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Using social–ecological syndromes to understand impacts of international seafood trade on small-scale fisheries

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ABSTRACT

Globalization has increased the speed and flow of people, information, and commodities across space, integrating markets and increasing interdependence of geographically dispersed places worldwide. Places historically driven by largely local forces and market demands are now increasingly affected by drivers at multiple scales. Trade is particularly important in driving these changes and more fish is now exported to international markets than ever before. When small-scale fisheries are integrated into global markets, local social–ecological systems change with potentially both positive and negative impacts on livelihoods, economics and ecology, but few studies systematically investigate how and why the outcomes of market integration vary from case to case.

This paper systematically assesses multiple (social, ecological, economic and institutional) local effects of market integration in cases around the world by drawing on the global environmental change syndromes approach. Furthermore, we examine the factors contributing to the syndromes observed. Our analysis identifies three distinct social–ecological syndromes associated with international seafood trade. Results suggest that the presence of strong and well-enforced institutions is the principal factor behind the syndrome characterized by sustained fish stocks, while a combination of weak institutions, patron–client relationships, high demand from China and highly vulnerable target species explain the other two syndromes distinguished by declining stocks, conflict and debt among fishers.

A key finding is that the factors emerging as important for explaining the different syndromes derive from different scales (e.g. local market structures vs distant market characteristics), indicating a need for multi-level governance approaches to deal with the effects of market integration. Furthermore, the meta-analysis shows that each syndrome encompasses fisheries from multiple continents. This suggests that the increasingly global nature of the seafood trade appears to be driving local dynamics by creating similar conditions for vulnerabilities in localities around the world, lending support to the notion of teleconnectivity across geographic space.

1. Introduction

The world is witnessing unprecedented levels of interconnection between different regions (Crutzen and Stoermer, 2000; Steffen et al., 2011) and international markets now play an increasingly important role for social, environmental and economic outcomes at multiple levels. Globalization increases the speed and flow of people, information, and commodities across geographic space, making markets economically integrated and often reducing the number and diversity of market actors (Adger et al., 2009; Österblom et al., 2015; Young et al., 2006). These forces of globalization increase interdependence of geographically dispersed places across the globe potentially leading to 'teleconnected vulnerabilities' (Adger et al., 2009). Places that were historically driven largely by local forces and market demands are now increasingly affected by drivers at multiple scales. Thus they are nested in the broader structures of global markets and international institutions creating interdependencies that increase exposure and affect economies, livelihoods, culture and environment at the local level (Adger et al., 2009; Liu et al., 2013). These connections can also lead to simultaneous interactions and feedbacks between multiple locations as pointed out by the 'telecoupling' framework of Liu et al. (2013). Fisheries are no exception. More fish is now traded on the international market than ever before (from 25% (8 million tonnes) in 1976 to 37%

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(58 million tonnes) in 2012), with developing countries representing a growing portion of that trade (FAO, 2014). This has led to growing risks to sustainability as geographically dispersed fish stocks are now 'tele-connected' via distant markets and depletion is increasing around the world (Berkes et al., 2006; OECD, 2010; Purcell et al., 2013). Yet the decline is largely masked from consumers through substitution of species or sources (Crona et al., 2015).

While fish is an important global commodity it is also vital for food security and employment at local levels (Smith et al., 2010). One billion people are estimated to rely on fish as primary source of protein (FAO, 2000) and globally 54.8 million people are directly engaged in capture fisheries and aquaculture (Bjorndal et al., 2014). Around three times as many people are also involved in upstream (e.g. boat building) and downstream (e.g. fish processing, marketing) activities (Bjorndal et al., 2014) and FAO estimates that the small-scale fisheries sector employs ca 90% of the world fishers, producing almost half of world fish production and supplying most of the fish consumed in the developing world (UN General Assembly, 2012). When small-scale fisheries are integrated into international markets, the local fisheries systems are changed with potentially positive and negative impacts on livelihoods, economics and ecology. Studies have drawn attention to both the possibility of overexploitation and commercial stocks extinction as well as increased economic development following such market integration, but no studies systematically investigate how and why the outcomes of market integration vary from case to case.

Understanding how increasing globalization of seafood trade affects the small-scale fisheries sector is therefore vital for ensuring sustainable and equitable development. This paper systematically examines cases from around the world, assessing the social, ecological, economic and institutional implications for local fisheries systems that result from market integration, as well as the factors contributing to the observed social–ecological outcomes. Our aim is to paint a fuller picture of how local dynamics of small-scale fisheries (SSF) interact with trade-related drivers at multiple scales to affect a multiplicity of local social–ecological outcomes.

2. Trade and social–ecological outcomes

2.1. The need for a multi-scale, multi-sectoral approach to understand trade impacts on small-scale fisheries

The impact of trade on social, economic and environmental outcomes in fisheries has been debated for some time. While one side ('pro-trade') argues that increased international fish trade would benefit development and thus alleviate poverty (e.g. FAO, 2007; Schmidt, 2003) 'anti-trade' arguments are often based on the premise that export of fish has potentially negative effects on food security and local livelihood options, particularly for poor people (Abgrall, 2003; Abila and Jansen, 1997; Kent, 1997; Ruddle, 2008). The pro-trade stance argues that the cash generated by fish exports in the exporting country can contribute to economic growth (Bostock et al., 2004; Thorpe, 2004; Virdin et al., 2004). Opponents of this view instead maintain that revenue from fish trade often does not materialize (Petersen, 2003), that export-oriented industry development results in local job loss (Abgrall, 2003; Abila and Jansen, 1997; Kaczynski and Fluharty, 2002), or that the economic gains are captured by elites and do not benefit the national fisheries sector, or people connected with it (Wilson and Boncoeur, 2008). In a review of the literature Béné et al. (2010) outline compelling evidence both for and against these two opposing narratives. The reason is that most 'pro-trade' analyses are conducted using national level data, focusing on state revenues and foreign exchange—not actual economic growth, food security or poverty alleviation *per se* (ibid:4). This assumes that mechanisms are in place to allow export revenues to be redistributed for the benefit of local communities and the fisheries sectors. However, lack of such redistribution mechanisms is an essential reason why anti-trade proponents argue trade is likely to cause increasing vulnerabilities, supported largely by case-based studies.

The lack of consensus and the sometimes polarized debate around the effects of international seafood trade thus largely stem from a discrepancy in analytical approaches. As noted by Kurien (2005) aggregate analyses are bound to hide important dynamics at the micro scale, while case-based studies often fail to account for drivers or effects at larger scales. What is needed to shed light on the nuances between these two extremes is thus an approach that considers multiple drivers, occurring across diverse scales and sectors, and which takes account of multiple and diverse outcomes.

2.2. Assessing impacts of seafood trade through syndromes of social–ecological change

While valuable for evaluating causal linkages, analyses of single facets of change, like declining stocks or social inequities among fisheries actors, cannot in themselves provide an accurate understanding of the multifaceted nature of real world social–ecological change. System change is more often the result of a complex set of factors, at multiple levels and in multiple sectors, which interact to produce particular outcomes. Schellnhuber et al. (1997) and Lüdeke et al. (2004) developed 'global environmental change syndromes' to overcome this tendency for sectoral, single-faceted approaches. They argue that bundles of interacting processes can be grouped into 'syndromes of change'. The notion of a syndrome stems from Greek, meaning "flowing together of many factors".

In a similar vein we use syndromes to identify local recurring patterns of social and ecological outcomes in relation to the development of international trade in marine commodities (c.f. Srinivasan et al., 2012). These social–ecological syndromes are value neutral—a syndrome is neither 'good' nor 'bad', but can be both depending on the case and the context. For example, fish stocks may be maintained through strong regulatory institutions but this may exclude certain people from the resource, which negatively impacts their income.

2.3. Systematic comparative analysis of complex, interacting drivers of social–ecological systems change

The literature on global environmental change and social–ecological system dynamics abounds with case studies of the effects of global drivers on local dynamics. Such place-based research is critical for in-depth understanding of complex systems and has the benefit of providing rich detail on specific cases. However, this richness simultaneously reduces generalizability. At the other extreme is the growing number of large N, aggregate analyses (referred to above for fisheries), which analyze broad trends in aggregate data. Such global studies have difficulty detecting trends at intermediate (regional) levels and are challenged by conjoint causation (when two or more variables interact) as the new interaction terms for such multi-factor causations quickly increase the number of variables in relation to case numbers, thus reducing the power of the analysis. Meta-analytical approaches that synthesize findings across multiple site-specific studies can provide a way to address these challenges. However, meta-analysis is also fraught with difficulties, particularly for synthesis of complex models where pooling and standardizing variables is impossible because of the varied methods of data collection across studies (Rudel, 2008). Qualitative comparisons are then a feasible option but as the number of cases to compare increases, this task rapidly becomes overwhelming without some formal means of data reduction dealing with conjoint causation. One method increasingly common for this type of synthetic approach is Qualitative Comparative Analysis (QCA). QCA is an analytic tool for comparing models across case studies (Rihoux and Ragin, 2009) using Boolean algebra to sort cases into minimal sets of factors that in combination can explain a particular outcome. QCA works well with binary data sets indicating presence or absence of a particular outcome and causal factor. These features of QCA make it ideal for a systematic analysis of trade-related drivers in small-scale fisheries and their effect on multiple social–ecological outcomes. However, the analyst still has to devise credible and transparent ways to select case studies and to code each for a common set of variables (see Rudel, 2008 for a full review of key aspects of meta-analysis of non-standardizable variables).

3. Methodology

We first identify social–ecological syndromes of change related to international seafood trade and then examine the most likely causal factors contributing to the observed syndromes around the world. Our analysis proceeds in four steps; sampling, coding of cases, identification of syndromes of social–ecological outcomes, and analysis of factors contributing to observed syndromes.

3.1. Sampling

A literature search was conducted with Google Scholar and ISI Web of Knowledge based on a set of key word combinations such as small scale fisheries, food security, seafood, trade, governance, and resilience (see Table A1 for full searches). The abstracts of all search results were reviewed to assess their relevance to the analysis (see Appendix A for detailed explanation). A case was included if it (1) described one (or several) small-scale fisheries that were connected to an international seafood market; (2) examined both social and ecological aspects of the small-scale fisheries systems at a local or regional scale; (3) defined and described a period in time when conditions were relatively stable (c.f. Schellnhuber et al., 1997:21; Srinivasan et al., 2012). We excluded cases that lacked sufficient information about trade, the environment, socio-economic conditions or institutions. A total of 18 cases were included in the final analysis (Fig. 1).

A full list of cases, including supporting papers coded for each case, is found in Table 1. Seven cases are found in countries ranked as low on the human development index (HDI), five are categorized as high, while six rank as intermediate HDI. Broadly the fisheries in these cases can be clustered into groups representing benthic shellfish fisheries (Chile, Belize and Maine), mixed coastal fisheries (Eritrea, Solomon Islands, Zanzibar and India), seacucumber fisheries (Galapagos and Zanzibar), live reef fish (LRF) fisheries (Indonesia, Malaysia, Philippines, Solomon Islands and Australia), one shrimp fishery (Louisiana) and one lake fishery (Lake Victoria). The fisheries are spread across five continents (North and South America, Asia, Africa and Australia, Figure 1). The benthic shellfish fishery in Chile constitutes two cases separated by the implementation of the 1991 Fisheries and Aquaculture Law (FAL; D.S:430), regulating access to benthic resources by the artisanal fisher subsector.

3.2. Coding of cases

3.2.1. Coding for factors

All coding (outcomes and factors) was done using Atlas.ti qualitative data analysis software. Selected papers were coded for proximate causal factors potentially influencing how market integration affected each case. Based on the broad literature from which cases were selected five factor types were identified as potentially important (Table 2 column A). These relate to the nature of the demand for a seafood product, the market system structure, socio-economic and institutional characteristics of the local fishery, and ecological characteristics of target species. We elaborate briefly on these below, explaining why they were selected as factor variables, and how they were translated into proximate causal factors used for coding and analysis.

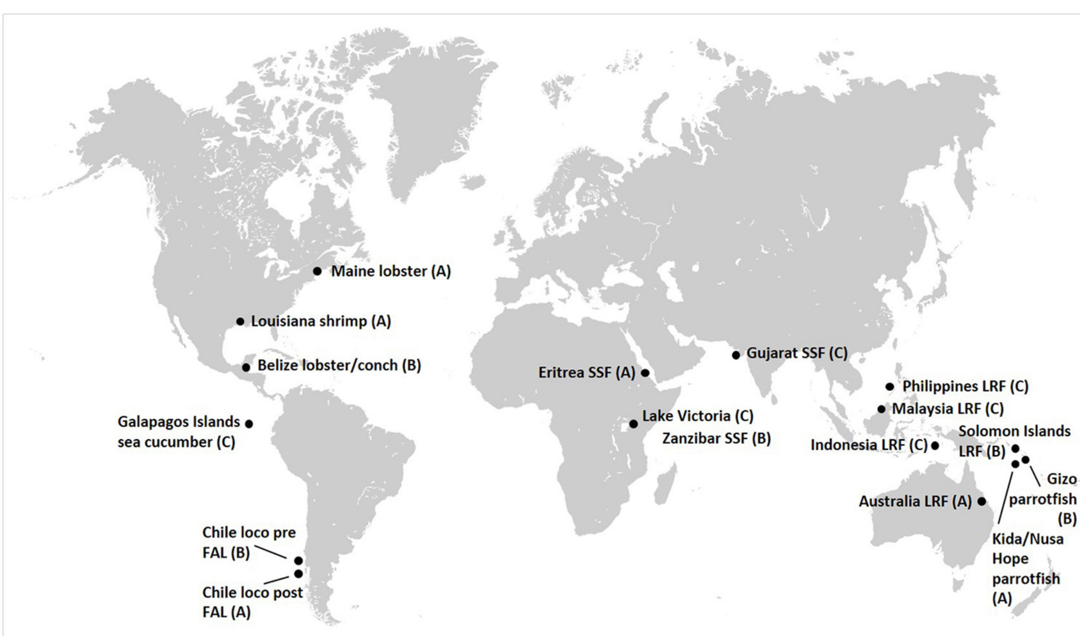

Fig. 1. Geographic distribution of the 18 cases included in the analysis. LRF refers to live reef fish fisheries, SSF to small-scale fisheries and FAL to the Chilean Fisheries and Aquaculture Law (1991). (A–C) indicates which syndrome each case falls within. For complete case names see Table 1.

Table 1
List of cases and supporting papers. LRF refers to live reef fish fisheries, SSF to small-scale fisheries and FAL to the Chilean Fisheries and Aquaculture Law (1991).

Case	Supporting papers
Australia LRF	Mapstone, B. D., Jones, A., Davies, C. R., Slade, S. J. and Williams, A. J. (2001a) The live fish trade on Queensland's Great Barrier Reef: changes to historical fishing practices. SPC Live Reef Fish Information Bulletin 9, 10–13. [online] ULR: http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/LRF/9/LRF9_10_Mapstone.pdf Mapstone, B. D., Davies, C. R., Slade, S. J. Jones, A., Kane, K. J. and Williams, A. J. (2001b) Effects of Live Fish Trading and Targeting Spawning Aggregations on Fleet Dynamics, Catch Characteristics, and Resource Exploitation by the Queensland Commercial Demersal Reef Line Fishery. CRC Reef Research Centre Townsville, 72 pp. [online] URL: http://crcreef.jcu.edu.au/publications/scientific/pdf/FRDC%2096-138%20Final%20Report.
Belize lobster/conch fishery	Huitric, M. 2005. Lobster and conch fisheries of Belize: a history of sequential exploitation. Ecology and Society 10 (1): 21. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art21/
Chile loco fishery post FAL	Castilla, J. C. and Gelcich, S. (2008) Management of the Loco (*Concholepas concholepas*) as a Driver for Self-Governance of Small-Scale Benthic Fisheries in Chile. In Townsend, R. Shotton, R. and Uchida, H. (eds). Case studies in fisheries self-governance. FAO Fisheries Technical Paper 504, Rome, FAO, 441–451. Gelcich, S., Hughes, T. P., Olsson, P., Folke, C., Defeo, O., Fernándeza, M., Foale, S., Gunderson, L. H., Rodríguez-Sickert, C., Scheffer, M., Steneck, R. S. and Castilla, J. C. (2010) Navigating transformations in governance of Chilean marine coastal resources. PNAS 107 (39), 16794–16799, doi:www.pnas.org/cgi/doi/10.1073/pnas.1012021107
Chile loco fishery pre FAL	Castilla, J. C. and Gelcich, S. (2008) Management of the Loco (*Concholepas concholepas*) as a Driver for Self-Governance of Small-Scale Benthic Fisheries in Chile. In Townsend, R. Shotton, R. and Uchida, H. (eds). Case studies in fisheries self-governance. FAO Fisheries Technical Paper 504, FAO, Rome, 441–451. Gelcich, S., Hughes, T. P., Olsson, P., Folke, C., Defeo, O., Fernándeza, M., Foale, S., Gunderson, L. H., Rodríguez-Sickert, C., Scheffer, M., Steneck, R. S. and Castilla, J. C. (2010) Navigating transformations in governance of Chilean marine coastal resources. PNAS 107 (39), 16794–16799, doi:www.pnas.org/cgi/doi/10.1073/pnas.1012021107
Eritrea SSF	Habtom M., Owusu-Frimpong, N. and Lutz C. (2009) The Role of Trust in Developing Business Relations between Fish Suppliers and Export Firms in Eritrea Repositioning African Business and Development for the 21st Century. Proceedings of the 10th Annual Conference of the International Academy of African Business and Development (IAABD). Tesfamichael D. (2012) Assessment of the Red Sea Ecosystem with Emphasis on Fisheries. A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, Faculty of Graduate Studies (Resource Management and Environmental Studies) University of British Columbia, Canada. Teweldemedhin M. Y. (2008) The fish industry in Eritrea: from comparative to competitive advantage. African Journal of Agricultural Research 3 (5), 327-333. Tsehaye, I. (2007) Monitoring fisheries in data-limited situations: A case study of the artisanal reef fisheries of Eritrea. PhD Thesis, Wageningen University, the Netherlands. ISBN: 978-90-8504-773-5
Galápagos sea cucumber fishery (Ecuador)	Bremner, J. M. P. H. and Perez, J. (2002) A Case Study of Human Migration and the Sea Cucumber Crisis in the Galapagos Islands. Ambio 31 (4), 306–310, doi:http://dx.doi.org/10.1579/0044-7447-31.4.306 Shepherd S. A., Martinez, P., Toral-Granda, M. V. and Edgar, G. J. (2004) The Galapagos sea cucumber fishery: management improves as stocks decline. Environmental Conservation 31 (2), 102–110, doi:10.1017/S0376892903001188
Gizo parrotfish (Solomon Islands)	Aswani S. and Sabetian A. (2009) Implications of Urbanization for Artisanal Parrotfish Fisheries in the Western Solomon Islands. Conservation Biology 24 (2), 520–530, doi: 10.1111/j.1523-1739.2009.01377.x
Gujarat SSF (India)	Armitage, D. R. and Johnson, D. (2006) Can resilience be reconciled with globalization and the increasingly complex conditions of resource degradation in Asian coastal regions? Ecology and Society 11(1): 2. [online] URL:http://www.ecologyandsociety.org/vol11/iss1/art2/ Johnson D. and Banvick M. (2004) Social Justice and Fisheries Governance: the View From India. Paper in the proceedings of the Fourth World Fisheries Congress. [online] URL:http://www.fishallocation.com/papers/pdf/papers/Johnson_Bavinck.pdf
Indonesia LRF	Thorburn, C. C. (2001) The House that Poison Built: Customary Marine Property Rights and the Live Food Fish Trade in the Kei Islands, Southeast Maluku. Development and Change 32 (1), 151–180, doi:10.1111/1467-7660.00200 Thorburn, C. C. (2003) Fatal adaptation: Cyanide fishing in the Kei Islands, Southeast Maluku. SPC Live Reef Fish Information Bulletin 11, 5–12.
Kida/Nusa Hope parrotfish (Solomon Islands)	Aswani S. and Sabetian A. (2009) Implications of Urbanization for Artisanal Parrotfish Fisheries in the Western Solomon Islands. Conservation Biology 24 (2), 520–530, doi: 10.1111/j.1523-1739.2009.01377.x
Lake Victoria fishery (Kenya)	Abila, R. O. (2003) Fish Trade and Food Security: Are They Reconcilable in Lake Victoria? In Report of the Expert Consultation on International Fish Trade and Food Security, Casablanca, Morocco, 27–30 January 2003, FAO Fisheries Report 708. FAO, Rome, 128–154. Abila, R. O. and Jansen, E. G. (1997) From Local to Global Markets: The Fish Exporting and Fishmeal Industries of Lake Victoria—Structure, Strategies and Socio-economic Impacts in Kenya. In: Socioeconomics of the Lake Victoria Fisheries. Report (IUCN), no. 2/World Conservation Union (IUCN), Nairobi (Kenya). Eastern Africa Regional Office, 1997, 38 p. Ikiara, M. M. and Odink, J. G. (2000) Fishermen Resistance to Exit Fisheries, Marine Resource Economics 14, 199–213.
Louisiana shrimp fishery (USA)	Marks, B. (2012) The Political Economy of Household Commodity Production in the Louisiana Shrimp Fishery. Journal of Agrarian Change 12 (2–3), 227–251, doi: 10.1111/j.1471-0366.2011.00353.x
Maine lobster fishery (USA)	Steneck R.S., Hughes T.P., Cinner, J. E., Adger, W. N., Arnold, S. N., Berkes, F., Bourdreau S.A., Brown, K., Folke, C., Gunderson. L., Olsson, P., Scheffer, M., Stephenson, E., Walker, B., Wilson, J. and Worm B. (2011) Creation of a Gilded Trap by the High Economic Value of the Maine Lobster Fishery. Conservation Biology, Volume 25 (5), 904–912, doi: 10.1111/j.1523-1739.2011.01717.x
Malaysia LRF	Fabinyi, M. (2013) Social Relations and Commodity Chains: The Live Reef Fish for Food Trade, Anthropological Forum: A Journal of Social Anthropology and Comparative Sociology 23(1), 36–57, doi: 10.1080/00664677.2012.748645

Table 1 (*Continued*)

Case	Supporting papers
	Poh, T-M. and Fanning, L. M. (2012) Tackling illegal, unregulated, and unreported trade toward Humphead wrasse (Cheilinus undulatus) recovery in Sabah, Malaysia. Marine Policy 36, 696–702, doi:10.1016/j.marpol.2011.10.011 Scales, H., Balmford, A. and Mania, A. (2007) Impacts of the live reef fish trade on populations of coral reef fish off northern Borneo. Proc. R. Soc. B 274, 989–994, doi:10.1098/rspb.2006.0280
Philippines LRF	Fabinyi, M. (2010) The Intensification of Fishing and the Rise of Tourism: Competing Coastal Livelihoods in the Calamianes Islands, Philippines. Hum Ecol. 38, 415–427, doi:10.1007/s10745-010-9329-z Fabinyi M. and Dalabajan D. (2011) Policy and practice in the live reef fish for food trade: A case study from Palawan, Philippines. Marine Policy 35, 371–378, doi:10.1016/j.marpol.2010.11.001 Fabinyi, M., Pido, M., Harani, B., Caceres, J., Uyami-Bitara, A., De las Alas, A., Buenconsejo, J. and Ponce de Leon E. M. (2012a) Luxury seafood consumption in China and the intensification of coastal livelihoods in Southeast Asia: The live reef fish for food trade in Balabac, Philippines. Asia Pacific Viewpoint 53 (2), 118–132, doi: 10.1111/j.1467-8373.2012.01483.x Fabinyi, M., Pido, M., De las Alas, M.A., Ponce de Leon, E. M., Buenconsejo, J., Uyami-Bitara, A., Harani, B., and Caceres, J. (2012) Livelihoods and the live reef fish for food trade in the municipality of Balabac, Palawan province, Philippines. ARC Centre of Excellence for Coral Reef Studies, James Cook University, and Center for Strategic Policy and Governance, Palawan State University: Townsville and Puerto Princesa City. Fabinyi, M. (2013) Social Relations and Commodity Chains: The Live Reef Fish for Food Trade, Anthropological Forum: A Journal of Social Anthropology and Comparative Sociology 23(1), 36-57, doi: 10.1080/00664677.2012.748645 Padilla, J. E., Mamauag, S., Braganza, G., Brucal, N., Yu, D. and Morales, A. (2003) Sustainability Assessment of the Live Reef-Fish For Food Industry In Palawan, Philippines. WWF. [online] URL: http://www.livefoodfishtrade.org/fishery/pdf/ WWF_Philippines_SustainabilityAssessmentReport.pdf
Solomon Islands LRF	Donnelly, R. J., Davis, D. C. and Lam, M. (2000) Socio-economic and biological aspects of the live reef food fish trade and its development in Solomon Islands. Discussion Paper No.1. Report to Australian Centre for International Agricultural Research, ACIAR, Canberra, 52 pp. Johannes, R. E. and Lam, M. 1999. The Live Reef Food Fish Trade in the Solomon Islands. SPC Live Reef Fish Information Bulletin 5, 8–15.
Zanzibar sea cucumber fishery (Tanzania)	Eriksson, H., de la Torre-Castro M., Eklöf, J. and Jiddawi, N. (2010) Resource degradation of the sea cucumber fishery in Zanzibar, Tanzania: a need for management reform. Aquatic Living Resources 23, 387–398, doi:10.1051/alr/2011002 Eriksson H., de la Torre-Castro M. and Olsson P. (2012) Mobility, Expansion and Management of a Multi-Species Scuba Diving Fishery in East Africa. PLoS ONE 7 (4): e35504. doi:10.1371/journal.pone.0035504
Zanzibar SSF	Crona B., Nyström, M. Folke, C. and Jiddaw, N. (2010) Middlemen, a critical social–ecological link in coastal communities of Kenya and Zanzibar. Marine Policy 34, 761–771, doi:10.1016/j.marpol.2010.01.023 Thyresson, M., Nyström, M. and Crona, B. (2011) Trading with Resilience: Parrotfish Trade and the Exploitation of Key-Ecosystem Processes in Coral Reefs. Coastal Management 39 (4), 396–411, doi: 10.1080/08920753.2011.589226. Thyresson, M., Crona, B., Nyström, M. de la Torre-Castro, M. and Jiddaw, N. (2012) Tracing value chains to understand effects of trade on coral reef fish in Zanzibar, Tanzania. Marine Policy 38, 246–256, doi: http://dx.doi.org/10.1016/j.marpol.2012.05.041

Table 2
Proximate and underlying factors determining impact of international seafood trade on local small-scale fisheries.

Factor type	Proximate factor	Underlying factors
Nature of demand	Demand from China	No underlying factors identified
	Fish for human consumption	Fish caught only for human consumption, thus not for fishmeal, fish oil etc.
Market system	Patron–client relationships	No underlying factors identified
Institutional characteristics	Lack of institutions	No institutions exist Low institutional capacity Political instability Institutions exist but they are inappropriate Low institutional capacity Low ecological knowledge Institutions exist but they are not complied with Corruption Lack of monitoring Lack of sanctions Poor knowledge of rules among fishers Rules are not perceived as legitimate
Socio-economic characteristics	Lack of infrastructure	Corruption Low economic development Political instability
	Increasing fishing pressure	Influx of fishers from other regions/countries Labor migration from other sectors
Ecological characteristics	High target species vulnerability	Low growth rate High age maturity Mobility low

First, the nature of the demand was examined by focusing on the particularly strong demand increasingly exerted by China for seafood. Some species are linked to cultural practices, such as shark fins, live reef fish and sea cucumbers (Anderson et al., 2011; Clarke et al., 2007; Sadovy et al., 2003) however, China's demand for other seafood products is rapidly rising and the country is increasing its free trade agreements with nations around the world, raising concerns that the scale of its needs and its trade will allow China to dictate the terms of trade thus potentially affecting production (Godfrey, 2014). Another type of demand stems from the increasing competition between fish supplied for human consumption and fish meal as fish resources grow scarcer, possibly affecting food security (Abila and Jansen, 1997; Alder et al., 2008). Some have also argued that the fish meal industry negatively affects local job opportunities (Abila and Jansen, 1997), and can lead to over-capacity and overexploitation of stocks (Abila and Jansen, 1997; Johnson, 2002).

Market structures and relationships among trade actors have been shown to affect fisheries outcomes (Thyresson et al., 2011, 2013; Crona et al., 2010), including power dynamics leading to labor exploitation (Alexander and Alexander, 1991; Russel, 1987). Wamukota et al. (2014) also noted higher income inequality among local fisheries actors involved in more integrated markets and Crona et al. (2010) showed how informal credit arrangements can influence sustainability trajectories in SSF by linking it to resource extraction patterns. We therefore examine the impact of patron–client relationships on SSF outcomes.

Socio-economic factors clearly play a role in determining impacts of trade at local levels, but fishing pressure and levels of infrastructure are specific issues discussed in relation to fisheries outcomes (Brewer et al., 2009; Teweldemedhin, 2008). Institutional factors have also been noted for their key role for sustainable resource management generally (Ostrom, 2005), and fisheries particularly (Andrew et al., 2007; Berkes et al., 2006). We thus include increasing fishing pressure, lack of infrastructure and lack of institutions as factors for coding.

Finally, ecological features of the resource itself can play a critical role for sustainability outcomes (Ostrom, 2005, 1990). For example, resources with easily observable standing stocks (such as forests) can be more easily assessed, monitored, and guarded than highly mobile resources like fish. Key ecological features identified for fisheries include life history traits, such as reproductive rates, which can play an important role in determining susceptibility of species to harvesting pressure (Jennings et al., 1998; Roberts, 2002). We used Fishbase (Froese and Pauly, 2004) as the main source of life history traits for finfish examined in the cases analyzed here. For non-finfish species, see Appendix A.

In summary, under the five factor types, seven proximate causal factors were included for coding (Table 2, column B). Following Geist and Lambin (2002) we used chain-logical causation (one or several underlying factors driving one or several proximate factors, resulting in an observed outcome) and concomitant occurrence (the independent operation of multiple factors resulting in a single outcome) to code for and arrive at proximate factors above. Fig. 2 illustrates this procedure for one factor and Table 2 lists all proximate factors (and associated underlying factors) included in the analysis. Once all proximate factors were determined, a case-by-factor matrix was created where each case received a 1 or 0 for each factor. This matrix formed the basis of the data set used in the QCA.

3.2.2. Coding for outcomes

Each case was first coded for local-level outcomes related to the international trade of seafood. This coding procedure was iterative and new codes were added as they appeared in the cases. After all cases had been coded once, the list of codes was reviewed and similar codes were consolidated. A final coding of all cases that included 12 outcomes was then conducted. These included declining fish stocks, sustained or increasing fish stocks, high levels of debt among fishers, declining fishers' income, sustained/increased fishers' income, reduced employment opportunities in fisheries, wealth accumulation among traders, increasing conflicts

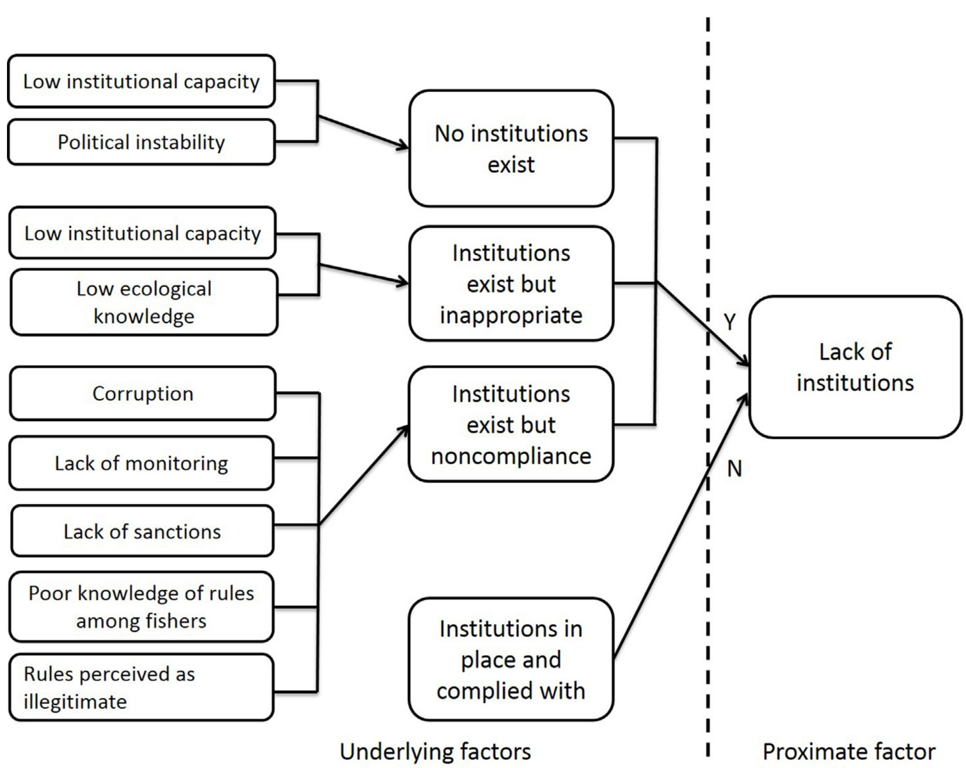

Fig. 2. Illustration of the process of arriving at proximate factors (adapted from Srinivasan et al., 2012 to fit our study).

among fisheries actors, destructive fishing practices, declining food security, fishing related health issues, and increasing local fisheries governance. Indicators used for coding of outcomes are presented in Table A2.

3.3. Identifying social–ecological syndromes

A case-by-outcome matrix was created where each case received a 1 or 0, respectively, if it exhibited a particular outcome or not. To identify syndromes a complete linkage cluster analysis was run on this matrix (Everitt et al., 2001) using Sørenson's similarity coefficient (McCune et al., 2002). The final three clusters used in the analysis were identified in multiple steps outlined in Appendix A. These three clusters separate at approximately 20% similarity (Fig. 3) and form the basis of the social–ecological syndromes discussed below (c.f. Lüdeke et al., 2004; Schellnhuber et al., 1997). Table 2 outlines the key characteristics of each cluster.

3.4. QCA analysis

We ran three separate QCA operations to determine the combination of proximate factors that explained each social–ecological syndrome. All 18 cases were included in each of the three QCA analyses. The case-by-factor matrix was organized into a truth table (Rihoux and Ragin, 2009), where each line corresponds to a logical combination of values (1/0) for causal factors, given a particular outcome. For each of the three analyses, the outcome variables were dichotomized so a case either exhibited the syndrome in focus (1) or not (0). Our results report the parsimonious solution of each QCA, which uses Boolean minimization procedure. Boolean minimization procedure is when two expressions that produce the same outcome and differ only by one factor can be reduced into a single, shorter expression. The solution lists the combination of proximate factors that generate a given outcome for each syndrome (Rihoux and Ragin, 2009).

4. Results

4.1. Untangling trade-related factors behind social–ecological syndromes in small-scale fisheries

Each syndrome exhibited multiple causal pathways (i.e. combinations of causal factors leading to a specific outcome) (Table 2). Each syndrome and its causal pathways are described in more detail below.

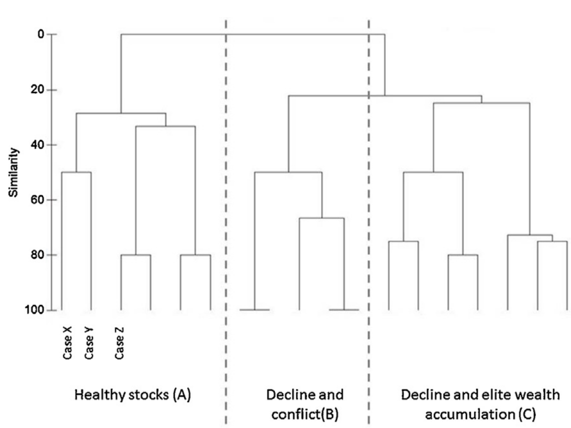

Fig. 3. Social–ecological syndromes as defined by a complete linkage cluster analysis of outcomes (see Table 3 for further description). Case descriptions in Table 1.

4.1.1. Syndrome A: healthy stocks

Syndrome A includes six cases and is characterized by sustained or recovered fish stocks. The fisheries comprising this syndrome include a shrimp fishery (Louisiana shrimp), two benthic fisheries (Chile loco post FAL and Maine lobster), two mixed coastal (reef-based) fisheries (Eritrea SSF and Kida/Nusa Hope parrotfish), and a live reef fish fishery (Australia LRF). Four of these fisheries operate in countries with well-developed infrastructure and institutions. In all but one case (83% raw coverage), the primary casual pathway explaining the observed outcome is well-functioning and enforced institutions along with the presence of infrastructure (Table 2). Infrastructure is unlikely to be an important explanatory factor given the location of four of the cases in industrialized country contexts where roads, storage facilities, and landing sites are generally well-developed. However, the lack of infrastructure may explain the Eritrea case, which falls within this syndrome despite lacking strong fisheries institutions. The lack of infrastructure probably impedes international market access, which contributes to sustained fish stocks. Moreover, in the Eritrea reef-based fishery most species are not highly vulnerable nor demanded on the Chinese luxury seafood market, which may also contribute to maintained stocks.

Fishers' incomes have decreased in three of the cases (Eritrea SSF, Louisiana shrimp, and Chile loco post FAL) (during the time period covered by the case) while in two cases (Maine lobster and Australia LRF) the situation is reversed and incomes have increased. Syndrome A can thus be considered as desirable from an ecological perspective, but not always from an economic perspective of individual fishers. Furthermore, in two of the cases (Kida/Nusa Hope parrotfish and Chile loco post FAL) an increased control over the fisheries resources by local communities has been observed. This indicates that sustained or recovered fish stocks can appear in combination with increased community control.

4.1.2. Syndrome B: declining stocks and rising conflict

Syndrome B consists of five cases and is characterized by decreasing fish stocks, either in combination with increasing conflicts between fisheries actors or increasing levels of debt among fishers. Lack of well-functioning and enforced institutions along with the absence of patron–client relationships is the main causal pathway for three of the cases in this syndrome (60% raw coverage) (Table 2). These cases represent quite different kinds of fisheries. In Belize (lobster/conch) and Chile (loco pre FAL), fisheries institutions exist, but were either insufficient because they do not incorporate the appropriate ecological knowledge or compliance with existing rules is low. In Gizo (parrotfish) the institutions were represented by local customary marine tenure systems and have been gradually weakened as international demand and the incentive to fish has increased. While part of the main causal pathway, the absence of patron–client relationships is unlikely to be a key predictor of this syndrome and may rather indicate lack of data.

The two remaining cases in this syndrome are not explained by the main causal pathway described above. The Zanzibar small-scale fishery (SSF) shares the lack of strong fisheries institutions but here patron–client relationships are present and debt among fishers has been observed, influencing fishers' extractive behavior by channeling external market demands to local fishers. An increasing number of fishers are also entering the fishery and there is easy access to external markets through gradually improving infrastructure such as roads and freezing facilities. In this particular case it is thus likely that the presence of patron–client relationships has contributed to observed outcomes of declining fish stocks and increasing debts among fishers.

The Solomon Islands live reef fish fishery stands out among cases within this Syndrome as strong fisheries institutions appear

Table 3
Social–ecological syndromes resulting from local small-scale fisheries interacting with the international seafood trade. The 'Conjunctural conditions' column shows the main causal pathway(s) behind each social–ecological syndrome. Numbers in parentheses indicate raw coverage (QCA output) for the main causal pathway for each syndrome. LRF refers to live reef fish fisheries, SSF to small-scale fisheries and FAL to the Chilean Fisheries and Aquaculture Law (1991).

Syndrome	Cases included	Description	Conjunctural conditions
Healthy stocks A	• Eritrea SSF • Louisiana shrimp • Chile loco post FAL • Kida/Nusa Hope parrotfish • Australia LRF • Maine lobster	• Sustained/recovered fish stocks • These cases can both have decreasing and increasing incomes among fishers, often in combination with high levels of debts among fishers. • Some cases have increased the local control over the resource.	~lack of institutions *~infrastructure (83%)
Decline and conflict B	• Chile loco pre FAL • Solomon Islands LRF • Belize lobster/conch • Zanzibar SSF • Gizo parrotfish	• Decreased fish stocks • Increased conflicts between fisheries actors • High levels of debt among fishers	lack of institutions *~patron–client relations (60%)
Decline and elite wealth accumulation C	• Galápagos sea cucumber • Malaysia LRF • Zanzibar sea cucumber • Philippines LRF • Lake Victoria • Indonesia LRF • Gujarat SSF	• Decreased fish stocks • Decreased incomes for fishers and an accumulation of wealth among traders • High levels of debt among fishers • Destructive fishing practices causing collateral damage on ecosystems and in some cases negative health issues • Increased conflicts between fisheries actors • Increased negative health issues	Demand China *patron–client relations (71%) OR patron–client relations *vulnerability high *~human consumption (29%)

Note: ~ indicates the lack of a particular factor/variable, * = AND.

to be in place. At the local level, customary marine tenure exists and national authorities have recently recognized these local property rights through the new Fisheries Act. However, the overexploitation of fisheries resources continues as LRF traders have been able to exploit administrative loopholes e.g. changing company names and striking fisheries operations deals within the government, because of poor communication between national and provincial governments and between ministries.

4.1.3. Syndrome C: declining stocks and elite wealth accumulation

The seven cases comprising syndrome C share similar outcomes to syndrome B such as declining fish stocks and high levels of debt among fishers. In addition, this syndrome is associated with decreasing incomes for fishers and an accumulation of wealth among traders. Five of the cases in the syndrome are explained by the presence of patron–client relationships, in combination with a high demand from China and highly vulnerable target species (71% raw coverage) (Table 3). These five cases (Galápagos sea cucumber, Malaysia LRF, Zanzibar sea cucumber, Philippines LRF, Indonesia LRF) are either live reef fish or sea cucumber fisheries all located in developing country contexts, which relatively recently connected to the international seafood market. Furthermore, three of these cases exhibit destructive fishing practices, such as cyanide and blast fishing that have caused collateral damage on the ecosystem as well as negative health issues associated with diving.

The remaining cases from Kenya (Lake Victoria) and India (Gujarat SSF) are mature fisheries that have been connected to the international seafood market since the 1950s–60s. These two cases were not explained by the main casual pathway and stand out by being the only fisheries among the 18 cases that not only captures fish for human consumption but also for the production of fish meal/oil. These cases most likely possess a dynamic that has not been well captured by our study, as the presence of fish meal production in itself is unlikely to explain the observed outcome in these two cases.

5. Discussion

5.1. Trade and social–ecological syndromes

Our meta-analytic review of 18 small-scale fisheries from around the world has identified patterns of local co-occurring outcomes associated with international seafood trade, which we propose could be seen as an early categorization of social–ecological syndromes (c.f. Lüdeke et al., 2004; Schellnhuber et al., 1997). Three distinct syndromes were identified, of which one was characterized by maintained or even increased fish stocks. Our analysis suggests that the presence of strong and well-enforced institutions is the principal factor behind this. This emphasizes the already well-known fact that local institutions are often critical in determining natural resource trajectories (Berkes et al., 2006; Ostrom, 2005; Scales et al., 2006; Smith et al., 2010). It is also an important contribution to the debate on the effects of trade liberalization as it provides empirical support for the conclusions drawn by Hannesson (2001) based on modeling—showing that how trade affects local resource dynamics is highly dependent on institutional arrangements.

The other two syndromes both share the distinguishing feature of declining fish stocks. In both syndromes we also see mounting conflict among actors involved in the fishery as well as rising levels of debt among fishers. However Syndrome C (decline and elite wealth accumulation) differs from B (decline and conflict) in that it also includes decreasing fishers' income and accumulation of wealth among traders higher in the value chain. In addition this syndrome exhibits destructive fishing practices causing collateral damage on ecosystems and in some cases even negative health issues for fishers.

While a comprehensive analysis of trade impacts has been lacking in fisheries, environmental economists have hypothesized these and other impacts for a long time, drawing, in particular, on the better studied sector of agriculture and its interaction with trade liberalization (Dragun and Tisdell, 1999a). In the literature on agriculture and trade we thus find many similar examples supporting the dynamics observed in the latter two syndromes identified here. For example, the accumulation of wealth among trading actors is commonly observed particularly at early stages of market expansion (Dragun and Tisdell, 1999b). This is because elite groups with access to market information and capital are in a better position to take advantage of new trade opportunities. In the longer term this tends to have negative effects on income distribution of producers. Similar evidence of accumulation of wealth among trade actors and unequal benefit distribution in fish value chains also abound, often resulting from the unequal power relations held by producers vis-à-vis processors and other trading partners (Bjorndal et al., 2014).

Examining the factors behind the two syndromes featuring declining stocks and multiple associated socio-economic impacts we see the lack of well-functioning institutions as a main causal pathway for producing Syndrome B. Again the agriculture and trade literature shows that small-scale producers can end up in situations of resource degradation that trap producers in unsustainable and inefficient production when they are exposed to export markets without long-term institutional support and commitment (Henry et al., 1999). We see clear evidence of this in most of the cases exhibiting this syndrome, which suggests that the connection of local systems to international markets through trade liberalization, without accompanying strategies (such as e.g. regulatory and other institutional support, and organizations for empowerment of small-scale producers vis-à-vis value chain actors) often lead to unsustainable trajectories, both socially and ecologically.

While lack of institutions was important for Syndrome B, the causal mechanisms behind Syndrome C tell a somewhat different story. Here we see that in several cases there are in fact institutions in place but they become overwhelmed by a combination of other factors. For example, in several of the cases representing live reef fish trade some regulatory institutions exist but the strong demand from China for the products creates such high economic incentives that fishing pressure persists. The strong patron–client relations existing in many of these cases have grown out of a desire among trade actors to secure access to resources, particularly as resources start to decline in response to the exploitation (a natural phenomenon observed when virgin stocks are initially exploited (Jackson et al., 2001)). These relations vary from labor tying to credit arrangements (Crona et al., 2010; Fabinyi, 2013) and often prevent fishers from easily exiting the fishery due to debts, thus locking them into unsustainable exploitation to repay loans. In addition, many of the species targeted for the LRF trade are highly vulnerable to fishing pressure. These three factors thus combine to create dynamics that seemingly overwhelm the capacity of institutions to respond efficiently, resulting in both resource decline and negative social and economic effects, particularly for the fishers involved.

5.2. Multi-scale factors influence syndromes

Examining the three syndromes and their causal pathways together we see that the factors emerging as important for explaining the different syndromes derive from different scales (local through to global). Starting with institutions we must note that while institutions and their enforcement at the local level are clearly important, they are generally situated in broader governance frameworks supported by laws and regulations devised at national scales despite the broadly observed global movement toward decentralization and co-management in fisheries governance (Andrew et al., 2007; Berkes, 2009). In the absence of enabling legislation and support for sanctioning from higher levels, locally devised rules risk failing (c.f. Crona and Rosendo, 2011; Eakin and Lemos, 2006; Smith et al., 2010) as was observed in the Solomon Islands LRF fishery (Syndrome B). Other factors, such as the existence of patron–client relations, are features of the local social system but also incorporate structures of the broader marketing system (i.e. international supply chains). These trade actors are key connectors linking local systems with larger geographic scales through supply of commodities (c.f. Crona et al., 2010). Species vulnerability is a feature of the ecosystem or the components within it and is thus a local systems level factor. Meanwhile, product demand in international trade originates at a global or at least international level far removed from local production systems. Through complex and increasingly globalized supply chain structures (Bjorndal et al., 2014; FAO, 2014) such global/regional scale factors are becoming critical in determining local dynamics, as shown by these results. This poses novel challenges for governance efforts to achieve sustainable social and environmental trajectories and highlights the need to develop approaches that can bridge across these scales.

For small-scale fisheries this means developing institutional frameworks that acknowledge and account for pressures and possible impacting factors emerging at different scales. Highly decentralized governance is unlikely to be fit for this task for several reasons. First, new markets for marine products are emerging at rapid speeds (Adger et al., 2009; Berkes et al., 2006) and such international trends are likely to be less obvious to local governance actors, thus reducing their ability to pre-empt market emergence with development of appropriate institutions or management measures. Second, institutional support is needed at multiple levels to ensure flexible enforcement capacity to respond timely to new exploitation patterns, in themselves often responses to rapid development of new markets (Berkes et al., 2006; Smith et al., 2010). Finally, institutional support is also needed to assist small-scale producers to organize in order to increase their price negotiating power vis-à-vis trade actors, increasing income and potentially reducing income inequalities which can reduce pressure to overexploit. This has been suggested as potentially critical for securing local benefits from trade liberalization policies (Henry et al., 1999).

The multi-scale nature of these issues highlights the need for multi-level governance approaches, which have been promoted for addressing other multi-scale problems like climate change (Nilsson and Persson, 2012). Fisheries governance has seen the development of multi-level approaches in several regions (Fidelman et al., 2012; Gelcich et al., 2010), but many small-scale fisheries in developing countries, such as ones reviewed in this paper, still operate in governance contexts largely characterized by top-down, hierarchical, national-level structures, which do not have sufficient resources, enforcement and institutional capacity at local scales nor means to anticipate and deal with supra-national pressures.

While multi-level governance would deal with some of the challenges facing fisheries in the new globalized economy, multi-sectoral approaches are also needed which account for inter-linkages between policies relating to natural resources, trade and development. Failing to recognize both the multifaceted nature of impacts at local social–ecological systems levels, as well as the multifaceted nature of the causal pathways leading to them, risks encouraging policies that promote sectoral change which may be counterproductive for other sectors and the social–ecological system as a whole (Liu et al., 2013). The rolling out of large scale trade liberalization policies in fisheries is one such example (Béné et al., 2010) but similar negative spill-over effects from lack of policy coherence can be seen in other sectors, such as climate change mitigation, freshwater and biodiversity protection (Nilsson and Persson, 2012).

5.3. Policy concerns for sustainability

Paying attention to the possible interactions among causal variables and what this may lead to is therefore important for sustainability but is an area where large gaps remain in our understanding. This study cannot provide clear answers but by allowing ourselves to speculate around interactions we can highlight some areas of policy concern. First, while institutions will likely continue to be key in mediating negative effects of trade on SSF system, a growing approach to achieving sustainable fisheries (particularly in countries with weak governance) is by working with supply chains (see efforts by e.g. WWF and Sustainable Fisheries Partnership through development of Fisheries Improvement Projects). However, this approach, in which retailers engage their suppliers to commit to sustainable sourcing and passing this demand down to producers, only works if there are no other significant markets to which 'unsustainable' producers can sell their products. A growing Chinese demand for, and import of, an increasing range of seafood has led to a stated concern for China's ability to dictate the terms of its needs through the sheer scale of its demand (Godfrey 2014). A market of such magnitude that does not prioritize environmental concerns presents a market place for unsustainable fish which could undermine efforts at sustainable sourcing and production through market measures, and put extra pressure on existing institutions (as already seen in several LRF fisheries examined here). However, Chinese environmental awareness is increasing and if, on the other hand, China became a growing market for sustainably sourced fish this could potentially drive the production toward sustainability in many SSF.

Another potential scenario is that trade liberalization risks driving small-scale producers out of the system in line with theoretical predictions of the most recent trade theory relating to firm heterogeneity and competitiveness (Melitz, 2003). This may have impacts not only on social sustainability and livelihood security, but may also impact environmental sustainability, as the small-scale sector has been shown to keep more value in the ecosystem compared to industrial operations, both in fisheries and in farming (Jacquet and Pauly, 2008; McMichael, 2009). While mere speculations at this point, these scenarios illustrate how the interactions of multiple causes identified in this analysis could potentially play out and the plausible consequences of this, referred to by Liu et al. (2013) as spill-over effects.

5.4. Future research

Our analysis of environmental impacts was necessarily limited in scope due to data availability. First, the scope of our environmental variable was limited to local biological stocks. While relevant for the SSF examined here, future studies should include broader ecological effects such as habitat damage driven by destructive gears, or biodiversity impacts from e.g. bycatch. Second, our analysis only considered effects on the local system, whereas market integration is likely to have 'spillover' impacts at other locations or scales (Liu et al., 2013). For example emissions resulting from fishing operations and from processing, and transport contribute to global greenhouse gas emissions. Emissions from catching, handling and transporting fish from SSF are poorly documented and highly variable (Parker and Tyedmers, 2014), but SSF generally have lower average fuel usage and thus transportation-related emissions may potentially exceed operational emissions particularly for intercontinental airfreight (Daw et al., 2009).

Second, we used crisp set QCA analysis (i.e. binary variables) and in the future fuzzy set QCA analysis might help to further tease apart some of the more complicated aspects of the system such as the types of governance across multiple sectors and scales.

Table A1
Search results for literature search in Google Scholar and ISI Web of Knowledge. The total number of search results is less than the cumulative numbers in listed below as some search results appeared under multiple key word search combinations.

Search key words Google Scholar: all publication types	# of Hits
"small scale fisheries" + "food security" + seafood + trade + governance + resilience	189
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system	187
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social	176
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology	166
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology + market	152
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology + market + women	95
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology + market + gender	73
Web of Knowledge: all databases, keywords searched in 'Topic'	
"small scale fisheries" + governance	48
"small scale fisheries" + trade	15
"small scale fisheries" + seafood	5
"small scale fisheries" + "food security"	26
"small scale fisheries" + gender	7
"small scale fisheries" + women	12
"small scale fisheries" + resilience	22
"small scale fisheries" + "developing countries"	45
"small scale fisheries" + Africa	77
"small scale fisheries" + Asia	36
"small scale fisheries" + Southeast Asia	12
"small scale fisheries" + "food security" + seafood + trade	0
"small scale fisheries" + "food security" + seafood + trade + governance	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology + market	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology + market + women	0
"small scale fisheries" + "food security" + seafood + trade + governance + resilience + system + social + ecology + market + gender	0
"small scale fisheries" + "social–ecology system"	0
"small scale fisheries" + social–ecology system	0

Fuzzy-set QCA allows for more nuanced separation as it does not have strict boundaries on the set.

Third, while we focused on the influence of seafood trade on fisheries, there may be other types of trade that indirectly affect the fisheries system. For example in areas of Chile, the global terrestrial pulp market partly drives seafood quality, and ultimately the price that fishers are paid for their catch (Van Holt et al., 2012; Van Holt 2012). These cross-sector linkages could reveal other sectoral structures that also influence outcomes.

Finally, the problem of poor documentation is a major challenge in meta-analytical approaches such as this one. Often cases on which published information exists present data on only one or a few of the many dimensions (either social, institutional, economic or environmental) needed to take a more systemic, cross-sectoral analytical approach. Despite our efforts to find cases of broad geographic range and different types of fisheries this raises the question of how representative our sample is for the global population of SSF. It also indicates the importance of including multiple both social and environmental variables when documenting cases in the future.

6. Conclusion

This meta-analysis of the impact of integrating small-scale fisheries into global markets has shown that the social–ecological syndromes identified in relation to international seafood trade are not confined to a specific place or region. Rather, the cases within each syndrome generally represent fisheries on multiple continents (Fig. 1) suggesting that similar outcomes can be produced through common causal pathways across multiple geographic and cultural contexts, lending support to the notion of tele-connectivity (sensu Adger et al., 2009) across geographic

Table A2
Indicators used in the coding of outcomes.

Outcome Type	Outcome variable	Outcome indicator variable
Ecological	Trends of declining fish stocks	Decline in abundance of target species Decline of catch per unit effort of target species Declining fish stocks/fish stocks low Reduced catches Catches contains of smaller sized fish or juveniles Stock collapse of target species Fishers perceive catches as declining and fish size as decreasing
	Trends of sustained or increasing fish stocks	Recovery of target species Increased catches after long-term decline Increased abundance and size of target species Target species abundant Fish stocks high/viable Increasing catches
Economic	(Relatively) high levels of debt among fishers	Fishers lack culture of saving money, thus easily exposed to debts Growing debts High percentage of income goes to repay loans Loan abuse/low loan repayments
	Trends of declining income/profits among fishers	Fishers profits per capita decrease Decreased profitability High percentage of income goes to repay loans
	Trends of sustained/increased income/profits among fishers	Increased profitability Fishers profits per capita increase Increased fish prices Value adding, e.g. through marketing LRF
Social	Trends of reduced employment opportunities in fisheries sector	New jobs created in fisheries sector goes to people in urban centers rather than to people from “traditional” fisheries sector Traditional jobs/fish processing in fisheries sector lost Women disadvantaged, pushed out of fisheries sector
	Indications of wealth accumulation among traders (rather than fishers)	Unequal distribution of benefits from fisheries Fishers receive low prices for their catch, while traders receive high prices
	Trends of increasing conflicts among fisheries actors	New conflicts appear Gear thefts Conflicts over fishing grounds between e.g. “insiders” and “outsider” and between villages
	Trends of destructive fishing practices (often associated with collateral damage on habitats/coral reefs)	Use of cyanide Blast fishing Beach seines Tembea (drift nets)
	Food insecurity/Food security impacts negative	People in local community with low purchasing power have no or little access to food fish, and thus low fish consumption
	Trends of increasing health issues associated with fishing	Dangerous fishing methods are used, such as scuba diving with unsafe equipment Health problems, in some cases even deaths, associated with fishing practices.
Institutional	Trends of increasing local control over fisheries governance	Local empowerment Co-management regime Increased stakeholder/fisher participation in management institutions and harvesting decisions

space. The increasingly global nature of the seafood trade appears to be driving local dynamics by creating similar conditions for vulnerabilities in localities around the world. The longer-term effects of this include the aggregate depletion of natural resources, in this case fisheries, across increasingly large scales. Exploitation patterns are also linked to socio-economic processes such as patron–client relationships and other credit arrangements which have the potential to create social–ecological traps (Cinner, 2011; Steneck, 2009; Crona et al., 2010) further undermining the resilience of local social–ecological systems. The multi-scale dynamics and telecouplings (sensu Liu et al., 2013) inferred by these results are important for our strive for sustainability in several ways. First, they shed light on the emerging trade-offs between global sourcing of fish, and local environmental sustainability and food and job security. Such trade-offs cut across scales and should be a key concern as global trade in marine resources is rapidly increasing. Second, identifying the interactions of potential causes and the plausible outcomes highlights what policy domains will need further dialog and integration to come to grips with challenges of achieving sustainability in small-scale fisheries; socially, economically and environmentally. We hope this can trigger academics and policy makers alike to improve understanding of these multi-scale interactions and work toward improved multi-level and multi-sectoral governance approaches needed in today's globalized world.

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Appendix A.

Methodology

If an abstract indicated potential relevance the paper was put into a pool of papers to be reviewed in more detail. In addition to the online search results the authors' personal libraries were scanned for relevant work using the same procedure. Finally an online survey was disseminated to members of the Too Big To Ignore Project (http://toobigtoignore.net), a global partnership for small-scale fisheries research, to solicit additional cases. All additional cases were added to the pool of potentially relevant cases. In addition, as the review process began, reviewed papers would occasionally refer to a case that seemed relevant but had not appeared in the online search. These were subsequently retrieved (if possible) and added to the pool of potentially relevant papers. A total of 146 papers were included in the final pool of potentially relevant papers. These included both peer-reviewed and gray literature. All 146 papers were subsequently read to determine which contained enough information to qualify for inclusion in the final analysis, i.e. *information that would allow an analysis of how one/several local fisheries have been affected by international seafood trade and the outcomes observed at the local level.* As such we did not include papers that presented aggregate analysis of outcomes in relation to international trade across multiple countries or regions. Some cases were described by only one paper, while others were represented by a collection of papers by the same or different authors.

For assessment of life history traits of Chilean loco (*Concholepas concholepas*) we relied on Manríquez, P.H. and Castilla, J.C. 2001. Significance of marine protected areas in central Chile as seeding grounds for the gastropod *Concholepas concholepas*, Marine Ecology Progress Series 215: 201–211 (see Tables A1 and A2).

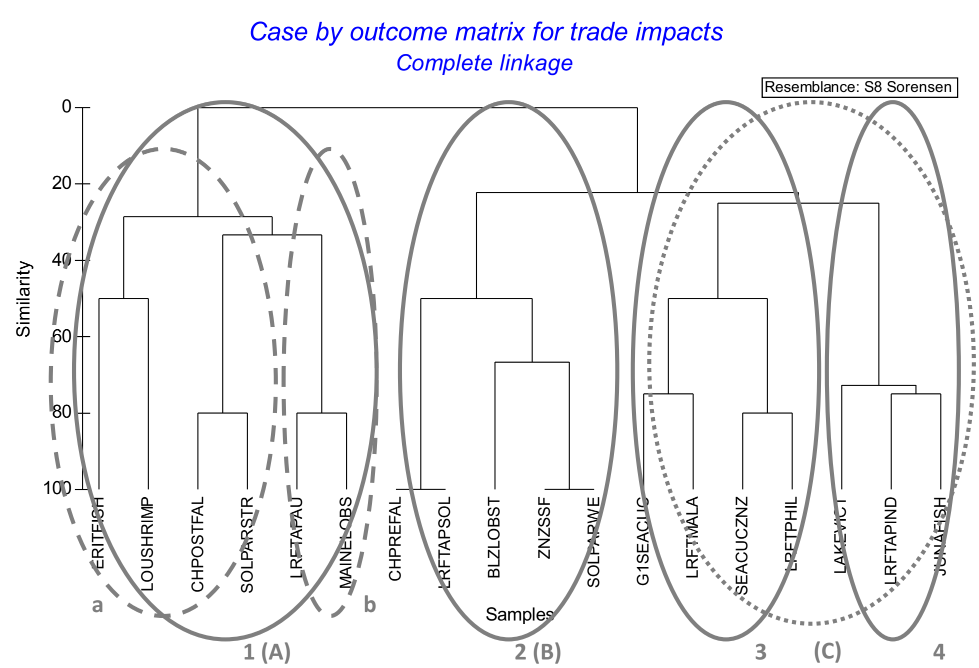

Fig. A1. Illustration of the iterative process of cluster identification and delineation. Letters A–C indicate the final clusters used in the analysis. The solid lines indicate the four main syndromes from the first clustering analysis. Dashed lines (a and b) indicate clusters that were aggregated through the iterative process described above. Dotted line (C) indicates the aggregate cluster resulting from combining clusters 3 and 4 in the final step.

Identification of clusters

All clustering analyses were run on the case-by-outcome matrix based on complete linkage in Primer 6.0 (Everitt et al., 2001), and using Sørenson's similarity coefficient (McCune et al., 2002).

We identified the clusters that were ultimately used for the discussion on social–ecological syndromes proceeded in multiple iterative steps.

1. A first clustering analysis distinguished four main syndromes A–E (Fig. A1—solid lines (1–4))
2. All cases in each cluster were examined to make sure the outcomes were consistent within clusters. Cluster 1 contained some contradictory outcomes, with some cases showing decreasing incomes for fishers, while others showing increasing or sustained incomes for fishers (Fig. A1—dashed lines). However, while they exhibited different outcomes in terms of fishers' incomes, having sustained or recovered fish stocks was considered to be the most important outcome characterizing these cases, given the focus of our analysis on sustainability of fisheries. Cluster 1 (cluster A in final analysis) was thus retained.
3. Next we ran the QCAs for each of the four clusters (1–4 in Fig. A1). This showed that two cases exhibited the same combination of factors but fell within different clusters, i.e. one case was classified as Cluster 3 and the other in Cluster 4. Consequently, the raw consistency in the truth table was 0.5 for these cases. This conflicted with the general rule of thumb in QCA that the limit for including cases is at 0.75. Using a small number of cases per outcome to be examined (in this case Clusters 3 and 4) can be problematic, in particularly when one out of three cases (as in Cluster 4) cannot be explained by the factors or has a low consistency in the truth table. We therefore examined the description of the outcomes for all cases in Clusters 3 and 4 again and noted that while they had initially been categorized into two separate clusters by the Primer algorithm, a review of their outcomes combined with background information showed so much similarity that we decided to aggregated them into one cluster by increasing the bar for distinguishing a cluster to approximately 20% similarity (see dashed line (C) in Fig. A1). The final number of clusters forming the basis of our suggested social–ecological syndromes is thus three (A–C).

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