quantitative scores along axes corresponding to the ethical principles being explored, as in the *Rapfish* approach depicted in Fig. 1, rather than an 'overall' score. This could then be used to facilitate decision-making by making ethical trade-offs explicit. The qualitative results given in Table 3 show how this novel ethical matrix-*Rapfish* method can be used to compare the ethical impacts of specific fisheries to aid fisheries policy and governance.

Aquaculture

Aquaculture produces 90.4 million tonnes (live weight equivalent) in 2012 (valued at US$ 144.4 billion), including 66.6 million tonnes of fish food and 23.8 million tonnes of aquatic algae (FAO 2014b). Food fish includes finfishes, crustaceans, molluscs, amphibians, freshwater turtles and other aquatic animals intended for human consumption (FAO 2014b). Aquaculture's phenomenal growth in recent decades has focused attention on its environmental impacts, distributional equity, and food safety issues. Damage to the marine environment and wild fish populations threaten not only the sustainability of aquaculture, but also ocean health and global food security. Chinese aquaculture contributes more than 60 % of the global aquaculture volume, but its impact on global wild fisheries and food security though recently characterized (Cao et al. 2015), remains controversial, motivating a robust assessment of its ethics and sustainability by the author in collaboration with Chinese and western scientists. Aquaculture offers promise for enhanced resilience through diversification of global food production systems, but for this to be realized, government policies must incentivize resource efficiency, equity, and environmental protection (Troell et al. 2014).

The cultivation of aquatic organisms varies greatly in its degree of intensification, integration, technology, and farmed species (carnivorous, herbivorous, or omnivorous). For example, commercial farms rely on intensive methods to produce commodities for global and regional markets, while family and cooperative farms typically rely on less intensive practices and low-value species for household subsistence or local markets (Naylor et al. 2001). Meanwhile, farmed freshwater finfish are often integrated within agricultural and polyculture systems, causing less environmental damage than marine fish and crustaceans, which are typically reared near shore and in coastal ponds, respectively, modifying habitats and degrading ecosystem services. Emerging technologies, such as culture system improvements, alternative feed strategies, and species selection, offer remedies, but raise new concerns (Klinger and Naylor 2012). Aquaculture systems, like agriculture systems, are not charged for discharges (of wastes, effluents, etc. into water) or other adverse environmental impacts, making it difficult for less harmful, more expensive technologies to compete in the marketplace. Finally, high-trophic-level, high-value farmed carnivorous species like Atlantic salmon (*Salmo salar*), exported predominantly to affluent countries in the global north, are rich in healthy omega-3 unsaturated fatty acids, but feed predominantly on fish oil and fishmeal extracted from low-trophic-level forage fish, often consumed for food by the poor in the global south. The composition of salmon feed has changed dramatically in the last decade to include more vegetable-based (e.g., soya) sources (Bendiksen et al. 2011), but this reduces its health benefits, attributed to its lower omega-3 fatty acid content. This variation in aquaculture systems should be reflected in evaluations of their ethics and sustainability.

Ethical concerns of aquaculture systems include: nutrient (loading from wastes and eutrophication) and chemical pollution; threats to wild species by farmed-fish escapes (interbreeding and competing with wild populations), parasites, and disease outbreaks; marine resource dependence via feeds; competition between human consumption and feed composed of forage fish, soybeans and grains; and limitations of freshwater and land resources to aquaculture growth (Naylor et al. 2001; Klinger and Naylor 2012). Over 50 % of aquaculture production is internationally traded, with a net flow from developing to developed countries, generating issues of distributional equity, energy use, and food miles. Farmed salmon may be reared in crowded pens, making them more susceptible to lice infestations and raising concerns over animal welfare, food safety, and public health. Note that the ethical matrix has been applied to examine aquaculture within the context of the precautionary principle as a crucial element of sustainable development, which depends on basic value perspectives, such as sustainability and food safety (Kaiser 1997; Kaiser and Stead 2002). More recently, the ethical matrix has been applied to explore attitudes to GM salmon (Bremer et al. 2013, 2015) and an ethical trade index of overall sustainability and safety of aquaculture products has been developed by mapping core values and ethical landscapes (Bremer et al. 2012).

Carnivorous Species

The farming of high-value, high-trophic-level, carnivorous species (e.g., salmon and shrimp) requires wild-caught fish for feed (Naylor et al. 2001). For example, Atlantic salmon (*S. salar*) are fed fishmeal and fish oils from the reduction of forage fish at a (wet biomass) ratio of wild fish input to total farmed-fish output (fish in-fish out, FIFO) as high as 4:1 (Cressey 2009), i.e., they are net *consumers* of fish that might otherwise be consumed by human populations or provide essential ecosystem services (Pikitch et al. 2014). However, significant progress has been made in aquaculture feed efficiency and feed inputs in recent decades, such as using feed oil of vegetable origin and reclaimed from fish processing waste, lowering the FIFO ratio to between 1.5 and 3.6, depending on the source of the feed oil (Bendiksen et al. 2011). Despite this, with the growth in the total volume of aquaculture production, the proportion of fishmeal and fish oil consumed by aquaculture compared with other food sectors or industrial uses has nearly doubled in the last decade (Klinger and Naylor 2012). As a byproduct of confining a large number of carnivorous fish or crustaceans in ponds, tanks or cages in coastal waters, especially mangroves and wetlands, aquaculture facilities can cause unmitigated environmental damage (though conditions have improved significantly in recent years in most producing countries, including Asia), viz.: nursery habitat destruction; eutrophication through excessive nutrients, wastes and antibiotics causing algal blooms and oxygen dead zones; sea lice and other diseases which can threaten wild fish; and escapes which can compete or hybridize with indigenous fish populations (Naylor et al. 2001). Salmon are now being fed a mixture of soya bean and fishmeal and fish oils, making them "more like pigs" (Cressey 2009), which reduces their omega-3 fatty acid content. Fast maturation and disease resistance traits are being introduced by selective breeding and testing of gene transfer technology, a form of genetic modification, which is raising ecological and human health concerns (Bremer et al. 2013, 2015). Recirculation systems that treat and reuse wastewater, if fully monitored and controlled, would avoid some of the potential hazards of fish in open cages in the ocean, but this eco-friendly technology has added costs which open systems do not bear without regulations for environmental damage. Offshore farms are also an option over near-shore farms, as they have higher water quality and fewer conflicts with recreational water users, but the engineering and licensing requirements are more complex (Cressey 2009).

Omnivorous and Herbivorous Species

Omnivorous and herbivorous species (e.g., tilapia and carp, respectively) and filter feeders (e.g., oysters, clams, and mussels) are lower in the food web and thus have less adverse impacts on ecosystems, as they consume primary producers (e.g., aquatic plants and plankton) and/or low-trophic-level fish. The Nile tilapia (*Oreochromis niloticus*), an omnivorous freshwater fish named the "aquatic chicken" for its speedy and efficient growth, converts fishmeal and fish oils at a rate of 1:3, i.e., they are net fish *producers* (Cressey 2009). They are less likely to build up toxins such as mercury in their flesh and have a sweet and inoffensive flavour, but they are seen as bland and not favoured in the west, being roughly a third less valuable than Atlantic salmon. Industrial-scale farming of omnivorous and herbivorous species still uses fishmeal and fish oil (about 15 %) for compound feed and thus potentially diverts food away from human consumption, livestock production, and other industrial uses, though the resulting omega-3 content in the farmed fish is less than in carnivorous fish.

Comparative Ethical Analysis for Farmed Carnivorous and Omnivorous Species

In Table 4, I refine my preliminary analysis (Lam 2013) to compare the ethics of farming a carnivorous species (Atlantic salmon) with an omnivorous species (Nile tilapia). Note that these are generalized case studies intended to illustrate the potential of the method, which is still being refined for aquaculture. The farming of carnivorous fish is evaluated to be less ethical than the farming of omnivorous fish, as carnivorous fish are dependent on wild fish stocks for fishmeal and oils, which depletes the forage fish available for human consumption. They also generate to a host of adverse ecological impacts and fish welfare conditions, such as crowding, escapes, lice infestations, parasites, eutrophication, etc. Eventually, with a refined methodology and improved data, specific aquaculture systems could be assessed semi-quantitatively to account for differences in degree of intensification, integration, technology, and farmed species. The welfare of farmed fish has been incorporated into this qualitative analysis, but detailed species-specific cognitive and emotional capacity information is not yet readily available. This would affect

Table 4 Comparing the ethics of farmed carnivorous and omnivorous species. (Color figure online)

AQUACULTURE: CARNIVOROUS SPECIES (Atlantic salmon)	**Wellbeing**	**Autonomy**	**Justice**	**AQUACULTURE: OMNIVOROUS SPECIES (Nile tilapia)**	**Wellbeing**	**Autonomy**	**Justice**
Ecosystem	Poor	Poor	Poor	Ecosystem	Average	Average	Average
Fish Populations	Poor	Poor	Poor	Fish Populations	Good	Good	Good
Individual Fish	Poor	Poor	Poor	Individual Fish	Good	Good	Good
Society	Average	Average	Poor	Society	Good	Average	Good
Government Agents	Average	Average	Poor	Government Agents	Average	Average	Average
Aquaculture Farmers	Good	Poor	Poor	Aquaculture Farmers	Average	Average	Average
Consumers	Average	Average	Poor	Consumers	Good	Average	Good
Other Stakeholders	Poor	Poor	Poor	Other Stakeholders	Good	Good	Good
Future Generations	Poor	Poor	Poor	Future Generations	Good	Good	Good
Overall	Average	Poor	Poor	**Overall**	Good	Average	Good

Good
Average
Poor

the evaluation of fish welfare in different aquaculture systems, as these capacities determine the sentience, behavioural complexity and experience of suffering of fish individuals and populations. For example, some species of tilapia, including farmed Nile tilapia, are mouth brooders, exhibiting complex parental care, mating behaviour, and a strict dominance hierarchy in groups. Their more complex cognition and behaviour, compared with salmon, for instance, suggests that their welfare should be evaluated on stricter criteria, as they are more aware of their surroundings and thus more affected by adverse environmental conditions.

Fisheries Ethics and Sustainability

The *Rapfish* ethical field evaluates ethical attributes of fisheries in relation to the overall sustainability of the fisheries (Pitcher et al. 2013) and was originally developed by an interdisciplinary team (Coward et al. 2000) from ethical theory and applied to examine the ethics of specific fisheries (Power-Antweiler and Pitcher 2008). Here, the *Rapfish* ethical field has been updated, with revised ethical attributes, issues scored, and justice type addressed listed in Table 5 and detailed at www.rapfish.org. It has yet to be tested rigorously for specific fisheries in a practical ethics context, but a qualitative *Rapfish* ethical analysis for global large- and small-scale fisheries is given in Table 5 (using data in Fig. 2 and other literature sources). Small-scale fisheries score average, large-scale fisheries score poorly in terms of their sustainability evaluated on ethical criteria, which compares favourably with their ethical evaluation using the ethical matrix. That is, small-scale fisheries are assessed to be more ethical, as well as more sustainable than large-scale fisheries.

Table 5 *Rapfish* ethical evaluation field and analysis of capture fisheries (version 3.1, revised from Pitcher et al. 2013; see www.rapfish.org for full description). (Color figure online)

Ethical attribute	Issue scored	Justice type addressed[h]	Large-scale	Small-scale
Adjacency[a]	Geographical proximity of fishers to resource	Distributive		
Iconicity[b]	Cultural or symbolic value of resource to community beyond its value as a source of food or income	Distributive		
Alternative livelihoods	Alternative sources of livelihood within fisheries sector and beyond, both in and out of community	Distributive		
Equity of access	Equitable, regulated access and entry to fishery	Distributive		
Just governance[c]	Equitable sharing of power and inclusion of fishers and local community in collaborative governance; also ecosystem impacts of decisions	Distributive/ Productive		
Illegal, unreported, and unregulated (IUU) fishing[e]	IUU fish catches from poaching, trans-shipments or non-compliance with size, place, species or quota regulations; effectiveness of measures to combat IUU	Distributive/ Retributive		
Harmful Impacts[d]	Harmful impacts from discards, waste and/or bycatch of non-target fish, seabirds, mammals, reptiles, benthic invertebrates, and consequent ecological damage and loss of information caused by fishery	Productive		
Mitigation of harm	Attempts to mitigate harmful impacts of gear on fish habitat and/or fisheries-induced ecosystem change to predators, prey or competing organisms, weighted by the effectiveness of mitigation attempts	Restorative		
Buyer choice[f]	Freedom of buyers (consumers and retailers) to make informed buying choices through access to ecolabels, buying guides, and awareness campaigns, weighted by their influence on the market and sustainability	Social		
Traceability[g]	Existence and validity of traceability documentation along entire seafood value chain	Social		
Overall				

[a] Formerly, "Adjacency and reliance"

[b] New attribute

[c] Formerly, "Just management"

[d] Formerly, "Discards and wastes"

[e] Formerly, "Illegal fishing"

[f] Formerly, "Consumer attitudes" in *Social* evaluation field

[g] New attribute

[h] From Table 1 of Lam and Pitcher 2012a

Further work, however, needs to be done—and is being done—to refine this qualitative analysis. In particular, a full sustainability analysis would require evaluation along all six *Rapfish* dimensions.

To investigate the ethics and sustainability of specific capture fisheries, the relationship between compliance to the UN Code of Conduct for Responsible Fisheries (CCRF) and *Rapfish* ethical status scores was explored (using the version of the ethical field published in Pitcher et al. 2013). The findings, which are displayed in Fig. 3, show that the two are correlated, with an $R^2 = 0.81$. This analysis extends previous work by Pitcher et al. (2009a) evaluating the compliance to the CCRF of fifty-three countries, representing 96 % of the global marine catch in 1999. Pitcher et al. (2009a) found that compliance for the fishing countries averaged

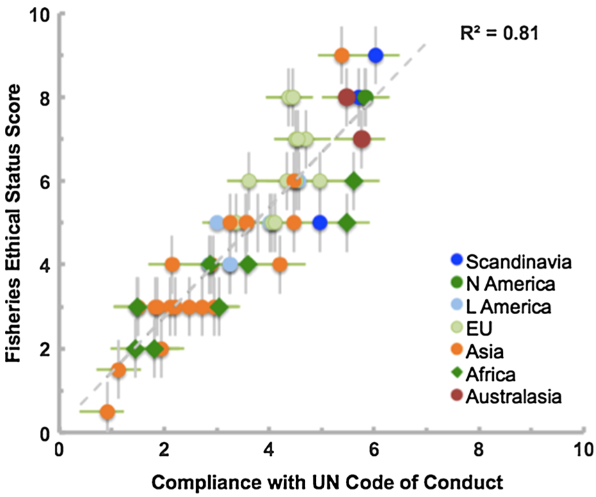


Fig. 3 Correlation between *Rapfish* ethical status scores and compliance with the UN code of conduct for 53 fishing nations representing 96 % of the global catch

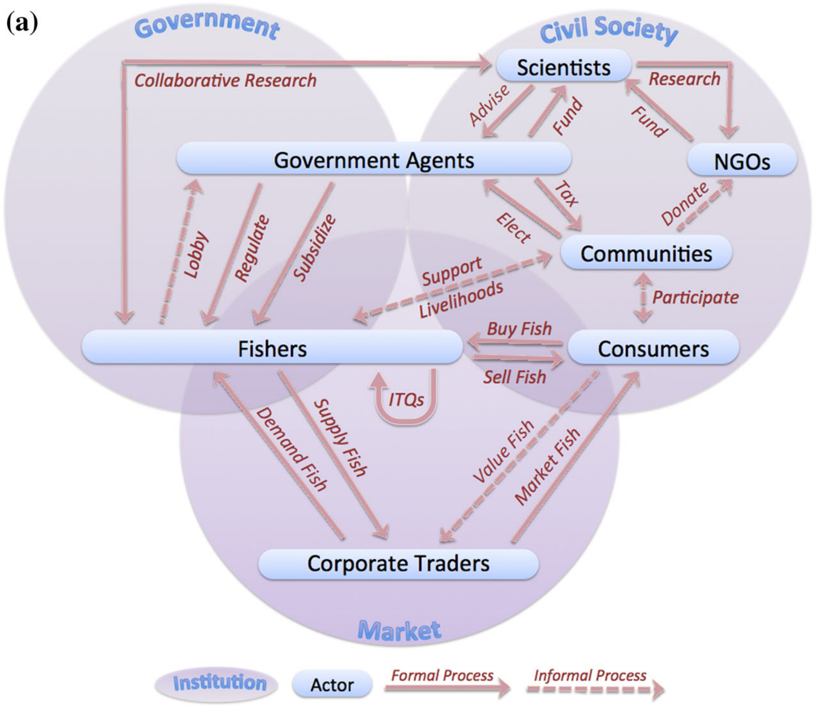
poor and was correlated positively to governance and anti-corruption indices. Code compliance has also been correlated to ecosystem "health" status, which is related to sustainability (Coll et al. 2013). Thus, greater compliance to the CCRF is correlated with higher ethical status scores and better ecosystem health status scores, implying that more ethical fisheries are also likely to be more sustainable. A comparable analysis is being conducted to investigate the ethics and sustainability of aquaculture systems, as well as its interaction with fisheries along the entire seafood value chain.

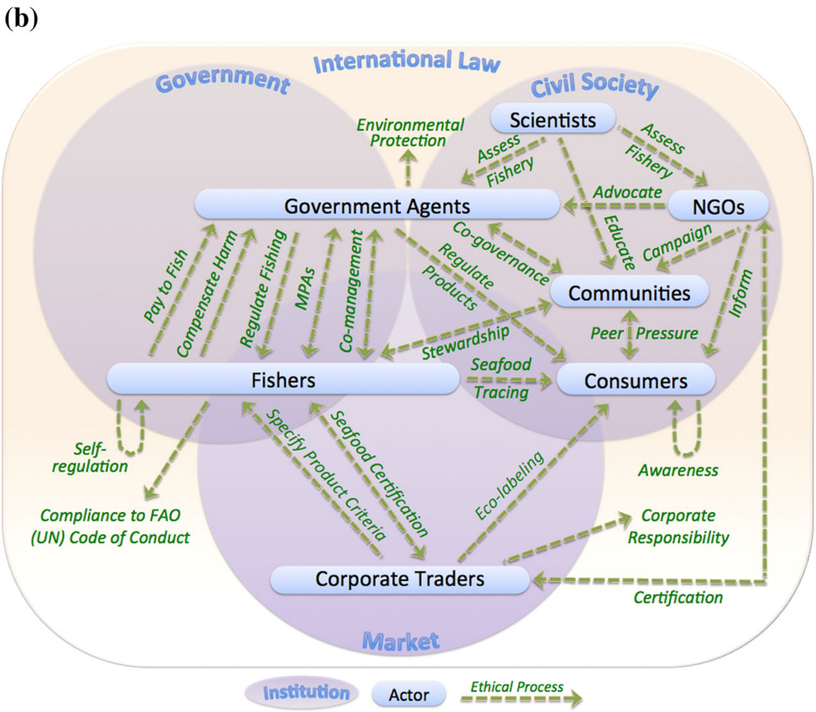
Seafood Value Chain

A complex suite of ethical issues arises along the entire seafood value chain: from production, through processing, distribution, and trade, to consumption. They are negotiated in seafood policy and governance by various social actors within civil society, the market, government, and the law (Fig. 4, from Lam and Pitcher 2012a). 'Food miles' is an overarching ethical issue in the seafood value chain, as it is increasingly recognized that all actors have a responsibility to counteract the global effects of climate change, where food production, distribution, and consumption are major contributing factors in CO_2 emissions (FAO 2006).

Policy-makers tend to focus on economic efficiency and competitiveness of seafood production within the global market, but further expansion of the fish sector must account for dwindling fishery resources and changing consumer attitudes. Growing seafood consumption in modern industrial societies is driven by health,

Fig. 4 Collaborative fisheries governance (reproduced with permission from Lam and Pitcher 2012a): **a** ▶ formal and informal and **b** ethical processes between key interacting human institutions (government, the market, civil society, and the law) and social actors (government agents, fishers, corporate seafood traders, consumers, communities of interest, scientists, and environmentalists, such as NGOs)


(a)
Government
Civil Society
Market
Collaborative Research
Scientists
Research
Advise
Fund
Fund
Government Agents
NGOs
Tax
Elect
Donate
Lobby
Regulate
Subsidize
Communities
Support Livelihoods
Participate
Buy Fish
Fishers
Consumers
Sell Fish
ITQs
Demand Fish
Supply Fish
Value Fish
Market Fish
Corporate Traders
Institution
Actor
Formal Process
Informal Process


(b)
International Law
Government
Civil Society
Environmental Protection
Scientists
Assess Fishery
Assess Fishery
Advocate
Government Agents
NGOs
Co-governance
Educate
Campaign
Regulate Products
Pay to Fish
Compensate Harm
Regulate Fishing
MPAs
Co-management
Communities
Inform
Stewardship
Peer Pressure
Seafood Tracing
Fishers
Consumers
Self-regulation
Specify Product Criteria
Seafood Certification
Eco-labeling
Awareness
Compliance to FAO (UN) Code of Conduct
Corporate Responsibility
Corporate Traders
Certification
Market
Institution
Actor
Ethical Process

diet, and safety concerns, as international and national health authorities recommend seafood for its omega-3 fatty acids and protein, while cautioning against too much mercury in finfish. Food consumption is increasingly influenced by growing globalization of consumer tastes and social, environmental, and ethical concerns, with product branding (Richey and Ponte 2011) and certification (Ponte 2012) now emerging as political spheres of action used to enhance market competitiveness. Ethical consumerism is rising, as consumers, particularly in North America and Europe, want to know what seafood is sustainable and ethical to buy and eat (Verbeke et al. 2007; Conathan 2012), as evident, for instance, by the public outcry over reported slavery in the Thai prawn supply chain (Smithers 2014).

Often driven by non-governmental organizations (NGOs), market-based tools, such as certification, eco-labelling, and tracing schemes, have emerged in the last decade to aid consumer choice in the purchase of sustainable and ethical seafood. The Marine (MSC 2013) and Aquaculture (Bush et al. 2013) Stewardship Councils certify products to be sustainably sourced through the chain of custody and enterprise level, respectively, but are biased toward industrial-scale producers (Ponte 2012; Jacquet et al. 2010). Seafood awareness campaigns, which include eco-labels, buying guides, and rating systems (e.g., Seafood Watch and SeaChoice), aim to inform consumers who "vote with their fork" to ensure a sustainable seafood supply. The environmental impacts of sustainability standards in seafood certification and eco-labelling programs (Ward and Phillips 2010) are ambiguous and limited (Tlusty 2012), though MSC eco-labels have been assessed to be reliable indicators of fish stock health (Gutiérrez et al. 2012). Global value chain analyses (Neilson et al. 2014) and life cycle assessments (Pelletier et al. 2007) can help assess the influence of such standards on ecological, economic, and social sustainability. Meanwhile, traceability tools such as ThisFish™ (Ecotrust Canada) track seafood from "boat to plate" to connect consumers with the fishermen who caught their seafood, while FishPopTrace (Nielsen et al. 2012) uses genetic markers to trace the identity and origin of fish from "ocean to fork" to combat illegally sourced seafood (e.g., Pramod et al. 2014). Yet despite growing consumer demand, seafood ethics and sustainability have not been rigorously or systematically analyzed. As a first step in that direction, I list below various ethical issues to be investigated along the seafood value chain.

Within seafood production systems, ethical issues include: (1) *the method of production*; (2) *ecosystem integrity*; (3) *fish welfare*; (4) *worker conditions*; and (5) *social justice*. Whether and how food regulations and policies favour alternative production methods, such as capture fisheries and aquaculture or large- and small-scale production systems, have ethical implications (Lam 2013). Environmental harm occurs in fisheries (Lam 2012) through non-selective or harmful gear, ghost fishing, and discards, and in aquaculture (Klinger and Naylor 2012), through nutrient and chemical pollution and farmed-fish threats to wild species. Fish welfare (Meijboom and Bovenkerk 2013; Röcklinsberg 2015) considers the treatment of wild (Sneddon 2006, 2011; Braithwaite et al. 2013) and farmed (Bovenkerk and Meijboom 2012, 2013; Bergqvist and Gunnarsson 2013) fish in capture and killing. Safe work conditions and sustainable livelihoods (Allison and Ellis 2001) are basic employment concerns. Social justice issues include: distributional equity (Lam and Pauly 2010; Pinkerton 2013), subsidies, which skew the global seafood industry

(Sumaila et al. 2010); catch share schemes, such as individual transferrable quotas, which privatize fishery resources (Lam and Calcari Campbell 2012); human rights (Allison et al. 2011, 2012), inequitable access agreements, such as EU-subsidized fleets fishing off the west coast of Africa, depleting local resources (Kaczynski and Fluharty 2002); and illegal, unregulated, and unreported fishing, which contravene formal institutions (Agnew et al. 2009). All highlight issues of ecological, economic and social sustainability, such as ecological integrity, economic viability, and equitable entry and access to resources, livelihoods, and fair trade.

Seafood consumption raises issues related to: (1) *food security*; (2) *consumer choice and food sovereignty*; (3) *niche markets and status foods*; (4) *fairness*; (5) *public health*; and (6) *food waste*. Food security implies access to safe, nutritious, adequate, affordable, and culturally appropriate food (FAO 2001; Cassman 2012). Seafood eco-labelling, certification, and tracing schemes (Ward and Phillips 2010) and awareness campaigns, which include eco-labels, buying guides, and rating systems, aid consumers to choose responsibly harvested or locally sourced seafood. Niche markets have emerged for seafood from specific provenances and for status foods (Zwart 2000), such as shark's fin soup in Asian cultures (Wong-Tam et al. 2013). The lucrative market for farmed finfish, such as salmon, fed on fishmeal reduced from forage fish, such as anchovies (Christensen et al. 2014), that otherwise might be consumed as food by the poor, raises fairness issues, as does the fair balance of prices between producer and consumer in the value chain. Western countries promote seafood consumption to improve public health and diminish obesity, decreasing wild fish supplies, as does food waste, which is increasingly recognized as an ethical issue that needs to be combatted (UNEP 2012).

Ethical issues in seafood transport, processing, distribution, and trade (involving wholesalers, middlemen, and retailers) include: (1) *illegal trans-shipments*, which lose track of the source and provenance of fish caught; (2) *fish welfare in transport and handling*, such as the stress and suffering of fish under various conditions of human treatment (Braithwaite et al. 2013; Bergqvist and Gunnarsson 2013); (3) *processing and re-processing* (seafood that is reduced, cured, frozen and canned) that obscures the identity and origin of the seafood, well-documented in China (Clarke 2009); (4) *commoditization* of fishery resources and the emergence of niche markets (Lam and Pitcher 2012; Pitcher and Lam 2015); (5) *competition* between human consumption and fishmeal reduction of forage fish (FAO 2014b; Pikitch et al. 2014); (6) *trade of illegally sourced seafood*, estimated, for example, to be 20–32 % by weight of U.S. fish imports (Pramod et al. 2014); (7) *trade of live seafood and ornamental fish*, prevalent in Southeast Asia (de Mitcheson et al. 2013; Sadovy and Vincent 2002); and (8) *food autarky*, protecting vulnerable countries from food being used as a means to subordinate or as a weapon of war (Mepham 1996).

Conclusions

The ethics and sustainability of capture fisheries and aquaculture were analyzed using an innovative practical ethics approach which adapts the ethical matrix, a conceptual tool that analyzes the wellbeing, autonomy, and justice of various human, animal, and environmental interest groups (Mepham 2008), with *Rapfish*, a semi-quantitative, multi-dimensional, normative rapid appraisal technique developed to evaluate the sustainability of fisheries (Pitcher et al. 2013). From qualitative combined ethical matrix-*Rapfish* analyses, small-scale fisheries were evaluated to be more ethical and more sustainable than large-scale fisheries and omnivorous (and likely herbivorous) aquaculture systems were assessed to be more ethical than carnivorous systems. Note that these qualitative analyses of capture fisheries and aquaculture are geared to illustrate the potential of the novel methodology, which is still being refined. For truly robust ethical assessments, normative attributes or indicators of ethical status must be specified which can be evaluated semi-quantitatively and compared among specific fisheries or aquaculture systems.

Lam and Pitcher's preliminary conclusion (2012a, p. 364) that "ethical fisheries are also sustainable" was corroborated, as compliance to the UN Code of Conduct which was correlated to ecosystem health (Coll et al. 2013), was also correlated with *Rapfish* ethical status scores. Note that while the tools presented here provide relatively strong assessment instruments, one needs to observe that the global dimensions of the seafood value chain also imply cultural variety, some of which may strongly affect what ethical principles and interest groups are included in the ethical matrix. Ethical toolds need to be sensitive to this cultural variation across societies, perhaps by blending the theoretically-based, normative, common morality approach of Mepham with the empirically-based, descriptive, values-based approach of Kaiser. However, what the precise impact of this will be would need to be substantiated by adequate empirical research to map out the relevant values landscapes, such as is being undertaken with Haida Gwaii communities for Pacific herring fishery management (Lam 2015b, c). In consequence, the practical ethics framework proposed here represents but the first step towards a truly global assessment of seafood ethics that accommodates a plurality of values and ethics.

Despite growing ethical consumerism, seafood ethics and sustainability have not hitherto been rigorously or systematically analyzed. As a step in that direction, ethical issues for various seafood production systems and value chains—from production, through processing, distribution, and trade, to consumption—have been overviewed. Within seafood production systems, ethical issues include: the method of production; ecosystem integrity; fish welfare in capture and killing; worker conditions; and social justice. Seafood consumption raises a host of issues, including: food security; consumer choice and food sovereignty; niche markets and status foods; fairness; public health; and food waste. Ethical issues in seafood transport, processing, distribution, and trade include: illegal trans-shipments; fish welfare in transport; processing and re-processing; commoditization of fishery resources and the emergence of niche markets; competition between human consumption and fishmeal reduction of forage fish; trade of illegally sourced seafood; trade of live seafood and ornamental fish; and food autarky.

This nascent seafood value chain analysis reveals that the complex and dynamic interplay among diverse social actors within human institutions (namely, civil society, the market, government, and the law), influences the ethics and sustainability of seafood systems. Social actors include government agents, fishers and aquaculture farmers, corporate seafood traders, including distributors, processors, wholesalers, and retailers, consumers, communities of interest, scientists, and environmentalists, all make decisions with varying attitudes and values toward sustainability. Notably, market-based tools, such as eco-labelling, seafood certification, and tracing, are enhancing consumer awareness and demand for ethical and sustainable seafood. Thus, seafood ethics has the potential to identify and weigh diverse values and interests, which, through the innovative practical ethics approach introduced here, could enable more transparent public decision-making to carve out seafood policies and governance that secure human wellbeing, animal welfare, and ecological sustainability.

Acknowledgments I am indebted to Matthias Kaiser for inviting me to attend the 11th EurSafe Congress in Uppsala, Sweden, September 2013, where this work was first presented and for his detailed and insightful comments on the manuscript. I am especially grateful to Tony Pitcher for stimulating discussions on this research and for providing Figs. 1 and 3. The *Rapfish* attributes have been revised in collaboration with him, Chloé Ormand, Nicolas Talloni-Alvarez, and Szymon Surma and will be detailed in a forthcoming paper. I thank Divya Varkey for her suggestion to include future generations in the combined ethical matrix-*Rapfish*. I cannot conclude this without thanking guest editors Helena Röcklinsberg and Per Sandin for their invitation to contribute to this special issue and Helena's helpful comments with regards to fish welfare, as well as the comments of an anonymous reviewer.

References

Agnew, D. J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J. R., & Pitcher, T. J. (2009). Estimating the worldwide extent of illegal fishing. *PLoS ONE, 4*(e4570), 1–8.

Allison, E. H., Åsgård, B., & Willmann, R. (2011). Editorial: Human rights approaches to governing fisheries. *MAST, 10*(2), 5–13.

Allison, E. H., & Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy, 25*, 377–388.

Allison, E. H., Ratner, B. D., Åsgård, B., Willmann, R., Pomeroy, R., & Kurien, J. (2012). Rights-based fisheries governance: From fishing rights to human rights. *Fish and Fisheries, 13*(1), 14–29.

Andersen, B. S., Jørgensen, C., Eliassen, S., & Giske, J. (in press). The proximate architecture for decision-making in fish. *Fish and Fisheries*.

Bavinck, M., Chuenpagdee, R., Jentoft, S., & Kooiman J. (Eds.). (2013). *Governability of fisheries and aquaculture: Theory and applications.* MARE publication series no. 7. Dordrecht: Springer.

Beauchamp, T. L., & Childress, J. F. (2001). *Principles of biomedical ethics*. Oxford: Oxford University Press.

Bendiksen, E. Å., Johnsen, C. A., Olsen, H. J., & Jobling, M. (2011). Sustainable aquafeeds: Progress towards reduced reliance upon marine ingredients in diets for farmed Atlantic salmon (*Salmo salar*). *Aquaculture, 314*(1), 132–139.

Béné, C., Macfadayen, G., & Allison, E. H. (2007). *Increasing the contribution of small-scale fisheries to poverty alleviation and food security*. Fisheries and Aquaculture Technical Papers 481. Rome: Food and Agriculture Organization of the United Nations.

Bergqvist, J., & Gunnarsson, S. (2013). Finfish aquaculture: Animal welfare, the environment, and ethical implications. *Journal of Agricultural and Environmental Ethics, 26*, 75–99.

Bovenkerk, B., & Meijboom, F. L. B. (2012). The moral status of fish. The importance and limitations of a fundamental discussion for practical ethical questions in fish farming. *Journal of Agricultural and Environmental Ethics, 25*, 843–860. doi:10.1007/s10806-011-9365-8.

Bovenkerk, B., & Meijboom, F. L. B. (2013). Fish welfare in aquaculture: Explicating the chain of interactions between science and ethics. *Journal of Agricultural and Environmental Ethics, 26*, 41–61. doi:10.1007/s10806-012-9395-x.

Braithwaite, V. A., Huntingford, F., & van den Bos, R. (2013). Variation in emotion and cognition among fishes. *Journal of Agricultural and Environmental Ethics, 26*, 7–23.

Bremer, S., Haugen, A. S., & Kaiser, M. (2012). Mapping core values and ethical principles for livelihoods in Asia. In T. Potthast & S. Meisch (Eds.), *Climate change and sustainable development:*

Ethical perspectives on land use and food production (pp. 419–424). Wageningen: Wageningen Academic Publishers.

Bremer, S., Millar, K., Wright, N., & Kaiser, M. (2015). Responsible techno-innovation in aquaculture: Employing ethical engagement to explore attitudes to GM salmon in Northern Europe. *Aquaculture, 437*, 370–381.

Bremer, S., Reddy, G. P., & Millar, K. (2013). Using engagement tools to encourage ethical reflection in bioscience and innovation research: Examining the GM animals case with Indian researchers using the ethical matrix. *Asian Biotechnology & Development Review, 15*(2), 21–39.

Bromley, D. W. (2008). The crisis in ocean governance: Conceptual confusion, spurious economics, political indifference. *MAST: Maritime Studies, 6*(2), 7–22.

Bromley, D. W. (2009). Perspective: Socioeconomics. Abdicating responsibility: The deceits of fisheries policy. *Fisheries, 34*(6), 280–290.

Brundlandt, G. H., & World Commission on Environment and Development. (1987). *Our common future: Report of the World Commission on Environment and Development*. Oxford: Oxford University Press.

Buchary, E. A., Pitcher, T. J., & Sumaila, U. R. (2011). Underaccounted values: Under-reporting sardine catches as a strategy against poverty in the Bali Strait, Indonesia. In R. E. Ommer, R. I. Perry, K. Cochrane & P. Cury (Eds.), *World fisheries: A social-ecological analysis* (pp. 203–223). Oxford: Wiley.

Burton, P. S. (1993). Intertemporal preferences and intergenerational equity considerations in optimal resource harvesting. *Journal of Environmental Economics and Management, 24*, 119–132.

Bush, S. R., Belton, B., Hall, D., Vandergeest, P., Murray, F. J., Ponte, S., et al. (2013). Certify sustainable aquaculture? *Science, 341*, 1067–1068.

Cao, L., Naylor, R., Henriksson, P., Leadbitter, D., Metian, M., Troell, M., & Zhang, W. (2015). China's aquaculture and the world's wild fisheries. *Science, 347*(6218), 133–135.

Cassman, K. G. (2012). What do we need to know about global food security? *Global Food Security, 1*, 81–82.

Chambers, R. (1994). The origins and practice of participatory rural appraisal. *World Development, 22*(7), 953–969.

Christensen, V., de la Puente, S., Sueiro, J. C., Steenbeek, J., & Majluf, P. (2014). Valuing seafood: The Peruvian fisheries sector. *Marine Policy, 44*, 302–311.

Chuenpagdee, R., Morgan, L. E., Maxwell, S. M., Norse, E. A., & Pauly, D. (2003). Shifting gears: Assessing collateral impacts of fishing methods in U.S. waters. *Frontiers in Ecology and the Environment, 1*(10), 517–524.

Clarke, S. (2009). *Understanding China's fish trade and traceability*. Hong Kong: TRAFFIC East Asia.

Coll, M., Libralato, S., Pitcher, T. J., Solidoro, C., & Tudela, S. (2013). Sustainability implications of honouring the Code of Conduct for Responsible Fisheries. *Global Environmental Change, 23*(1), 157–166. doi:10.1016/j.gloenvcha.2012.10.017.

Conathan, M. (2012). *Fish on Fridays: The ethics of seafood*. Center for American Progress. May 11, 2012. https://www.americanprogress.org/issues/green/news/2012/05/11/11648/fish-on-fridays-the-ethics-of-seafood/. Accessed December 1, 2014.

Coward, H., Ommer, R., & Pitcher, T. (Eds.). (2000). *Just fish: Ethics and Canadian marine fisheries.* Social and economic papers no. 23. St. John's, NF: Institute of Social and Economic Research Books, Memorial University of Newfoundland.

Cressey, D. (2009). Aquaculture: Future fish. *Nature, 458*, 398–400.

de Mitcheson, Y. S., Craig, M. T., Bertoncini, A. A., Carpenter, K. E., Cheung, W. W. L., Choat, J. H., et al. (2013). Fishing groupers towards extinction: A global assessment of threats and extinction risks in a billion dollar fishery. *Fish and Fisheries, 14*, 119–136.

Economist. (2006). *Food politics: Voting with your trolley*. http://www.economist.com/node/8380592. Accessed November 30, 2014.

Evans, P. T., Marschke, M., & Paudyal, K. (2004). *Flood forests, fish, and fishing villages: Tonle Sap, Cambodia. A collaborative study by the Food and Agriculture Organization of the United Nations, Siem Reap and Asia Forest Network.* Community Forest Management Trends in Southeast Asia. Bohol: Asia Forest Network.

Farm Animal Welfare Council (FAWC). (2009). *Farm animal welfare in Great Britain: Past, present, and future*. London: FAWC.

Food and Agriculture Organization of the United Nations (FAO). (1995). *Code of Conduct for Responsible Fisheries*. Rome: FAO.

FAO. (2001). *Ethical issues in food and agriculture.* FAO ethics series 1. Rome: FAO.

FAO. (2005). *Ethical issues in fisheries.* FAO ethics series 4. Rome: FAO.

FAO. (2006). *Livestock's long shadow: Environmental issues and options.* Rome: FAO. ftp://ftp.fao.org/docrep/fao/010/A0701E/A0701E00.pdf. Accessed December 1, 2014.

FAO. (2014a). *FAO statistical yearbook*. Rome: FAO.

FAO. (2014b). *The state of world fisheries and aquaculture 2014: Opportunities and challenges*. Rome: FAO.

FAO. (2014c). *Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication.* Committee on Fisheries (COFI) report. COFI/2014/Inf.10. Rome: FAO. http://www.fao.org/cofi/23885-09a60857a289b96d28c31433643996c84.pdf. Accessed December 1, 2014.

Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO). (2004). *FAO/WHO expert consultation on the safety assessment of foods derived from genetically modified animals, including fish.* Rome: FAO. ftp://ftp.fao.org/docrep/fao/006/y5316E/y5316E00.pdf. Accessed December 1, 2014.

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures, 25*(7), 739–755.

Grafton, R. Q., Arnason, R., Bjørndal, T., Campbell, D., Campbell, H. F., Clark, C. W., et al. (2006). Perspective: Incentive-based approaches to sustainable fisheries. *Canadian Journal of Fisheries and Aquatic Sciences, 63*, 699–710.

Gutiérrez, N. L., Valencia, S. R., Branch, T. A., Agnew, D. J., Baum, J. K., Bianchi, P. L., et al. (2012). Eco-label conveys reliable information on fish stock health to seafood consumers. *PLoS ONE, 7*(8), e43765.

Hauck, M. (2011). Small-scale fisheries compliance: Integrating social justice, legitimacy and deterrence. In R. S. Pomeroy & N. L. Andrew (Eds.), *Managing small-scale fisheries: Frameworks and approaches* (pp. 196–215). London: CABI Publishing.

Jacquet, J., & Pauly, D. (2008). Funding priorities: Big barriers to small-scale fisheries. *Conservation Biology, 22*(4), 832–835.

Jacquet, J., Pauly, D., Ainley, D., Holt, S., Dayton, P., & Jackson, J. (2010). Seafood stewardship in crisis. *Nature, 467*, 28–29.

Kaczynski, V. M., & Fluharty, D. L. (2002). European policies in West Africa: Who benefits from fisheries agreements? *Marine Policy, 26*(2), 75–93.

Kaiser, M. (1997). Fish-farming and the precautionary principle: Context and values in environmental science and policy. *Foundations of Science, 2*, 307–341.

Kaiser, M. (2005). Assessing ethics and animal welfare in animal biotechnology for farm production. *OiE Scientific and Technical Review of the World Organization for Animal Health (Rev.sci.tech.Off.int.Epiz.), 24*(1), 75–87.

Kaiser, M. (2012a). The ethics and sustainability of aquaculture. In D. M. Kaplan (Ed.), *The philosophy of food* (pp. 233–249). Berkeley, CA: University of California Press.

Kaiser, M. (2012b). Why German consumers need to reconsider their preferences: The ethical argument for aquaculture. In T. Potthast & S. Meisch (Eds.), *Climate change and sustainable development: Ethical perspectives on land use and food production* (pp. 321–325). Wageningen: Wageningen Academic Publishers.

Kaiser, M., & Forsberg, E.-M. (2001). Assessing fisheries—Using an ethical matrix in a participatory process. *Journal of Agricultural and Environmental Ethics, 14*, 191–200.

Kaiser, M., Millar, K., Thorstensen, E., & Tomkins, S. (2007). Developing the ethical matrix as a decision support framework: GM fish as a case study. *Journal of Agricultural and Environmental Ethics, 20*, 65–80. doi:10.1007/s10806-006-9023-8.

Kaiser, M., & Stead, S. M. (2002). Uncertainties and values in European aquaculture: Communication, management and policy issues in times of "changing public perceptions". *Aquaculture International, 10*, 469–490.

Kalueff, A. V., Stewart, A. M., Kyzar, E. J., Cachat, J., Gebhardt, M., Landsman, S., et al. (2012). Time to recognize zebrafish 'affective' behaviour. *Behaviour, 149*, 1019–1036.

Kirsch, S. (2001). Lost worlds: Environmental disaster, "culture loss", and the law. *Current Anthropology, 42*(2), 167–198.

Klinger, D., & Naylor, R. (2012). Searching for solutions in aquaculture: Charting a sustainable course. *Annual Review of Environment and Resources, 37*, 247–276. doi:10.1146/annurev-environ-021111-161531.

Kooiman, J., Bavinck, M., Jentoft, S., & Pullin, R. (Eds.). (2005). *Fish for life: Interactive governance for fisheries*. MARE publication series no. 3. Amsterdam: Amsterdam University Press.

Lam, M. E. (2012). Of fish and fishermen: Shifting societal baselines to reduce environmental harm in fisheries. *Ecology and Society, 17*(4), 18. doi:10.5751/ES-05113-170418.

Lam, M. E. (2013). Comparing the ethics of capture fisheries and aquaculture. In H. Röcklinsberg & P. Sandin (Eds.), *The ethics of consumption: The citizen, the market, and the law* (pp. 305–310). Wageningen: Wageningen Academic Publishers.

Lam, M. E. (2015a). Aboriginal freshwater fisheries as resilient social-ecological systems. In J. Craig (Ed.), *Freshwater fisheries ecology* (pp. 422–437). Oxford: Wiley-Blackwell.

Lam, M. E. (2015b). Reconciling Haida ethics with Pacific herring management. In D. E. Dumitras, I. M. Jitea & S. Aerts (Eds.), *Know your food: Food ethics and innovation. Proceedings from the 12th EurSafe Congress*, Cluj-Napoca, Romania, May 28–30, 2015 (pp. 169–175). Wageningen: Wageningen Academic Publishers.

Lam, M. E. (2015c). Opinion: Herring fishery needs integrated management plan. *The Vancouver Sun*, November 9, 2015. http://www.vancouversun.com/technology/opinion+herring+fishery+needs+integrated+management+plan/11505147/story.html?__lsa=91d0-173f.

Lam, M. E., & Borch, T. (2011). Cultural valuing of fishery resources by the Norwegian Saami. In L. Westra, K. Bosselmann & C. Soskolne (Eds.), *Globalisation and ecological integrity in science and international law* (pp. 361–376). Cambridge: Cambridge Scholars Publishing.

Lam, M. E., & Calcari Campbell, M. E. (2012). The privilege to fish. *Ecology and Society, 17*(4), 19. doi:10.5751/ES-04156-170419.

Lam, M. E., & Pauly, D. (2010). Who is right to fish? Evolving a social contract for ethical fisheries. *Ecology and Society,* 15(3), 16. http://www.ecologyandsociety.org/vol15/iss3/art16/. Accessed December 1, 2014.

Lam, M. E., & Pitcher, T. J. (2012a). The ethical dimensions of fisheries. *Current Opinion in Environmental Sustainability, 4*, 364–373.

Lam, M. E., & Pitcher, T. J. (2012b). Fish commoditization: Sustainability strategies to protect living fish. *Bulletin of Science, Technology & Society, 32*(1), 31–40.

Lamberts, D. (2006). The Tonle Sap Lake as a productive ecosystem. *International Journal of Water Resources Development, 22*(3), 481–495. doi:10.1080/07900620500482592.

Lin, A. C. (2006). The unifying role of harm in environmental law. *Wisconsin Law Review, 3*, 897–986.

Lund, V., Mejdell, C. M., Röcklinsberg, H., Anthony, R., & Håstein, T. (2007). Expanding the moral circle: Farmed fish as objects of moral concern. *Diseases of Aquatic Organisms, 75*, 109–118.

Lund, V., & Olsson, I. A. S. (2006). Animal agriculture: Symbiosis, culture or ethical conflict? *Journal of Agricultural and Environmental Ethics, 19*, 47–56.

Macdonald, J. M. (1995). Appreciating the precautionary principle as an ethical evolution in ocean management. *Ocean Development & International Law, 26*, 255–286.

Marine Stewardship Council (MSC). (2013). *Marine Stewardship Council global impacts report 2013: Monitoring and evaluation*. London: MSC.

Martins, C. I. M., Galhardo, L., Noble, C., Damsgård, B., Spedicato, M. T., Zupa, W., et al. (2012). Behavioural indicators of welfare in farmed fish. *Fish Physiology and Biochemistry, 38*, 17–41.

Meijboom, F. L. B., & Bovenkerk, B. (2013). Fish welfare: Challenge for science and ethics—Why fish makes the difference. *Journal of Agricultural and Environmental Ethics, 26*, 1–6.

Mepham, T. B. (1995). Ethical aspects of animal biotechnology. *Journal of the University of Wales Agricultural Society, 75*, 3–22.

Mepham, T. B. (1996). Ethical analysis of food biotechnologies: An evaluative framework. In T. B. Mepham (Ed.), *Food ethics* (pp. 101–119). London: Routledge. Reproduced in 2002 in R. Chadwick and D. Schroeder (Eds.), *Applied ethics: Critical concepts in philosophy* (pp. 343–359). London: Routledge.

Mepham, B. (2000a). A framework for the ethical analysis of novel foods: The ethical matrix. *Journal of Agricultural and Environmental Ethics, 12*, 165–176.

Mepham, T. B. (2000b). The role of food ethics in food policy. *Proceedings of the Nutrition Society, 59*, 609–618.

Mepham, B. (2006). The ethical matrix as a decision-making tool with specific reference to animal sentience. In J. Turner & J. D'Silva (Eds.), *Animals, ethics and trade* (pp. 134–145). London: Earthscan.

Mepham, B. (2008). *Bioethics: An introduction for the biosciences* (2nd ed.). Oxford: Oxford University Press.

Mepham, B. (2012a). Agricultural ethics. In R. Chadwick (Ed.), *Encyclopedia of applied ethics* (2nd ed., Vol. 1, pp. 86–96). San Diego, CA: Academic Press.

Mepham, B. (2012b). Food ethics. In R. Chadwick (Ed.), *Encyclopedia of applied ethics* (2nd ed., Vol. 2, pp. 322–330). San Diego, CA: Academic Press.

Millar, K., Thorstensen, E., Tomkins, S., Mepham, B., & Kaiser, M. (2007). Developing the ethical Delphi. *Journal of Agricultural and Environmental Ethics, 20*(1), 53–63.

Myers, R. A., & Worm, B. (2003). Rapid worldwide depletion of predatory fish communities. *Nature, 423*, 280–283.

Naylor, R. L., Goldburg, R. J., Primavera, J., Kautsky, N., Beveridge, M. C. M., Clay, J., et al. (2001). Effects of aquaculture on world fish supplies. *Issues in Ecology, 8*, 12.

Neilson, J., Pritchard, B., & Yeung, H. W.-C. (2014). Global value chains and global production networks in the changing international political economy: An introduction. *Review of International Political Economy, 21*(1), 1–8. doi:10.1080/09692290.2013.873369.

Nielsen, E. E., Cariani, A., Mac Aoidh, E., Maes, G. E., Milano, I., Ogden, R., et al. (2012). Gene-associated markers provide tools for tackling illegal fishing and false eco-certification. *Nature Communications, 3*, 851. doi:10.1038/ncomms1845.

Padilla, E. (2002). Intergenerational equity and sustainability. *Ecological Economics, 41*, 69–83.

Pauly, D. (2006). Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. *MAST, 4*(2), 7–22.

Pauly, D., Christensen, V., Guénette, S., Pitcher, T. J., Sumaila, U. R., Walters, C. J., et al. (2002). Towards sustainability in world fisheries. *Nature, 418*, 689–695.

Pauly, D., & Zeller, D. (2016). Global catch trends in marine fisheries. In D. Pauly & D. Zeller (Eds.), *Global atlas of marine fisheries: A critical appraisal of catches and ecosystem impacts*. Washington, DC: Island Press (in press).

Pauly, D., & Zeller, D. (in press). Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. *Nature Communications*.

Pelletier, N. L., Ayer, N. W., Tyedmers, P. H., Kruse, S. A., Flysjo, A., Robillard, G., et al. (2007). Impact categories for life cycle assessment research of seafood production systems: Review and prospectus. *International Journal of Life Cycle Assessments, 12*(6), 414–421.

Pikitch, E. K., Rountos, K. J., Essington, T. E., Santora, C., Pauly, D., Watson, R., et al. (2014). The global contribution of forage fish to marine fisheries and ecosystems. *Fish and Fisheries, 15*(1), 43–64. doi:10.1111/faf.12004.

Pinkerton, E. (2013). Alternatives to ITQs in equity-efficiency-effectiveness trade-offs: How the lay-up system spread effort in the BC halibut fishery. *Marine Policy, 42*, 5–13.

Pitcher, T. J. (1999). *Rapfish, a rapid appraisal technique for fisheries, and its application to the Code of Conduct for Responsible Fisheries*. FAO Fisheries circular no. FIRM/C: no. 947. Rome: FAO.

Pitcher, T. J. (2008). The sea ahead: Challenges to marine biology from seafood sustainability. Keynote paper, 41st European Marine Biology Symposium, Cork, Ireland, September 4, 2006. *Hydrobiologia, 606*, 161–185.

Pitcher, T. J. (2012). Fisheries. In R. C. Anderson, et al. (Eds.), *The Berkshire encyclopedia of sustainability. Volume 10: The future of sustainability* (Vol. 10, pp. 108–115). Great Barrington, MA: Berkshire Publishing Group.

Pitcher, T. J., Bundy, A., Preikshot, D., Hutton, T., & Pauly, D. (1998). Measuring the unmeasurable: A multivariate interdisciplinary method for rapid appraisal of health of fisheries. In T. J. Pitcher, P. J. B. Hart, & D. Pauly (Eds.), *Reinventing fisheries management* (pp. 31–54). London: Chapman and Hall.

Pitcher, T. J., & Cheung, W. W. L. (2013). Fisheries: Hope or despair? *Marine Pollution Bulletin, 74*(2), 506–516.

Pitcher, T. J., Kalikoski, D., Pramod, G., & Short, K. (2008). *Safe conduct? Twelve years fishing under the UN Code*. Gland: World Wildlife Fund.

Pitcher, T. J., Kalikoski, D., Pramod, G., & Short, K. (2009a). Not honouring the Code. *Nature, 457*, 658–659.

Pitcher, T. J., Kalikoski, D., Short, K., Varkey, D., & Pramod, G. (2009b). An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. *Marine Policy, 33*, 223–232.

Pitcher, T. J., & Lam, M. E. (2010). Fishful thinking: Rhetoric, reality, and the sea before us. *Ecology and Society,* 15(2), 12. http://www.ecologyandsociety.org/vol15/iss2/art12/. Accessed December 1, 2014.

Pitcher, T. J., & Lam, M. E. (2015). Fish commoditization and the historical origins of catching fish for profit. *Maritime Studies (MAST), 14*(1), 1–19.
Pitcher, T. J., Lam, M. E., Ainsworth, C., Martindale, A., Nakamura, K., Perry, R. I., & Ward, T. (2013). Improvements to the 'Rapfish' rapid evaluation technique for fisheries: Integrating ecological and human dimensions. *Journal of Fish Biology,* 83(4), 865–889. Special Issue: Selected Papers from the Sixth World Fisheries Congress.
Pitcher, T. J., & Preikshot, D. B. (2001). *Rapfish*: A rapid appraisal technique to evaluate the sustainability status of fisheries. *Fisheries Research, 49*(3), 255–270.
Ponte, S. (2012). The Marine Stewardship Council (MSC) and the making of a market for 'sustainable fish'. *Journal of Agrarian Change, 12*(2 and 3), 300–315.
Power-Antweiler, M. D., & Pitcher, T. J. (2008). Reconciling fisheries and allocation using a justice-based approach: Troll fisheries score best. In J. L. Nielsen, J. J. Dodson, K. Friedland, T. R. Hamon, J. Musick & E. Verspoor (Eds.), *Reconciling fisheries with conservation: Proceedings of the 4th World Fisheries Congress* (pp. 63–78). Bethesda, MD: American Fisheries Society, Symposium 49.
Pramod, G., Nakamura, K., Pitcher, T. J., & Delagran, L. (2014). Estimates of illegal and unreported fish in seafood imports to the USA. *Marine Policy, 48*, 102–133.
Rawls, J. (1971). *A theory of justice*. Oxford: Oxford University Press.
Richey, L. A., & Ponte, S. (2011). *Brand aid: Shopping well to save the world*. Minneapolis, MN: University of Minnesota Press.
Röcklinsberg, H. (2015). Fish consumption: Choices in the intersection of public concern, fish welfare, food security, human health and climate change. *Journal of Agricultural and Environmental Ethics, 28*, 533–551.
Sadovy, Y. J., & Vincent, A. C. (2002). Ecological issues and the trades in live reef fishes. *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem, 2*, 391–420.
Sen, A. (2009). *The idea of justice*. Cambridge, MA: Belknap Press.
Smith, M. D., Roheim, C. A., Crowder, L. B., Halpern, B. S., Turnipseed, M., Anderson, J. L., et al. (2010). Sustainability and global seafood. *Science, 327*, 784–786.
Smithers, R. (2014). Slavery in prawn trade: Consumers urged to check source of seafood. *The Guardian.* June 11, 2014. http://www.theguardian.com/world/2014/jun/11/slavery-prawn-shoppers-boycott-unethical-seafood-greenpeace. Accessed December 1, 2014.
Sneddon, L. U. (2006). Ethics and welfare: Pain perception in fish. *Bulletin of the European Association of Fish Pathologists, 26*(1), 6–10.
Sneddon, L. U. (2011). Cognition and welfare. In C. Brown, K. Laland, & J. Krause (Eds.), *Fish cognition and behavior* (2nd ed., pp. 405–434). Oxford: Wiley-Blackwell.
Stigler, G. J. (1971). The theory of economic regulation. *Bell Journal of Economics and Management Science, 2*, 3–21.
Sumaila, U. R. (2004). Intergenerational cost–benefit analysis and marine ecosystem restoration. *Fish and Fisheries, 5*, 329–343.
Sumaila, U. R. (2007). Getting values and valuation right: A must for reconciling fisheries with conservation. *American Fisheries Society Symposium, 49*, 587–592.
Sumaila, U. R., Khan, A. S., Dyck, A. J., Watson, R., Munro, G., Tyedmers, P., & Pauly, D. (2010). A bottom-up re-estimation of global fisheries subsidies. *Journal of Bioeconomics, 12*, 201–225.
Sumaila, U. R., & Walters, C. (2005). Intergenerational discounting: A new intuitive approach. *Ecological Economics, 52*, 135–142.
Tlusty, M. F. (2012). Environmental improvement of seafood through certification and ecolabelling: Theory and practice. *Fish and Fisheries, 13*(1), 1–13.
Troell, M., Naylor, R. L., Metian, M., Beveridge, M., Tyedmers, P. H., Folke, C., et al. (2014). Does aquaculture add resilience to the global food system? *Proceedings of the National Academy of Science of the United States, 111*(37), 13257–13263.
Turner, N. J., Gregory, R., Brooks, C., Failing L., & Satterfield, T. (2008). From invisibility to transparency: Identifying the implications. *Ecology and Society,* 13(2), 7. http://www.ecologyandsociety.org/vol13/iss2/art7/.
United Nations Convention on the Law of the Sea (UNCLOS III, concluded December 10 1982, entered into force November 16 1994), 1833 United Nations Treaty Series 397, United Nations Document A/Conf.61/122. http://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf. Accessed December 1, 2014.
United Nations Environment Programme (UNEP). (2012). *Avoiding future famines: Strengthening the ecological foundation of food security through sustainable food systems*. Nairobi: UNEP.

Verbeke, W., Vanhonacker, F., Sioen, I., Van Camp, J., & De Henauw, S. (2007). Perceived importance of sustainability and ethics related to fish: A consumer behavior perspective. *AMBIO: A Journal of the Human Environment, 36*(7), 580–585. doi:10.1579/0044-7447(2007)36[580:PIOSAE]2.0.CO;2.

Ward, T., & Phillips, B. (2010). Seafood ecolabeling. In R. Q. Grafton, R. Hilborn, D. Squires, M. Tait, & M. Williams (Eds.), *Handbook of marine fisheries conservation and management* (pp. 608–617). Oxford: Oxford University Press.

Weeratunge, N., Béné, C., Siriwardane, R., Charles, A., Johnson, D., Allison, E. H., et al. (2014). Small-scale fisheries through the wellbeing lens. *Fish and Fisheries, 15*(2), 255–279. doi:10.1111/faf.12016.

Wong-Tam, K., Jang, K., & Hui, J. (2013). Banning shark fin soup ban has nothing to do with discrimination. *The Star Commentary*. http://www.thestar.com/opinion/commentary/2013/03/24/banning_shark_fin_soup_ban_has_nothing_to_do_with_discrimination.html. Accessed December 1, 2014.

Worm, B., Hilborn, R., Baum, J. K., Branch, T. A., Collie, J. S., Costello, C., et al. (2009). Rebuilding global fisheries. *Science, 325*, 578–585.

Zwart, H. (2000). A short history of food ethics. *Journal of Agricultural and Environmental Ethics, 12*, 113–126.