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Conserving wild fish in a sea of market-based efforts

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Abstract Over the past decade conservation groups have put considerable effort into educating consumers and changing patterns of household consumption. Many groups aiming to reduce overfishing and encourage sustainable fishing practices have turned to new market-based tools, including consumer awareness campaigns and seafood certification schemes (e.g. the Marine Stewardship Council) that have been well received by the fishing and fish marketing industries and by the public in many western countries. Here, we review difficulties that may impede further progress, such as consumer confusion, lack of traceability and a lack of demonstrably improved conservation status for the fish that are meant to be protected. Despite these issues, market-based initiatives may have a place in fisheries conservation in raising awareness among consumers and in encouraging suppliers to adopt better practices. We also present several additional avenues for market-based conservation measures that may strengthen or complement current initiatives, such as working higher in the demand chain, connecting seafood security to climate change via life cycle analysis, diverting small fish away from the fishmeal industry into human food markets, and the elimination of fisheries subsidies. Finally, as was done with greenhouse gas emissions, scientists, conservation groups and governments should set seafood consumption targets.

Keywords Consumption targets, effectiveness, fisheries subsidies, fishmeal, life cycle analysis, Marine Stewardship Council, sustainable seafood, traceability

Introduction

Fish consumption is on the rise globally. The USA now consumes almost five times more fish than it did 100 years ago (c. 2.2 million t in 2004 vs c. 500,000 t in 1910; NMFS, 2006), and Chinese consumers are now consuming almost five times more seafood per capita than they did in 1961 (25.4 kg person⁻¹ in 2005 vs 4.8 kg person⁻¹ in 1961; Halweil, 2006). Worldwide, per capita consumption of marine fishes has nearly doubled since the 1960s (9 kg in the 1960s vs 16 kg in 1997; WHO, 2006) while the human population also doubled over this same time period. Future projections show that seafood supply from capture fisheries is decreasing and that, overall, today's marine fisheries are unsustainable (Pauly et al., 2002; Worm et al., 2006).

To meet predicted demands for seafood by 2020 aquaculture production will need to double. Alternatively, how and for what we fish (e.g. low trophic-level species for which there exists a far greater amount of biomass available for consumption) will require reform (Pitcher, 2008). Because the growing demand for seafood has been implicated in the marine fisheries crisis, it is appropriate that some effort be directed at reforming the human appetite (Grescoe, 2008). So far, this reform has largely manifested itself in a host of market efforts to encourage what is popularly referred to as 'sustainable seafood', the meaning of which is generally broad, covering ecologically responsible fishing that minimizes the bycatch of non-target species and brings acceptable levels of ecosystem and environmental impacts. Here we aim to provide an overview of these initiatives, expand upon Jacquet & Pauly (2007) in reviewing common difficulties, and present several possible avenues for improving market-based approaches to conserve wild fish.

Overview of market-based sustainable seafood initiatives for marine capture fisheries

Marine capture fisheries peaked in the late 1980s (Watson & Pauly, 2001), although the problem was not realized until the early 1990s. The first major seafood campaign was the boycott of canned tuna in the late 1980s, which led to the first seafood eco-label, the 'dolphin-safe' label, in 1990 (Ward, 2008).

In 1997 the first certification scheme created specifically for sustainable fisheries was established in the form of the Marine Stewardship Council (MSC; Kaiser & Edwards-Jones, 2006). The MSC designed a set of ecological criteria for sustainable and well-managed fisheries along with a label for fish products that receive MSC approval; two

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of us (TP and DP) participated in this process. Today, the MSC label is the best established and most widely discussed fisheries certification and, at the end of 2007, c. 7% (c. 5.25 million t) of the annual global landings of marine fisheries were MSC certified.

One year after the MSC's inception the National Audubon Society and Carl Safina developed the first consumer seafood guide and, in 2000, the Monterey Bay Aquarium published a seafood wallet card. The first trade association, the Seafood Choices Alliance, founded in 2001, provided infrastructure for the initiatives that would follow (Table 1). Globally, market-based sustainable seafood initiatives are on the rise (Table 1). The fundamental goals of these initiatives are to raise awareness and ultimately reduce overexploitation of sensitive species by reducing demand (by shifting purchasing decisions towards products from more sustainable fisheries). They can be considered in the following categories (as in Roheim & Sutinen, 2006): (1) evaluation system, i.e. criteria to determine sustainability and to generate items in (2)–(5); (2) boycotts; (3) eco-labels; (4) consumer seafood guides (including cookbooks); (5) distributor seafood guides (often used jointly with pressure on, and engagement with, retailers not to carry particular species or to improve practices); and (6) trade associations.

Common difficulties

One major concern in sustainable seafood initiatives is defining sustainability. Each initiative has a different definition of sustainability and a different methodology to assess it. A recent assessment used 18 criteria to assess nine systems for evaluating fisheries sustainability and found that there were several areas that none of them addressed adequately: (1) socio-economic attributes, (2) food security, (3) capacity of the assessment to adapt to local issues and unique aspects of the fishery, and (4) peer review of assessment decision (Leadbitter & Ward, 2007).

Also lacking in most sustainable seafood initiatives is consideration of environmental implications of bringing both fisheries and aquaculture products to market (Pelletier & Tyedmers, 2008). These include use efficiencies and emissions intensities of compounds such as greenhouse gases, acid precipitants, ozone-depleting and eutrophication agents and a wide variety of chemicals with ecotoxicological effects (Pelletier et al., 2006). A growing body of life cycle and energy analyses of fisheries and aquaculture identify the key stages of seafood supply chains and facilitate comparisons of eco-efficiency between competing production technologies (Pelletier & Tyedmers, 2008).

The difficulties associated with assessing and communicating sustainability also manifest themselves in consumer confusion. For instance, the 2007 Seafood Watch wallet card from Monterey Bay Aquarium lists 12 different tuna types (i.e. species, method of fishing, country) between

the three columns of 'best choices', 'good alternatives' and 'avoid'. WWF's seafood choice card in Spain lists bluefin tuna (*Thunnus thynnus*, *Thunnus maccoyii* or *Thunnus orientalis*) as species to avoid but as a 'best choice' if the tuna come from coastal fishing traps. Although these complexities reflect the reality of the global seafood market, they also confuse consumers (Jacquet, 2007). This confusion is intensified by government agencies recommending the consumption of seafood because of its nutritional value (Brunner et al., 2009) at the same time as other agencies recommend eating less of certain species because of their high concentrations of mercury and other toxic compounds (e.g. Environmental Defense Fund's Seafood Selector; Environmental Defense Fund, 2009). In addition, many seafood guides have a regional focus, despite the global nature of the seafood market. In the USA consumer seafood guides focus mainly on fish caught by national fisheries (Roheim & Sutinen, 2006), which is inappropriate, given that the USA imports > 80% of its seafood.

Furthermore, different consumer guides provide different recommendations depending on their criteria for ranking seafood, so that there is confusion generated not only by each card but also between cards. Each sustainable seafood initiative must have some way of assessing sustainability, which invariably leads to inconsistencies. This confusion is evident at the International Seafood Guide (2009), which was intended to enable the querying of seafood guides by web-enabled phones (R. Froese, IFM-GEOMAR, Kiel, Germany, pers. comm.) but has inadvertently exposed inconsistencies between the guides it covers. The website presents seafood guides for 19 countries and displays interesting results for countries with more than one guide (e.g. the website presents three for Germany and nine for the USA). While different organizations may generate a unanimous recommendation (i.e. 'avoid') for some species (e.g. Atlantic cod *Gadus morhua*, Atlantic bluefin tuna *T. thynnus*), the recommendations can be inconsistent for other species. For example, six organizations (including the Blue Ocean Institute), rank Atlantic halibut *Hippoglossus hippoglossus* as a fish to avoid, whereas Environmental Defense recommends consuming it with caution and Friends of the Sea and Monterey Bay recommend it as a sustainable choice. Similarly, inconsistent recommendations are generated for albacore *Thunnus alalunga*, bigeye tuna *Thunnus obesus*, lingcod *Ophiodon elongatus*, Atlantic haddock *Melanogrammus aeglefinus* and many other species.

Consumer boycotts and consumer guides have also been criticized for being indiscriminate towards responsible and irresponsible fishing operators, imposing an economic cost on responsible operators (Kaiser & Edwards-Jones, 2006; Roheim & Sutinen, 2006). It has been argued that eco-labelling, on the other hand, is capable of rewarding individual operators because it engages consumers in rewarding certain members or sub-sectors of the fishing community

TABLE 1 Timeline and overview of market-based sustainable seafood initiatives (all internet addresses were correct at 15 February 2009).

Year	Country	Sponsor	Category	Name	Remarks/URL
Late 1980s	USA	Earth Island Institute	Boycott/eco-label	Dolphin-safe logo	Boycott of canned tuna resulted in the first seafood eco-label, the 'dolphin-safe' logo; http://www.earthisland.org/dolphinSafeTuna/consumer/
1995	Global	UN Food & Agriculture Organization (FAO)	Evaluation system	Code of Conduct for Responsible Fisheries	Voluntary agreement that sets out principles & international standards for fisheries management; http://www.fao.org/DOCREP/005/v9878e/v9878e00.htm
1997	Global	WWF & Unilever	Eco-label/evaluation system	Marine Stewardship Council (MSC)	Became independent in 1999; http://www.msc.org
1997	USA	Monterey Bay Aquarium	Consumer seafood guide/evaluation system	Seafood Watch Program	Began as a list of sustainable seafood for an aquarium exhibit & in 2000 became a wallet card; other aquaria use the same information with a different interface; http://www.mbayaq.org/cr/seafoodwatch.asp
1998	USA	National Audubon Society	Consumer seafood guide/evaluation system	Seafood Lover's Guide	First consumer seafood guide, produced by Carl Safina who, at the time, was working for Audubon; today, it is also co-sponsored by the Wildlife Conservation Society; http://seafood.audubon.org/
1998–2000	USA	SeaWeb & Natural Resources Defense Council	Boycott	Give Swordfish a Break	700 chefs boycott swordfish until the international fishery commission cut quotas; http://www.seaweb.org/programs/swordfish/
1999	Global		Evaluation system	RapFish	RapFish considers five areas: ecological, economic, ethical, social & technological (Pitcher & Preikshot, 2001) as well as the FAO Code of Conduct (Pitcher, 1999); <i>Microsoft Excel</i> software for RapFish is available (Kavanagh & Pitcher, 2004); http://www.fao.org/DOCREP/005/X4175E/X4175E00.HTM
1999	USA		Eco-label/evaluation system	EcoFish	New England-based company selling sustainably caught fish; in 2001 EcoFish was certified as sustainable by the MSC (the first seafood distributor to earn such certification); also have a new seafood-safe logo based on contaminant testing; http://www.ecofish.com/
1999	Australia		Evaluation system	Environment Protection & Biodiversity Conservation Act	Legislation that requires fisheries that fall into certain categories to undergo sustainability assessments that are then submitted to the Department of Environment & Heritage (has been done for nearly every export species); http://www.environment.gov.au/epbc/
1999	Australia		Consumer seafood guide/evaluation system	Victoria National Parks Association	Evaluates the status of important commercial fishery species from southern Australia
2000	USA		Consumer seafood guide	Fish for Thought: An Eco-Cookbook	
2001	USA		Trade association	Seafood Choices Alliance	Http://www.seafoodchoices.com/home.php

TABLE 1 (Continued)

Year	Country	Sponsor	Category	Name	Remarks/URL
2001	USA	Environmental Defense	Consumer seafood guide	Oceans Alive	Programme was formerly known as Seafood Selector Website & Pocket Guide & was renamed the Oceans Alive programme in 2005; http://www.oceansalive.org/home.cfm
2001	USA	EarthEasy	Consumer seafood guide	Sustainable Seafood Guide	Http://www.eartheasy.com/eat_sustainable_seafoods.htm
2001	USA	Seafood Choices Alliance	Distributor seafood guide	Sourcing Seafood	Http://www.seafoodchoices.com/resources/sourcingseafood.php
2001	USA		Distributor seafood guide	Choice Catch	Sponsored by New England Aquarium & Ahold; formerly known as EcoSounds, Choice Catch audits domestic & international sources of seafood for environmental impact & sustainability based on scientific information available to ensure sustainability & traceability of Ahold's seafood products (Ahold is the fifth largest US grocery chain); http://www.neaq.org/choicecatch/
2001	Global		Eco-label/evaluation system	Marine Aquarium Council certification & eco-label	Marine Aquarium Council is a third-party certifier; http://www.aquariumcouncil.org/
2002	Global		Evaluation system	Traffic Lights	Unilever's internal fishery assessment system based on FAO guidelines; http://www.seafoodchoices.com/membership/champions_unilever.php
2002–2007	USA	National Environmental Trust (NET)	Boycott	Take a Pass on Chilean Sea Bass campaign	Programme ended when NET merged with Pew Charitable Trusts
2002	USA	Environmental Defense	Distributor seafood guide	Business Guide to Sustainable Seafood	101-page document available at http://www.environmentaldefense.org/documents/2532_BusinessGuideSustainableSeafood.pdf
2002	USA	Sustainable Fishery Advocates	Eco-label	FishWise	Began in California & is now implemented in 34 stores; as of 2005 also provides retailers/consumers with information regarding contaminants; http://www.sustainablefishery.org/
2002	USA	South Carolina Aquarium	Distributor seafood guide	Sustainable Seafood Initiative	Restaurant partners agree to remove Chilean sea bass, orange roughy & shark from their menus; collaboration between southern business & NGOs; http://www.scaquarium.org/SSI/default.html
2002	UK	Marine Conservation Society	Distributor seafood guide	Good Fish Guide	Has been used by some UK supermarkets looking at sustainability; http://www.fishonline.org/
2002–2005	Canada	Endangered Fish Alliance	Distributor seafood guide	Endangered Fish Alliance	Ask that members not serve swordfish, Chilean sea bass, orange roughy & certain types of caviar; 161 pioneer members; in 2005 merged with Environmental Defense; http://www.endangeredfishalliance.org/

TABLE 1 (Continued)

Year	Country	Sponsor	Category	Name	Remarks/URL
2003	USA	Blue Ocean Institute	Consumer seafood guide/evaluation system		Fully transparent; based on the methodology developed by Carl Safina in the Audubon Society's Seafood Lover's Almanac; other aquariums use the same information with a different interface (e.g. Shedd aquarium relabels it as Right Bite)
2004	USA	Star Chefs	Consumer seafood guide	Sustainable Seafood Guide	Http://www.starchefs.com/features/food_debates/html/sustainable_seafood.shtml
2004	Canada		Eco-label?	Organic Ocean	Group of independent British Columbia fishermen who sell sustainable seafood; Http://www.organicocean.com/
2004	New Zealand	New Zealand Forest & Bird	Consumer seafood guide/evaluation system	Best Fish Guide	Have full evaluation online; first independent ecological ranking for New Zealand commercial fisheries; http://www.forestandbird.org.nz/bestfishguide/index.asp
2004	USA	The Smithsonian Institution	Consumer seafood guide	One Fish, Two Fish, Crawfish, Bluefish	Sustainable seafood cookbook
2004	Australia	Marine Conservation Society	Consumer seafood guide	Sustainable Seafood Guide	Http://www.amcs.org.au/default2.asp?active_page_id=137
2004	South Africa	WWF	Consumer seafood guide	Seafood pocket guide	Text messaging available; http://www.panda.org.za/sassi/
2005	USA		Consumer seafood guide	Co-op American Safe Seafood Wallet List	Article that combined information from the Food & Drug Administration, Monterey Bay Aquarium & Blue Ocean Institute; reprinted by other magazines
2005	European Union		Trade association	Seafood Choices Alliance	European branch
2005	UK	Greenpeace	Distributor seafood guide	Recipe for Disaster	Reviews sustainability of common fish in UK supermarkets by combining recommendations from Australian, New Zealand, USA & UK NGOs
2005	Italy, Switzerland	Friends of the Sea	Eco-label/evaluation system		Uses FAO guidelines & third-party certification (includes aquaculture) & is used by Italy-based retailer Co-op &, in October 2007, the Swiss retailer MANOR; also allows text messaging
2005	Canada	Vancouver Aquarium	Distributor seafood guide/evaluation system/eco-label	Ocean Wise	Vancouver-based restaurants
2005	Spain	Greenpeace	Consumer seafood guide	Guia para el consumo responsable de pescado	Report & consumer guide
2006	USA	PCC Natural Markets	Consumer seafood guide	Seafood choices for a healthier ocean	Partnership with Monterey Bay Aquarium
2006	USA	Environmental Defense, Wegman's & Bon Appetit	Distributor seafood guide	First corporate purchasing partnership	Http://www.environmentaldefense.org/page.cfm?tagID=1464
2006	Canada	Various NGOs	Consumer seafood guide/evaluation system	SeaChoice	

TABLE 1 (Continued)

Year	Country	Sponsor	Category	Name	Remarks/URL
2006	European Union	IncoFish Project	Miscellaneous	FisherMin	A ruler against which shoppers can measure their fish to ensure they are not buying juveniles (Froese, 2004); http://www.incofish.org/Results/tools/FishNorth.php
2007	European Union/N America	WWF, the North Sea Foundation (Dutch), Greenpeace, Seafood Choices Alliance	Evaluation system	A Common Tool for Assessing Seafood Sustainability	Http://www.seafoodchoices.org/newsroom/CommonMethods.php
2007	European Union/North America		Distributor seafood guide	Sustainable Fisheries Partnership/FishSource	
2007	European Union		Trade Association	Responsible Fishing Alliance	Sustainable Food Lab will work with business-to-business seafood trade focusing on small-scale capture fishers & aquaculture
2007	USA	Blue Ocean Institute	Consumer seafood guide	Fish Phone	
2007	Belgium	WWF	Consumer seafood guide		
2007	Denmark	WWF	Consumer seafood guide		
2007	Finland	WWF	Consumer seafood guide		
2007	France	WWF	Consumer seafood guide		
2007	Germany	WWF	Consumer seafood guide		
2007	Hong Kong	WWF	Consumer seafood guide		
2007	Indonesia	WWF	Consumer seafood guide		
2007	The Netherlands	WWF	Consumer seafood guide		
2007	Norway	WWF	Consumer seafood guide		
2007	Poland	WWF	Consumer seafood guide		
2007	Spain	WWF	Consumer seafood guide		
2007	Sweden	WWF	Consumer seafood guide		
2007	Switzerland	WWF	Consumer seafood guide		
?	The Netherlands	North Sea Foundation	Consumer seafood guide	North Sea Foundation <i>De Goede Visgids</i>	Http://www.goedevis.nl/
2002	Germany	Greenpeace	Consumer seafood guide	<i>Magazin</i>	Http://www.greenpeace.de/themen/meere/fischerei/
2008	The Netherlands	Greenpeace	Consumer seafood guide	<i>Maak Schoon Schap</i>	Http://www.maakschoonschap.nl/
2008	USA	New England Aquarium	Consumer seafood guide	Celebrate Seafood	Http://neaq.org/documents/CelebrateSeafoodGuide.pdf

who conduct responsible fishing practices (Roheim & Sutinen, 2006). Unfortunately, rewarding individual operators may also be at odds with creating simple messages. The MSC certification of the fishery for Patagonian toothfish *Dissostichus eleginoides* in British-controlled waters off South Georgia, for instance, rewarded responsible fishing operators in that one region but sent a mixed message to consumers who were simultaneously being advised by the US-based National Environmental Trust to boycott the fish (Jacquet, 2007).

Other points of concern for the MSC eco-label are the lack of consideration of stock declines, key life history

characteristics, food chain, bycatch and habitat effects and/or a failure to identify all stakeholders (for instance, in the MSC's certification of Alaska pollock *Theragra chalcogramma*, New Zealand hoki *Macruronus novaezelandiae* and Western Australian rock lobster *Panulirus cygnus*; Ward, 2008). Moreover, another round of controversy could begin if the MSC certifies fisheries that target fish to reduce to animal feed because of the wastefulness of converting wild fish into smaller, but more valuable, amounts of farmed fish.

Other debates have arisen over the MSC and other eco-labels because they cannot accommodate small-scale fisheries (Jacquet & Pauly, 2008a; Gulbrandsen, 2009). Small-scale

fisheries are probably the best hope for sustainable fisheries as they typically favour passive gears (which catch fewer unwanted species), although there are exceptions to this. On a global scale, small-scale fisheries employ 25 times more people and use 25% of the fuel to catch approximately the same amount of fish for human consumption as the large-scale industrial fishing sector (Chuenpagdee et al., 2006). But in the marketplace small-scale fisheries are at a disadvantage when competing for market access with large-scale industrial fleets, which are often heavily subsidized (Sumaila & Pauly, 2006).

For seafood that is not MSC certified, which is > 90% of seafood consumed globally, traceability is also an issue. For seafood awareness programmes to obtain their desired outcomes it is essential that seafood consumers have accurate information and that eco-labels acquire and/or maintain their integrity. But in the USA more than one third of all fish appear to be mislabelled (Tennyson et al., 1997) and many fish are also renamed. Mislabelling and renaming subvert sustainable seafood initiatives, including those aimed at consumers (Jacquet & Pauly, 2008b).

After distributing > 1 million seafood wallet cards, the Monterey Bay Aquarium conducted a study that revealed no overall change in the market and that fishing pressures had not decreased for targeted species (Quadra Planning Consultants Ltd, 2004). A review of 30 non-profit organizations with market-based sustainable seafood campaigns during 1999–2004 found that consumer-oriented campaigns increased awareness and visibility for the sustainable seafood issue but that there is ‘no clear evidence that this increased salience is leading to big changes in buying practices, nor accelerated fisheries policies’ (Bridgespan Group, 2005).

Eco-labels may also not have the impact conservationists desire. The dolphin-safe tuna label is often perceived as the most effective seafood-related label. The label, combined with several national and international regulatory schemes (e.g. the US Marine Mammal Protection Act, the US embargo on non-dolphin-safe tuna and the International Dolphin Conservation Act), has helped reduce dolphin mortality because of a reduction in the number of boats setting on dolphins, and certain populations, such as the bottlenose *Tursiops truncatus* and short-beaked common dolphins *Delphinus delphis* in the eastern tropical Pacific, have increased (Gerrodette et al., 2008). This is why, in 2003, NOAA fisheries scientists suggested the definition of the label not be watered down, under international political pressure, to allow tuna caught with chasing-and-encircling techniques to be certified as ‘dolphin safe’.

However, several dolphin populations have not recovered as quickly as expected. For instance, time series data of population estimates for the north-eastern pan-tropical spotted dolphin *Stenella attenuata attenuata* and eastern spinner dolphin *Stenella longirostris* populations in the eastern tropical Pacific from 1978 to 2000 show essentially

no change in abundance over that time (Gerrodette & Forcada, 2005). There does appear to have been a slight increase in the abundance of the two species in recent years (Gerrodette et al., 2008) but spotted dolphins and spinner dolphins are estimated to be at 19 and 29%, respectively, of their abundance levels prior to 1959, the year when a yellowfin tuna *Thunnus albacares* purse seine fishery began in their region (Wade et al., 2007). The tuna purse seine fishery continues to have negative effects on dolphin populations because of unreported bycatch, the separation of mothers and calves and/or other factors (Gerrodette & Forcada, 2005; Cramer et al., 2008). These data, along with Ward (2008), show that certain dolphin populations are still in trouble, despite the label, 100% observer coverage and strict regulations, because so-called dolphin-safe methods of catching tuna did not lead to a sufficient reduction in overall fishing pressure and hence bycatch.

Furthermore, MSC certification is unlikely to arrest the decline in fish stocks (Ward, 2008; Gulbrandsen, 2009). There are many concerns over the MSC-certified Alaska pollock fishery, which has been regarded as a poster fishery for sustainable seafood. For example, pollock recruitment data are below average in 6 of the past 7 years, fishers are travelling greater distances to find fish and northern fur seals *Callorhinus ursinus*, which feed on pollock, are in decline. Acoustic surveys indicated that the 2008 pollock biomass was almost 50% below the biomass from the previous year, prompting NOAA officials to recommend to the North Pacific Fishery Management Council a sustainable catch of 815,000 metric t for 2009, an 18.5% reduction from 2008 (NOAA, 2008a). In some cases, such as in Western Australia, MSC certification may even be giving fishing interests leverage against establishing fishing sanctuaries on the grounds that sanctuaries are unnecessary if the affected fisheries are already certified (Sutton, 2003).

In the USA, the country where most consumer-based efforts focus, per capita demand for seafood has increased from 6.9 kg person⁻¹ in 2000 to 7.4 kg person⁻¹ in 2007 (NOAA, 2008b). Many of the species considered least sustainable by conservation groups (e.g. shrimp, tuna and salmon) remain the most desirable (perhaps because consumers are more attracted to rare species than common ones; Gault et al., 2008; Angulo & Courchamp, 2009). Whereas there may be regional exceptions, overall, eco-labels on behalf of dolphins and fisheries appear to be weak instruments for conservation (Ward, 2008) and consumer campaigns do not seem effective at reducing demand or fishing pressure.

More effective market-based efforts to conserve wild fish?

Given the limitations of consumer-based efforts to promote sustainable seafood, perhaps the large investment in the household consumer sector was premature. Based on our

collective experience and evidence, we present several additional avenues for market-based conservation measures that may strengthen or complement current initiatives. We also argue that these proposed ideas should be tested in accordance with scientific methods and evidence-based conservation (Sutherland et al., 2004).

Labelling standards

Consumers cannot always be sure that the seafood they purchase is the fish that the label or menu claims (Jacquet & Pauly, 2008b). Without access to information on country of origin (where the fish is caught, not processed) and fishing method, let alone the correct species, consumers cannot make effective decisions on behalf of sustainable seafood. Therefore, all market-based initiatives must consider putting additional effort into improving labelling standards.

Of all the sustainable seafood initiatives the MSC offers the best model of traceability in the form of chain of custody standards, which traces fish from the fishery of origin to the point of sale. There is evidence that traceability standards in fisheries (e.g. South Georgia Patagonian toothfish) have improved as a result of MSC certification (Roheim & Sutinen, 2006). Without proper labelling, consumer-oriented campaigns will continue to be undermined by cheating.

Directing efforts higher than households

In recognition of the limitations and pace of affecting household consumers, efforts to promote sustainable seafood should aim higher in the demand chain and focus on affecting large buyers. Focusing on large retailers is the new goal of Seafood Choices (Bridgespan Group, 2005) and several other groups (Table 1). In May 2008, for instance, 14 American and Canadian organizations formed the Conservation Alliance for Seafood Solutions and released their Common Vision for Environmentally Sustainable Seafood. Among food retailers the 10 largest companies account for nearly 50% of the US seafood market (Bridgespan Group, 2005). In the UK nearly 90% of seafood is now sold through supermarkets, which have gained immense buying power, particularly compared to formerly, when fish was primarily sold through local fishmongers (Greenpeace, 2005). This focus on targeting large retailers, which consolidate seafood purchases, is likely to have a bigger and faster market impact than consumer guides. Furthermore, large retailers appear concerned about wild fish stocks on the grounds that sustainability is good business and perhaps also for the sake of an increase in reputation.

Balancing positive and negative messaging in the marketplace

While it is true that environmental NGOs can use retailers as allies to force change, another strategy that is underused,

particularly in North America, is the use of negative messaging to affect retailer reputation. According to research related to cooperation, a good reputation is valuable currency and is gained by playing by the rules of a social community. On the other hand, uncooperative behaviour may be profitable unless it negatively affects reputation (Semmann et al., 2004). Also, whenever individual or institutional behaviour is relevant to the public good, it should be made public (Pfeiffer & Nowak, 2006). Under these premises, one way to motivate large seafood retailers is to generate bad press that highlights unsustainable practices. This negative messaging uses the base of consumer awareness that has been raised by wallet cards and eco-labels to push companies already engaged in sustainability efforts to step up their efforts.

Greenpeace is one group using reputation in market-based seafood efforts. Firstly in Europe (in the UK, followed by the Netherlands, Denmark, Germany, France, Spain, Austria and Norway) and most recently in the USA, Greenpeace has used a ranking system to assess supermarket chains in terms of the sustainability of their seafood (Greenpeace, 2005, 2006). The ranking has created competition at all levels, with some retailers taking steps to try to get to the top of the ranking and others seeking to get off the bottom. In the lead-up to the publication of Greenpeace's ranking of US retailers, top-scoring Whole Foods Market agreed to stop selling red-listed orange roughy *Hoplosthesus atlanticus*, Target committed to dropping red snapper *Lutjanus campechanus* and Wegman's dropped bluefin tuna. In every country where Greenpeace ranked retailers, several retailers adopted sustainable seafood procurement policies and dropped several red-listed items. Within just 2 months of the release of the Swedish report, all but one major Swedish retailer had dropped all 14 products on Greenpeace Nordic's Red List.

Greenpeace also uses public displays to affect reputation and catalyse change in seafood markets. In November 2008 Greenpeace erected 'crime scenes' at eight Loblaw grocery stores in Toronto with the message 'caught red-handed selling Red-List fish'. The following day Loblaw officials were reportedly 'disappointed' but said they would work to offer more MSC-certified fish (Fiorillo, 2008). The more conventional methods of positive messaging and alliance with retailers are complemented (and could be even more so) using negative messaging and reputation to motivate large seafood retailers to act.

Connecting seafood to climate change

The concern for global warming presents opportunities to connect seafood to climate change using life cycle analysis. Global fuel use by fisheries, just to catch and land fish (not process and ship it further), has been estimated as 1.2% of global oil consumption (Tyedmers et al., 2005). No

discussion about seafood sustainability should be complete without considering the relationships between its resource dependencies and emissions and the stability of the broader biogeochemical cycles that cumulatively provide the basis for healthy marine ecosystems.

Fish sticks could be made of heavily managed MSC-certified Alaska pollock but the fish might have travelled 6,900 km before reaching the processing plant. Salmon farmed in Chile, filleted in China, processed and packaged in Canada and eaten by a customer in San Diego could travel as far as 35,800 km (Grescoe, 2008). In the growing Mediterranean bluefin tuna ranching industry highly threatened fish are taken from the wild and towed back to large cages where they are fattened on herring and other wild-caught forage fish. A full-grown bluefin tuna may include energy costs of finding, catching and towing the tuna, as well as of catching, transporting and freezing the feed fish. The inclusion of life cycle thinking would, at a minimum, underscore the importance of promoting energy-efficient fisheries and aquaculture production, as well as low trophic level culture systems (Pelletier & Tyedmers, 2008), and industrial fisheries would probably be considered far less sustainable than small-scale fisheries.

Eliminating the wasteful fishmeal industry

In North America and Europe there has been a call to eat lower on the food web (Pimentel & Pimentel, 2003; Pollan, 2008) and this has been echoed for marine food webs (Hall, 2007; Grescoe, 2008). However, humans currently must compete with factory-farmed animals for this meal of small pelagic fish. Currently, c. 30 million t of fish (36% of world fisheries catch) are ground up each year into fishmeal and oil, mostly to feed farmed fish, chicken and pigs (Alder et al., 2008).

We argue that decreasing the amount of fish used for the production of animal feed should be a top priority of the sustainable seafood movement, particularly because pigs and chickens alone consume six and two times the amount of seafood as US and Japanese consumers, respectively. One premise of sustainable seafood should be that no fishery that catches fish for the production of animal or feed fish oil should be eco-certified. Instead, groups interested in promoting sustainable seafood should encourage direct human consumption of forage fish.

In Peru, for instance, the anchovy *Engraulis ringens* fishery, which began in the early 1950s, now produces half of the world's fishmeal. But, whilst Peru exports fishmeal and other products derived from its catch of 5–10 million t of anchovy each year, half of its population (15 million people) lives under conditions of critical poverty and 25% of infants are malnourished. This discrepancy led to a major campaign in 2006 involving scientists, chefs and politicians to remake the image of the anchovy. The goals were to

increase the real and perceived value of these fish, to develop local and export markets and to make investing in freezing and canning facilities attractive so that Peru could afford to shift away from turning perfectly edible fish into fishmeal. During the week dedicated to promoting the anchovy, 18,000 Peruvians tasted the small fish at more than 30 restaurants in Lima, the nation's capital. Anchovies are much more valuable to the Peruvian economy as canned fillets than as fishmeal. One t of fillets is sold for five times the price of 1 t of meal and requires half the fish (3 t for 1 t fillets vs 6 t for 1 t meal). The government decided to dedicate 30% of its annual food security budget, or c. USD 80 million, for programmes that will go to supplying anchovies. As a result, by late 2007, 1 year after the campaign began, demand for fresh anchovies had grown by 46% and demand for canned anchovies was up by 85%. It is hoped that higher prices for anchovies will limit their use in fishmeal industry, thereby causing an overall reduction in demand for anchovies.

Without fishmeal, protein alternatives for animal feed are needed. There is a new interest in soymeal as well as meals made from mass-producing insects (Ratliff, 2008) as a sustainable protein source to replace fishmeal in fish and livestock feeds, and experimental trials show that a fishmeal alternative, at least partially, may be possible. More importantly, agriculture and aquaculture need to revert back to less intensive systems, requiring only plant-based inputs (Pimentel & Pimentel, 2003).

Eliminating harmful fisheries subsidies

Arguably, a powerful market force driving overfishing is fisheries subsidies. Globally, fisheries subsidies are an estimated USD 30–34 billion annually, USD 20 billion of which contributes directly to encouraging excess fishing capacity (e.g. fuel subsidies, boat construction; Sumaila & Pauly, 2006) and favours industrial fisheries over small-scale, more sustainable ones. Yet the US conservation community's investment in eliminating harmful fisheries subsidies has been < 4% of the investment into consumer-oriented market-based campaigns over the past decade (Jacquet & Pauly, 2008b). The market-oriented goal of eliminating harmful fisheries subsidies must become a global conservation priority. Efforts by the World Trade Organization to discipline fisheries subsidies should be pursued with greater rigour (Sumaila & Pauly, 2006).

Setting seafood targets

Finally, to warrant continued investment, each market-based conservation programme should be designed so as to produce outcomes and testable results (Sutherland et al., 2004). The sustainable seafood movement must also place more emphasis on measurable results, numeracy, data

sharing and publishing results. The number of consumers reached by a seafood choice campaign is not a measure of success unless it is accompanied by a measurable improvement in wild fish populations. Simply creating demand for an eco-certified product is not enough unless there is a concurrent decrease in demand for other overfished species. All programmes should be designed with a series of testable outcomes, e.g. a measurable decline in demand for certain species (or overall seafood demand), increases in biomass estimates and overall reduction in harmful subsidies.

Sustainable seafood initiatives must also be integrated and coordinated with others and have a common goal. In the same way that coordinated efforts by the scientific community and governments have determined targets for greenhouse gas emissions, national and international targets are needed for seafood catch and consumption (and at what trophic level) to shift global fisheries to sustainable enterprises. Such an analysis must be regional to take into account national differences in fishing capacity (industrial vs artisanal fleets) and complexity of the markets (local vs global). This analysis could yield an 'optimal sustainable consumption rate' of wild fish and, in turn, determine the rate of increase in aquaculture production and other alternatives to seafood to meet demand.

Discussion

Seafood is one of the only wild foods (aside from fungi) that westerners eat with any regularity. After more than a decade of market-based sustainable seafood initiatives the demand for this last wild food source is higher than ever and has resulted in further declines of fish populations (Pauly et al., 2002; Worm et al., 2006) and a complementary rapid domestication of marine species (Duarte et al., 2007).

Individuals and groups working to curb overfishing in the 1980s and 1990s first attempted to work within regulatory frameworks but became frustrated with the pace of regulatory approaches and the tactics of powerful interest groups. Many abandoned the political process in favour of the market. In 1992 Carl Safina unsuccessfully lobbied for a CITES listing of bluefin tuna, which would have banned the trade of tuna (Grescoe, 2008). Safina later assisted in designing the first seafood wallet card and then formed the Blue Ocean Institute, dedicated to creating a new ethic but also to developing seafood guides and working closely with consumers. These efforts snowballed into the concerted international effort aimed at household consumers today.

We do not argue against the principle that consumers should make a point of choosing products that reflect their ideals, a premise that is especially prevalent in food choices (Clover, 2006; Grescoe, 2008; Pollan, 2008). But, in terms of monetary outlays and human energy, we argue that putting too much emphasis on consumers is not an effective

market-based strategy. There is simply too much cheating in the marketplace (e.g. mislabelling), too much misleading information, too many inconsistencies and, so far, too few results.

Just as consumers experienced fatigue in the 1990s after corporate eco-advertising amounted to little action or outcome, so may this decade witness the same fatigue in sustainable seafood campaigns. For instance, in 2002, Sainsbury's in the UK committed to sourcing all its wild fish from sustainable sources by 2010. But after working closely with the MSC, MSC-certified fish only amount to 1% of total fish sales (Roheim & Sutinen, 2006). In 2006 Wal-Mart pledged to source all its capture fish from the MSC by 2010 (Gunther, 2006), a goal Wal-Mart is not likely to meet. The 'greenwashing' that corporations were accused of in the 1990s could turn into a 'bluwashing' today.

However, it is important to note that these corporations are motivated to make these promises because they believe their consumers want them to act. In this way, it is clear that consumers can help drive changes in the market. However, to avoid the bluwashing phenomenon, sustainable seafood campaigns must be goal oriented and communicate whether or not goals are met. National and international seafood consumption targets for specific species and/or overall demand could help determine these goals. To achieve reduction in seafood demand more quickly, sustainable seafood initiatives could work higher in the demand chain, begin connecting seafood to climate change, campaign to divert small fish away from livestock feed and into consumer markets, and work to eliminate harmful fisheries subsidies.

The conservation movement's emphasis on consumers and market-based initiatives is perhaps a result of the Reagan-Thatcher-Bush years, during which government was perceived as the problem and markets as panaceas. Today, this perception is changing. Working with household consumers alone cannot save fish. Although government regulations are far from perfect, the successes of government efforts to improve fisheries have been more obvious and measurable (e.g. marine protected areas). Even within a market-based approach there is a need to ensure that information is correct and that conservation efforts are not obstructed by harmful subsidies. In other words, working with consumers and retailers also brings the imperative of working with governments.

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References

- ALDER, J., CAMPBELL, B., KARPOUZI, V., KASCHNER, K. & PAULY, D. (2008) Forage fish: from ecosystems to markets. *Annual Review of Environmental Resources*, 33, 7.1–7.14.
- ANGULO, E. & COURCHAMP, F. (2009) Rare species are valued big time. *PLoS ONE*, 4(4), e2515. Doi:10.1371/journal.pone.0005215
- BRIDGESPAN GROUP (2005) *Seafood Choices Evaluation Prepared for the David & Lucile Packard Foundation*. Bridgespan Group, Boston, USA.
- BRUNNER, E.J., JONES, P.J.S., FRIEL, S. & BARTLEY, M. (2009) Fish, human health and marine ecosystem health: policies in collision. *International Journal of Epidemiology*, 38, 93–100.
- CHUENPAGDEE, R., LIGUORI, L., PALOMARES, M.L.D. & PAULY, D. (2006) Bottom-up, global estimates of small-scale marine fisheries catches. *Fisheries Centre Research Reports*, 14, 112.
- CLOVER, C. (2006) *The End of the Line: How Overfishing is Changing the World and What We Eat*. New Press, New York, USA.
- CRAMER, K.L., PERRYMAN, W.L. & GERRODETTE, T. (2008) Declines in reproductive output in two dolphin populations depleted by the yellowfin tuna purse-seine fishery. *Marine Ecological Progress Series*, 369, 273–285.
- DUARTE, C.M., MARBA, N. & HOLMER, M. (2007) Rapid domestication of marine species. *Science*, 316, 382–383.
- ENVIRONMENTAL DEFENSE FUND (2009) <http://www.edf.org/page.cfm?tagID=1521> [accessed 14 August 2009].
- FIORILLO, J. (2008) *Loblaw to Expand Eco-Label Fish*. Intrafish News Service. <http://www.intrafish.no/global/news/article232637.ece> [accessed 7 November 2008].
- FROESE, R. (2004) Keep it simple: three indicators to deal with overfishing. *Fish and Fisheries*, 5, 86.
- GAULT, A., MEINARD, Y. & COURCHAMP, F. (2008) *Less Is More: Rarity Trumps Quality in Luxury Markets*. Nature Precedings. <http://precedings.nature.com/documents/1690/version/1> [accessed 2 February 2009].
- GERRODETTE, T. & FORCADA, J. (2005) Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. *Marine Ecological Progress Series*, 291, 1–21.
- GERRODETTE, T., WATTERS, G., PERRYMAN, W. & BALANCE, L. (2008) *Estimates of 2006 Dolphin Abundance in the Eastern Tropical Pacific with Revised Estimates from 1986–2003*. NOAA Technical Memorandum April 2008. NOAA, National Marine Fisheries Service, La Jolla, California.
- GREENPEACE (2005) *A Recipe for Disaster: Supermarkets' Insatiable Appetite for Seafood*. Greenpeace, London, UK. http://www.greenpeace.org.uk/files/pdfs/migrated/oceans/supermarkets/report/supermarkets_seafood.pdf [accessed 12 August 2008].
- GREENPEACE (2006) *A Recipe for Change: Supermarkets Respond to the Challenge of Sourcing Sustainable Seafood*. Greenpeace, London, UK. <http://www.greenpeace.org.uk/media/reports/a-recipe-for-change> [accessed 12 August 2008].
- GRESKOE, T. (2008) *Bottomfeeder: How to Eat Ethically in a World of Vanishing Seafood*. Bloomsbury, London, UK.
- GULBRANDSEN, L.H. (2009) The emergence and effectiveness of the Marine Stewardship Council. *Marine Policy*, 33, 654–660.
- GUNTHER, M. (2006) *Saving Seafood*. CNNMoney.com, July 31, 2007. http://money.cnn.com/2006/07/25/news/companies/plugged_in_gunther_fish.fortune/index.htm [accessed 12 August 2008].
- HALL, M. (2007) Eat more anchovies. *Conservation Magazine*, 8(3). <http://www.conbio.org/cip/article30713.cfm> [accessed 4 April 2008].
- HALWEIL, B. (2006) *Catch of the Day: Choosing Seafood for Healthier Oceans*. Worldwatch Institute, Washington, DC, USA.
- INTERNATIONAL SEAFOOD GUIDE (2009) <http://www.seafoodguide.org> [accessed 14 August 2009].
- JACQUET, J. (2007) *The Toothfish That Bit Al Gore*. The Tyee, Vancouver, Canada. <http://thetyee.ca/Views/2007/07/20/Toothfish/> [accessed 20 July 2007].
- JACQUET, J.L. & PAULY, D. (2007) The rise of seafood awareness campaigns in an era of collapsing fisheries. *Marine Policy*, 31, 308–313.
- JACQUET, J.L. & PAULY, D. (2008a) Funding priorities: big barriers to small-scale fisheries. *Conservation Biology*, 22, 832–835.
- JACQUET, J.L. & PAULY, D. (2008b) Trade secrets: renaming and mislabeling of seafood. *Marine Policy*, 32, 309–318.
- KAISER, M.J. & EDWARDS-JONES, G. (2006) The role of ecolabeling in fisheries management and conservation. *Conservation Biology*, 20, 393–398.
- KAVANAGH, P. & PITCHER, T.J. (2004) Implementing Microsoft Excel software for rapfish: a technique for the rapid appraisal of fisheries status. *Fisheries Centre Research Reports*, 12.
- LEADBITTER, D. & WARD, T.J. (2007) An evaluation of systems for the integrated assessment of capture fisheries. *Marine Policy*, 31, 458–469.
- NMFS (NATIONAL MARINE FISHERIES SERVICE) (2006) *Fisheries of the USA, 2005*. NMFS, Silver Springs, USA.
- NOAA (NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION) (2008a) *NOAA Finds Decline in Pollock; Recommends Catch Cut to Council*. http://www.noaanews.noaa.gov/stories2008/20081120_pollock.html [accessed 20 November 2008].
- NOAA (NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION) (2008b) *Seafood Consumption Declines Slightly in 2007*. http://www.noaanews.noaa.gov/stories2008/20080717_seafood.html [accessed 11 November 2008].
- 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.
- PELLETIER, N. & TYEDMERS, P. (2008) Life cycle considerations for improving sustainability assessments in seafood awareness campaigns. *Environmental Management*, 42, 918–931.
- PELLETIER, N., AYER, N., TYEDMERS, P., KRUSE, S., FLYSJO, A., ROBILLARD, G. et al. (2006) Impact categories for life cycle assessment research of seafood production: review and prospectus. *International Journal of Life Cycle Assessment*, 12, 414–421.
- PFEIFFER, T. & NOWAK, M.A. (2006) All in the game. *Nature*, 441, 583–584.
- PIMENTEL, D. & PIMENTEL, M. (2003) Sustainability of meat-based and plant-based diets and the environment. *American Journal of Clinical Nutrition*, 78, 660S–663S.
- PITCHER, T. (1999) *RapFish, A Rapid Appraisal Technique for Fisheries and its Application to the Code of Conduct for Responsible Fisheries*. FAO Fisheries Circular, No. 947. Food and Agriculture Organization of the United Nations, Rome, Italy.
- PITCHER, T. (2008) The sea ahead: challenges to marine biology from seafood sustainability. *Hydrobiologia*, 606, 161–185.
- PITCHER, T. & PREIKSHOT, D.B. (2001) RapFish: A rapid appraisal technique to evaluate the sustainability status of fisheries. *Fisheries Research*, 49, 255–270.
- POLLAN, M. (2008) *In Defense of Food: An Eater's Manifesto*. Penguin Press, New York, USA.
- QUADRA PLANNING CONSULTANTS LTD (2004) *Seafood Watch Evaluation: Summary Report*. Galiano Institute for the Environment, SaltSpring Island, Canada.
- RATLIFF, B. (2008) *Producers Might Put Fish on Diet of Mass-Produced Insects*. Delta Farm Press. http://deltafarmpress.com/mag/farming_producers_put_fish/ [accessed 8 March 2009].
- ROHEIM, C. & SUTINEN, J. (2006) *Trade and Marketplace Measures to Promote Sustainable Fishing Practices*. International Centre for Trade and Sustainable Development, Paris, France.

- SEMMANN, D., KRAMBECK, H.J. & MILINSKI, M. (2004) Strategic investment in reputation. *Behavioral Ecology and Sociobiology*, 56, 248–252.
- SUMAILA, U.R. & PAULY, D. (2006) Catching more bait: a bottom-up re-estimation of global fisheries subsidies. *Fisheries Centre Research Reports*, 14, 114.
- SUTHERLAND, W.J., PULLIN, A.S., DOLMAN, P.M. & KNIGHT, T.M. (2004) The need for evidence-based conservation. *Trends in Ecology & Evolution*, 19, 305–308.
- SUTTON, D. (2003) An unsatisfactory encounter with the MSC—a conservation perspective. In *Eco-labelling in Fisheries: What is it all about?* (eds B. Phillips, T. Ward & C. Chaffee), 114–119. Blackwell Publishing, Oxford, UK.
- TENNYSON, J.M., WINTERS, K.S. & POWELL, K. (1997) A fish by any other name: a report on species substitution. *Presented at the 22nd Annual Meeting of Seafood Science, Technology Society of the Americas, Biloxi, USA, 6 October 1997*. <http://wwt.ifas.ufl.edu/22nd/Ann/file08.pdf> [accessed 1 May 2007].
- TYEDMERS, P.H., WATSON, R. & PAULY, D. (2005) Fueling global fishing fleets. *Ambio*, 34, 635–638.
- WADE, P.R., WATTERS, G.M., GERRODETTE, T. & REILLY, S.B. (2007) Depletion of spotted and spinner dolphins in the eastern tropical Pacific: modeling hypotheses for their lack of recovery. *Marine Ecological Progress Series*, 343, 1–14.
- WARD, T.J. (2008) Barriers to biodiversity conservation in marine fishery certification. *Fish and Fisheries*, 9, 167–177.
- WATSON, R. & PAULY, D. (2001) Systematic distortions in world fisheries catch trends. *Nature*, 424, 534–536.
- WHO (WORLD HEALTH ORGANIZATION) (2006) *Global and Regional Food Consumption Patterns and Trends: Availability and*

Consumption of Fish. http://www.who.int/nutrition/topics/3_foodconsumption/en/index5.html [accessed 3 November 2007].

WORM, B., BARBIER, E.B., BEAUMONT, N., DUFFY, E., FOLKE, C., HALPERN, B.S. et al. (2006) Impacts of biodiversity loss on ocean ecosystem services. *Science*, 314, 787–790.

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