Journal of Environmental Policy & Planning

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjoe20

Materialities, discourses and governance: scallop culture in Sechura, Peru

Lotta Clara Kluger, Achim Schlüter, Maria Garteizgogeascoa & Gerardo Damonte

To cite this article: Lotta Clara Kluger, Achim Schlüter, Maria Garteizgogeascoa & Gerardo Damonte (2022): Materialities, discourses and governance: scallop culture in Sechura, Peru, Journal of Environmental Policy & Planning, DOI: 10.1080/1523908X.2022.2047620

To link to this article: https://doi.org/10.1080/1523908X.2022.2047620

Published online: 22 Mar 2022.

JOURNAL OF ENVIRONMENTAL POLICY & PLANNING
https://doi.org/10.1080/1523908X.2022.2047620

Materialities, discourses and governance: scallop culture in Sechura, Peru

Lotta Clara Kluger [a,b,c,d], Achim Schlüter [c,e], Maria Garteizgogeascoa [d] and Gerardo Damonte [f,g]

[a]Center for Ocean and Society, Kiel University, Kiel, Germany; [b]Department of Agricultural Economics, Kiel University, Kiel, Germany; [c]Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany; [d]Artec Sustainability Research Center, University of Bremen, Bremen, Germany; [e]Department of Business and Economics, Jacobs University, Bremen, Germany; [f]Department of Social Sciences, Pontifical Catholic University of Peru, Lima, Peru; [g]Group for the Analysis of Development, Lima, Peru

ABSTRACT

This paper looks at the institutional emergence, particularly space rights, within the culture of the Peruvian bay scallop (*Argopecten purpuratus*) in Sechura Bay. The institutional system developed within a period of 20 years from an open-access, gold rush scenario to a rather structured, formal activity – however, still relies on a lot of informality. This work uses the matrix provided by the material dependency framework presented in this special issue distinguishing between nature, human and hybrid-made materialities that influence the emergence of institutional structures, on the one axis and path-, inter- and goal dependencies on the other axis. In this work, we argue that existing natural (high environmental risks associated with scallop culture in this setting), hybrid (need to process quickly) and human-made (export-oriented production) materialities have shaped different path dependencies in institutional development in favour of larger firms who gradually took over the control of scallop production from small-scale producers, who in turn became piece wage labourers. Yet, the realities of both actors are necessarily intertwined, with informal loop holes being intentionally left open, shaping different institutional solutions over time. Applying the material dependency framework shows how materialities and goal dependencies are intertwined in this particular case of scallop bottom aquaculture.

ARTICLE HISTORY
Received 30 June 2021
Accepted 20 February 2022

KEYWORDS
Scallop mariculture; aquaculture governance; materialities

Introduction

Aquaculture is the most quickly growing food sector worldwide: with an annual growth rate of 5.3% (for the period 2001–2018), the sector is expanding faster than other food-producing industries (FAO, 2020). It has a lot of potential in relation to food security and to solve sustainability issues in relation to wild-catch fisheries (e.g. Barange et al., 2014; Gentry et al., 2017). However, as it can be clearly observed, aquaculture is also not a silver bullet, but it comes along with social, economic and ecological challenges. Through the occupation of formerly open-access marine space, extensive aquaculture is regularly related to forms of sea grabbing, it capitalizes the sea and therewith often excludes the poor (Campling & Colas, 2021). And despite the global discourse often promoting aquaculture as the ultimate solution to meet the growing nutritional demand of the increasing world population, important parts of aquaculture production done in the global South produce seafood for export to Western markets (North America, European Union). It is not necessarily used for

CONTACT Achim Schlüter achim.schlueter@leibniz-zmt.de Leibniz Centre for Tropical Marine Research (ZMT), Fahrenheitstraße 6, Bremen 28359, Germany; Jacobs University, Campus Ring 1, 28759 Bremen, Germany

feeding local populations (Garlock et al., 2020). In many countries, small pelagic fish is reduced to fishmeal/oil to be used as feed input for aquaculture and is thus not available anymore for vital human consumption (Cashion et al., 2017; Majluf et al., 2017). Depending on the species cultured, aquaculture facilities interact with the surrounding environment in many ways, generating both costs and benefits at different social, economic and ecological scales (Kluger & Filgueira, 2021). Entire ecosystems may be destroyed, either because of space requirements or a high nutrient and pollution load (for an overview of aquaculture–environment interactions, see e.g. Edwards, 2015). Such a fast-growing sector, hardly existing 30 years ago, requires a lot of governance mechanisms to be developed allowing a sustainable path. This strong need for the development of governance mechanisms is sharply in contrast with the little amount of literature on the topic (Partelow et al., 2021).

Aquaculture production, might it be pond-based, or flow-through systems or mariculture, is always a highly interdependent social-ecological system (Asche et al., 2016; Naylor et al., 2021). The fluidity of water and the industrial intensity at which it takes place are just some of the reasons for those strong interdependencies. From this perspective, it seems obvious that, on the one hand, materialities of the natural but also human-made environments have a strong influence on the potential and possible governance regimes. On the other hand, the prevailing governance regime – due to the new emergence of the sector, it is often a laissez-faire regulation – has strong influences on the materialities, i.e. converting completely the appearance and functions of, for example, an estuary or bay. Not only that there is a lack of academic literature on governance challenges on aquaculture. Governance scholars, usually having a social science background, also focused for long mainly on social and economic characteristics influencing the governance regime (Bear, 2013; Epstein et al., 2013; Vogt et al., 2015) and only recently the material characteristics, the ecological fit gets more attention (Duineveld et al., 2017; Epstein et al., 2015). This is confirmed also for the field of aquaculture. Out of the roughly 2900 social science contributions to aquaculture in Scopus, nearly 1800 have an economic focus, in which marketing and supply chains play important roles. Roughly 600 papers research explicitly governance issues. Ecology plays a major role. However, an explicit perspective on materialities, might it be of nature, of products or technology is rare (19 out of which 14 come from the last five years; for example: Fairbanks, 2019). The special issue to which this paper is contributing to is aiming to fill that gap within environmental governance as a whole. This particular paper contributes to the fast expanding aquaculture sector. Having an understudied governance system like that of aquaculture, which is due to its characteristics highly interdependent on material properties, makes it a particular interesting study object.

This paper is a case study that applies the material dependency framework developed by Van Assche and colleagues in this special issue to the emergence of governance of scallop culture in Sechura Bay in the North of Peru (Figure 1). Apart from filling the observed gap of governance analysis in the aquaculture sector, it has the objective to provide a better understanding between materialities and their influence on governance evolution. Governance, to a good degree characterized by different types of institutions, is understood 'as radically evolutionary: all elements of governance are subject to evolution, they co-evolve, and most of them are the product of governance itself' (Van Assche et al., 2014, p. 5). By applying the material dependency framework, one also learns about its usefulness.

Scallop bottom culture provides a good study case, as, first, it is more than other production systems relying on the natural material property of the system – there is no additional feed required, scallops on the bottom and fishers are completely exposed to the natural environment, scallops are extremely sensitive before and after harvesting – and, second, it has seen a rapid institutional development within a period of 20 years, evolving from a nearly unregulated system, with open-access to the sea floor, to a private property regime (Kluger et al., 2019; Schlüter et al., 2021).

Within the Sechura case, there are two important, not necessarily always contradicting but, however, clearly distinguishable visions on what the (governance) system shall look like: These are, on the one side, small-scale fishers (SSF) and on the other side larger producers. SSF shaped the early onsets of scallop mariculture in Sechura Bay, searching for new income opportunities by experimenting with the culture of a species that was mainly targeted through fisheries before, ultimately providing grounds for the rise of a lucrative sector in the region (see, e.g. Badjeck et al., 2009; Kluger et al., 2019). This origin has led to the clearly formulated feeling of ownership of SSF, and the wish to continue to dominate the business. Larger producers entered the

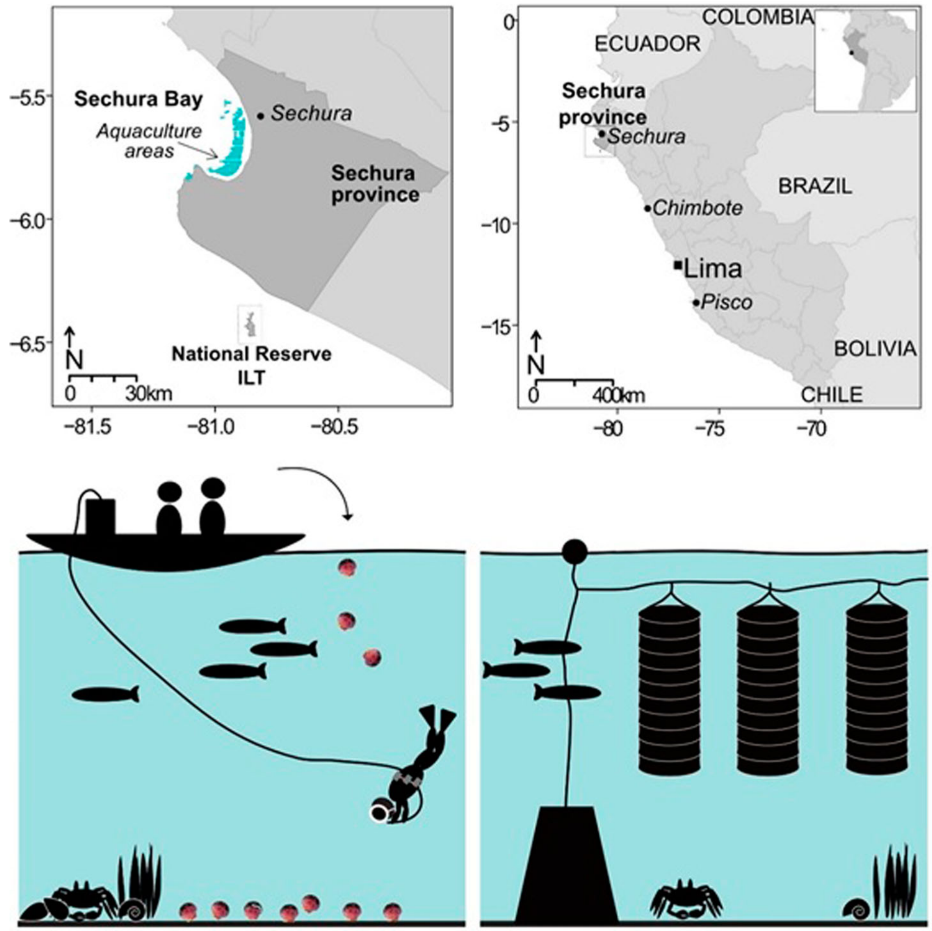

Figure 1. Contextualizing the case study: Sechura Bay in the province of Sechura, North of Peru, indicating the aquaculture concession areas (in blue, as of February 23, 2021); ILT, Island Lobos de Tierra (upper left panel). Map of Peru, with the black square indicating the map section as shown to the left, and a subplot locating Peru within Latin America (upper right panel). Schematic visualization of scallop mariculture in Sechura Bay: conducted by small-scale fishers while diving in bottom cultures (lower left panel) and carried out by larger producers in a suspended net culture that are installed on long-lines (lower right panel). Upper two panels based on Figure 2 in Schlüter et al. (2021)*, lower two panels by the first author, created in Affinity Illustrator. *Upper two panels were constructed in the R environment (R Core Team, 2021), using the maps (Brownrigg, 2018), sp (Pebesma & Bivand, 2005; Bivand et al., 2013) and sf (Pebesma, 2018) packages. Bordering countries and Peruvian administrative areas (region – and province-level) were retrieved from the Database of Global Administrative Areas (GADM, www.gadm.org, subdivision levels 0, 1 and 2). Geographic information for National Reserves and the Aquaculture areas was downloaded from the webpage of the Peruvian National Service for Natural Protected Areas (http://geo.sernanp.gob.pe/visorsernanp/) and the aquaculture cadastre of the Peruvian ministry for Production (http://catastroacuicola.produce.gob.pe/web/), respectively.

scene after the early trial phase (cf. Kluger et al., 2019; Sanchez, 2015), quickly taking over the strategic parts of the value chain (processing, exporting). They used an intertwined set of informal and formal regulations to shape the process in their favour (reducing uncertainties) and to manage the sector in Sechura Bay. Each view has found its equivalent in two different aquaculture laws, successively altering access regimes to the resource and its culture. Visions and goals of both actor groups are strongly shaped by the different materialities present; this setting provides an excellent opportunity to discuss the framework of Van Assche and colleagues (in press).

The paper develops as follows: First, the context of scallop culture in Sechura Bay is provided with much more detail. Then, the typology of material dependencies provided by Van Assche and colleagues (in press) is discussed, which aims to link material properties to what communities want to do and what their values are in

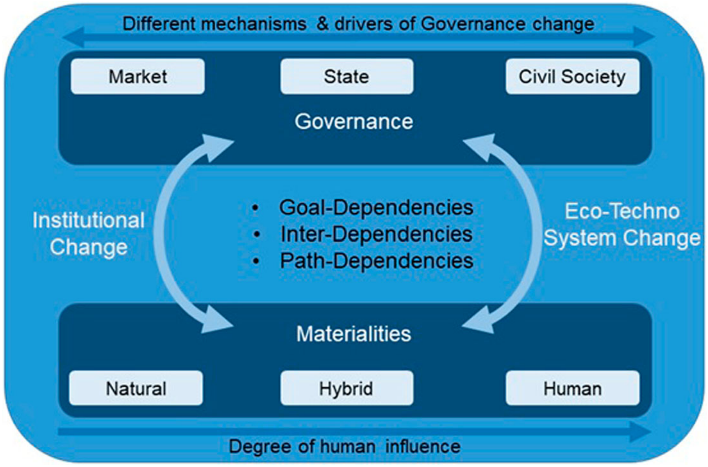

Figure 2. Dependencies between (natural, hybrid and human-made) materialities and governance (market, state, civil society) that can be both enabling or disabling.

relation to the governance regime. Here, we briefly describe the material and methods on which this study is built, and a description of our interpretation of the analytical lens used in this paper, for then being able to present the case in the light of this lens. The paper closes with a discussion and conclusion section.

The case of Sechura

With the coastal stretch of Peru being desertic, the ocean has always played an important role in nutrition and livelihoods in Peruvian coastal communities (e.g. López de la Lama et al., 2021). The harvesting of the Peruvian bay scallop (*Argopecten purpuratus*) dates back to precolonial times, and since the 1950s they represent one of many species collected by small-scale diving (hookah) fishers along the entire coastline. During the strong El Niño events of 1983/84 and 1997/98, scallops occurred in great abundances in the region of Pisco, attracting fishers and fish workers from all over the country to join the rush (Wolff, 1987; Wolff et al., 2007). Sechura Bay gained importance only after that, with natural banks (at the island Lobos de Tierra, ILT, Figure 1) being exploited by fishers since the 1990s. First culture attempts in the region of Pisco were not successful in the long run but provided grounds for adventurous fishers to explore their luck in the large bay of Sechura further north. Here, scallop culture was initiated in the early 2000s by small-scale fishers, many of which were migrants from the south of the country (Pisco region) (Badjeck et al., 2009; Kluger et al., 2019). The culture technique applied involves the collection of scallop seed in the wild (within the bay of Sechura or at the island ILT), to place those onto the sea bottom of own culture plots for grow out (Figure 1). When having reached harvestable sizes (>65 mm shell height), scallops are collected by divers for the transport to shore, where processing (shucking, cleaning, freezing) has to be done quickly as to maintain freshness. This bottom culture type is also referred to as sea ranching or capture-based aquaculture, due to its close relatedness to fishing and its dependency on the natural environment. The success of the first groups soon attracted many people from all over the country to join the expanding sector (Badjeck et al., 2009; Kluger et al., 2019, 2020). What started as an informal, trial-and-error activity was soon legally captured through the establishment of a first aquaculture law (Law N°27460[1] and its management scheme D.S. N°030-2001-PE[2]) indispensably linking the activity of sea ranching to small-scale holders (Ministerial Resolution R.M. N°102-2006-PRODUCE[3], modified through R.M. N°204-2006-PRODUCE[4] and R.M. N°293-2006-PRODUCE[5]). It was, however, not only until 2009, that national aquaculture law was implemented in Sechura Bay through the issuing of a regulation (Supreme Decree D.S. N°016-2009-PRODUCE[6]) for the spatial management of the bay, i.e. designating large areas of Sechura Bay to the concession type for sea ranching (and thus SSF users), even though the law also permitted suspended culture (cf. Figure 2) in a different type of concessions. In the following years, the bay's area was gradually assigned to a growing number of small-scale fisher organizations (OSPA for their abbreviation in Spanish: *Organización Social de Pescadores Artesanales*), a step that often simply formalized groups' already ongoing culture activities. In 2015, 158 OSPAs cultured scallops within the bay (Mendo, 2015). For a more detailed overview of the management scheme in place, see López de la Lama et al. (2018) and Garteizgogeascoa et al. (2020) and for a detailed recount of the transformation process of Peruvian scallop fishery to aquaculture, see Kluger et al. (2019).

While it were small-scale fishers who started the scallop cultures in Sechura Bay, other actors soon came along. With the opening/registration of Sechura Bay for international markets in 2009 (Kluger et al., 2019), several larger processing plants were established, restructuring the business. Ever since, these plants represent the bottleneck for all those who wish to produce scallops for export (which is 85% of production, comparing internal sales and export values, in PRODUCE, 2019a), because they incorporate all steps of the processing and organize the export. According to Mendo and Quevado (2020), four of such plants currently exist in the region. While these plants buy scallops from all types of producers, they established also their own line of productions through aquaculture concessions designated for suspended scallop culture (Figure 1). This culture type is comparatively intensive with respect to labour and financial needs, as scallop seed is placed in a successive series of hanging nets (of different mesh sizes) until harvestable sizes are reached. These nets require regular cleaning (e.g. against biofouling), and heavy machines (cranes) to be lifted. In 2015, a second aquaculture law (Law D.L. N°1195[7] and modifications Supreme Decree D.S. N°003-2016-PRODUCE[8], D.S. N°014-2017-PRODUCE[9], R.M. N°157-2019-PRODUCE[10], D.S. N°002-2020-PRODUCE[11]) was passed, that now requires commercial aquaculture producers (including SSF) to be medium or large-scale firms.

We divide into those two main actor groups (small-scale fishers and larger scallop-producing companies) as if they would be antagonists. It has to be made clear, however, that the separation is not as strict as portrayed here, because there are many forms of cooperation and interlinkages between these actors. However, those two groups are clearly identifiable to have had different intentions on how the governance structure should look like.

Materials and methods

This paper relies on many years of ecological and social research done in Sechura Bay by the first author, who focused both her PhD and four years of post doc research on Sechura (including fieldwork in 2013 and 2014 (6 months each), 2015 and 2017 (1 month each), and 2018 (2 months)), and shorter fieldwork by the co-authors in 2019. It draws on documents, interviews and participant observation. All interview data were collected with the prior informed consent of survey and interview participants, and participation was always voluntary. Anonymity and confidentiality were secured. A snowball sampling method was applied using various entries into the research field, as there exist clearly distinguishable stakeholder groups, with conflicting interests. The study did not go through a process of ethical clearance as such a process is not yet common neither in the German nor the Peruvian social science system. However, researchers are obliged and committed to follow the code of good scientific practice, laid out by the German Science Foundation.

For analysing the data, we used a diagnostic and iterative process (Epstein et al., 2020; Flick, 2013), which uses, firstly, a concept and, secondly, a data-driven approach to analysis (Kuckartz, 2019; Schreier, 2012). The analytical and theoretical categories mainly stemmed from the framework applied in the research. The data analysis was done with different tools like MAXQDA 2020 (VERBI Software, 2019). Most of the time empirical claims are supported with references to already published material. If the arguments are built on more recent not yet utilized interviews for other publications, a number in brackets within the text refers to particular interviews. The data had been already used and had been interpreted using other lenses, e.g. a social-ecological lens (Kluger et al., 2019), a migration theory lens (Kluger et al., 2020), and an Institutional Analysis and Development Framework and institutional change lens (Schlüter et al., 2021). This paper re-codes and re-analyses the material using the material dependencies lens. It was an iterative diagnostic process, where the authors revisited and discussed the data in the light of the framework. Each framework or lens used has a different focus. Therefore, it provides a different piece of the puzzle and is able to answer a different research question.

From this perspective, the application of the material dependency framework was not meant to compare its contribution to an overall understanding of the case, but rather it was seen as a means to understand the relationship between materiality and the evolution of institutions.

Material and other dependencies as an analytical lens

Working in an inter- or multidisciplinary environment, we realize that many natural scientists tend to believe that the earth or environmental systems are mainly driven by environmental variables and on the other hand social scientists are believing that the main variables to be considered are human-related variables. This seems natural, as our senses, but also our norms and values are deeply influenced by the specific discipline we have been trained in (Freeth & Caniglia, 2020). Therefore, we see only particular aspects of our socially constructed reality. It is common that even social scientists with the best intention and an interdisciplinary perspective (Ostrom, 2007) forget nevertheless to properly consider the material or ecological characteristics driving the social-ecological system (Epstein et al., 2013; Vogt et al., 2015). The terminus social-ecological itself, however, also seems to turn a blind eye on another aspect, which considerably shapes the social-ecological system: technology (Hagedorn, 2008). Human-made materialities, which shape considerably material and non-material structures, that enable or disable certain modes of governance are important to be considered. Two authors of this paper are trained as biologists, two others as social scientists (social anthropology and economics), though all are now mainly working with a social science focus, however, concentrating on the understanding of interactions of people with natural resources and the environment. From this perspective, a particular focus on the material properties of a system and to analyse how far they influence the institutional structure is an extremely reasonable exercise to do. From a day-to-day research perspective, we realize how the material realities and the governance properties are closely and dynamically intertwined (Epstein et al., 2020; Schlüter et al., 2019). This holds particularly true for the marine environment due to its material properties and social properties, like fluidity or the intersection of various jurisdictions (Schlüter et al., 2020; Van Assche et al., 2020). On the one hand, materialities, might they be natural, like the tide, human made, like a particular fishing gear, or hybrid materialities, like a warmer ocean bringing scallops under stress, are not only influencing but even determining the option space for governance structures. Individual tradable quotas, an iconic institutional structure of the marine realm, believing to provide efficiency (Kompas & Che, 2005), sustainability (Arnason, 2012) and injustice (Knott & Neis, 2017; Mansfield, 2004), might serve as an example. The reason why human beings invented individual tradable quotas for fish, which are not granting private property rights to the resource, but only the right to a certain share of a product, is not because some of us would not like to have a private share of this common heritage of human kind (Said et al., 2016), but it is due to the impossibility to assign private property rights to a fish, which is swimming through an ocean without physical yet jurisdictional borders (Bromley, 2016). On the other hand, the governance structure is determining materialities of a system. For example, an institutional structure that provides huge incentives to extract resources (e.g. fishing) or to heavily pollute the water body (as can be a result of aquaculture), might lead to system shifts, changing permanently materialities (Holmer et al., 2008). A governance regime might favour, foster or hinder technological change and therewith human-made materialities, and influences the areas in which such material changes take place, with which purpose and for whom. A governance system that does not allow child labour or which has particularly demanding hygiene standards is pushing for different innovations than a system that allows for cheap child labour supply or does not regulate the required freshness of fish or scallops (Bromley, 2006). Taking a general perspective on the marine sector, one would argue that the mutual dependence between materialities, discourses and governance argued for by Van Assche et al. (in press) in this special issue also seems to hold true for a marine environment.

Looking at material dependencies, it is important to distinguish between natural, hybrid and human-made materialities (Van Assche et al., in press), because they are on a continuum between hardly being shaped by humans to being entirely human-made. The latter does not necessarily mean that their development could be easily determined or sometimes even willingly be influenced by humans, as the emergence of governance is a complex evolutionary process (Beunen et al., 2015). It is influenced and shaped by many actors and involving a lot of uncertainties and interactions with society and the materialities (Duineveld et al., 2017). Even if we cannot influence the natural material property of a system, we are often able to shape our governance, so that we are better or worse able to cope with the materialities of the system. For example, a well-established insurance system enables to cope with natural (storm surge) or social (piracy) extreme events (Campling & Colas, 2021). Apart from material dependencies, which result from more stable properties, material events can have an effect on governance. Material events add a time dimension to materiality. 'A material event occurs when materiality alters something, sparks or creates something in governance' (Van Assche et al., in press, p. 18). Good examples might be a Tsunami, a drought, or as we currently live through the emergence of a new dangerous virus.

From a governance perspective, it is important to distinguish between markets, states and civil society as the three main arenas where governance happens and governance changes take place (Kooiman & Bavinck, 2013). This is important because the mechanisms and drivers of change in those three domains are considerably different (Schlüter, 2001). Markets are second-order institutional structures, which are, as all governance mechanisms, human-made and therefore can be altered according to (societal) norms, values and preferences. However, governance evolving within the structure of a market – like contracts, supply chain organization or the institutional setup of a firm – is different than the evolution of state governance, i.e. with the help of laws. It is not argued that a different set of drivers, like discourses, transaction costs savings or power asymmetries, are at play, but their relative importance depends on the domain. This also shapes the abilities and mechanisms of influencing the change of governance.

Finally, we must distinguish into path-, inter- and goal dependencies (Van Assche et al., in press). Path- and interdependencies can stem from both, governance and materialities and they can affect both. A governance system has, as first described by North (1981), a strong influence on the subsequent governance regime (path dependency). It also has an influence on the material structure. Bluntly speaking an open-access, common property or a privately managed resource or ecosystem will look differently and will have different consequences in terms of their sustainability – yet scholars are not sure, which one of those performs better. Materialities of the environment and the governance system are interdependent, as is the argument of the entire special issue this paper is embedded in (Van Assche et al., in press). It is an endless iterative process, which means that past materialities influence future governance structures. Goal dependencies describe the relationship between goals of actors and their influence on actor/institution configurations (Van Assche et al., 2014). Goals are embedded in discourses and discourses shape to a large degree governance, which then might have an influence on materiality (Van Assche et al., in press). To refer to an example from above, individual tradable quotas are largely the result of a neoliberal discourse and might have the expected positive outcome on materialities, the fish stock. However, individual tradable quotas as a governance structure are not only shaped by a neoliberal discourse, but also, as discussed above, by the material and ecological properties of fish. A more general example might be the Sustainable Development Goals (SDGs), being the result of a global discourse process, emerging from observed undesirable hybrid and human-made materialities. The defined 17 goals and the many sub-goals resulted from a huge number of discourses at many places within our society. Hopefully, the SDGs as a global consensus on sustainability targets have an influence on governance structures and therewith indirectly, but also directly on materialities. Figure 2 synthesizes the above argumentation.

Manifestations of entwined materialities and governance in scallop culture of Sechura Bay

In the following, we go through the three types of materialities and analyse how far they enable or disable the intended governance structures of the above two identified main actors (small-scale fishers, large producers). Within enabling and disabling factors, we follow Van Assche et al. (in press) and distinguish into positively and negatively influencing materialities. A positively enabling aspect would not only help the intended goal, but it would be also at a larger sense be positive for the actor group. On the contrary, a negative enabler comes along with other negative influences for the actor group. Table 1 summarizes the materialities mentioned in the text and adds others, which have not been described in the text due to space limitations.

Table 1. Factors enabling or limiting intentions of processors/large investors or small-scale fishers to control the production process (Typology of material dependency developed by Van Assche et al., in press in this special issue). Light grey influence on intentions of larger investors; grey, influence on intentions of SSF; dark grey influence on both.

	Enabling		Disabling	
	+	-	+	-
Natural				
Shallow bay	Allows less expensive bottom culture			Suspended culture is difficult, exclusivity of SSF for conducting bottom culture reduces own influence
Scallop seed abundant in the wild	Only SSF allowed to harvest scallop seed (cheaper input)	Seed can be partially paid by labour & diver health		Only SSF allowed to harvest scallop seed (informal access)
Complex productive ecological properties	Trial and error attitude allowed early entrant SSF to make profits High financial capabilities allow larger producers to buy in required knowledge			High uncertainty of production difficult to deal with for SSF
High environmental variability leads to fluctuations in productivity	High financial capabilities enable larger producers to cope better with short-term losses			High gains and high losses difficult for SSF with short financial breath
High environmental variability (El Niño, warming events) require quick responses	Those producers with direct connection or own possibility to process in favour			SSF depend on processing plant's capacity/willingness to process their product
Hybrid				
Scallops have high hygienic requirements	Managing supply chain is knowledge intensive but easier for suspended culture			Managing sanitary standards is more difficult in bottom cultures due to external influences
Supply chains for foreign market require big production units	Capital owners have considerable advantage Actors controlling scallop processing and export in favour			
Anthropogenic factors and climate change create risk of fatal algal blooms			Suspended culture less likely to be strongly affected; Marine biologist & processing capacity at hand	Bottom culture more likely to be strongly affected; SSF can neither anticipate nor do emergency harvest
High costs to produce seeds in hatchery	Gives exclusive access to markets of certified products, which require hatchery seed input Gives exclusive market for SSF extracting scallop seed from the environment (also for the larger producers)			Forces SSF to continue extracting seed from the environment – at the risk of being criminalized and of their own health
Stocking density creates nutrient scarcity				Limits economic potential & reduces negative environmental impacts
Due to huge weight of scallops and quantities required many transport boats required	Capital owners have considerable advantage			SSF with no collateral must get well organised or are outcompeted
Processing needs to be done quickly in huge plants				SSF are exposed to asymmetrically dependent on processors
Human-made				
Compressor diving	Favours discourse of mariculture being an artisanal activity established by SSF who are willing to take the (health) risk Suspended culture (i.e. larger producers) do not depend on diving - favouring their discourse of a cleaner, more organized activity	SSF risk own health		Suspended culture (i.e. larger producers) do not depend on diving, favouring their narrative of a cleaner, more organized activity Suspended culture still uses scallop seed from the wild (i.e. collected by SSF)
Technology/machinery requires high investments	Capital owners have considerable advantage			SSF cannot access those means
High demand from rich distant consumers requires cooling chain & big sizes	Market knowledge & investment in cold chain required; Capital owners have considerable advantage			SSF cannot access those means; market access only through larger producers

Natural materialities

A necessary condition for bottom scallop culture (sea ranching) is the *shallowness of the bay*. Scallops are cultured at a depth of 5–15 m, while suspended culture requires a depth of at least 10 m. The fact that Sechura Bay is such a large, relatively shallow bay made it really attractive to small-scale fishers installing first-bottom cultures. If it was deeper, the sector might have never established or would have been exclusively restricted to producers with more capital and knowledge. This is so, because in a deeper environment, only suspended culture would have been possible. However, suspended culture requires much larger investments into seeds, gears and machinery for lifting the heavy nets out of the sea (at least 1.5–2 times higher than for bottom culture, according to one key informant). Suspended culture is, at the same time, the pre-requisite for acquiring sustainability certificates such as that of the Aquaculture Stewardship Council (ASC), so higher production costs may be turned in the gaining of access to exclusive, lucrative markets (7).

A natural phenomenon, which is an important ingredient for the overall development of scallop culture in Sechura, is the existence of *abundant scallop seed in the wild*, particularly at the island Lobos de Tierra (ILT, *cf.* Figure 1). The collection of seed from natural banks is formally linked to subsistence fishers (which is equated here with SSF). They are the only being allowed to harvest seeds from the wild. Formally, this is only on natural banks within Sechura Bay (and other open-access areas along the coast), but not at the nature reserve of ILT. Though informally, this is a legitimate practice (Mendo et al., 2008, 2016; Kluger et al., 2019; Laínez Del Pozo & Jones, 2021). The island is an 8–10 h boat ride away from landing sites within Sechura Bay, and control and enforcement of existing regulation (i.e. prohibition of scallop collection of any size, incl. seed, and/or their transport to other areas; up to 5 years of prison can be pronounced for collecting scallops at the island[12]) is rarely implemented (but see Laínez Del Pozo & Jones, 2021; PRODUCE, 2019b). Though the extraction of seed from the wild implies considerable financial capital (for fuel, food, payment of divers) and a good portion of the investments into seeds is made through own labour (often, the entire fisher organization collectively go out for the collection of seed). However, it does not require as much capital as seed from the hatchery (prices for seed stemming from hatcheries can be two times higher than from those originating from ILT; Kluger, 2013 with data from 2013, newer interviews revealed even higher prices differences). Capital is difficult to obtain for SSF (12). Formally, the larger producers are obliged to use seeds from hatcheries, though buying seeds from small-scale fishers is common (Sanchez, 2015). This tolerated practice (5) enabled SSF for a substantial amount of time to be in control of the main bottleneck of scallop production: seed. However, the downside and negative enabler is depicted by the fact that at ILT, scallop seed appears at depths of up to 20 m and with SSF divers using compressors (Figure 2) staying many hours under water that comes along with considerable health risks (Kluger et al., 2019). One could therefore argue that both SSF and larger producers are willing to partially pay seed with diver's health.

The *complex productive ecological properties* of the scallop production in the Bay of Sechura and the huge uncertainty involved are a double-edged sword enabling and disabling the production by SSF. Starting the business was an extremely uncertain and unknown venture, and the first years were characterized by trial and error (12). The SSF, most of them originating from the Pisco area, discovered the natural potential while on the search of income opportunities (e.g. Badjeck et al., 2009; Kluger et al., 2020). If the cultured batch survived the grow-out cycle, the revenues were (and still are) huge, especially when compared to other income sources in the region. These huge gains not only attracted other fishers and workers from all over the country but also larger investors that became interested once the SSF had shown that the natural conditions of the bay allow for starting this business. However, in the medium run, the little knowledge and the huge uncertainty of the production process is much easier to be handled by the larger-scale producers (4, 7). After all, long-term success will also depend on whether or not the group conducting aquaculture (be it SSF or larger firms) knows about and can deal with the associated (financial) risks, e.g. when a bad harvest leaves the producer with no income for a year (12). Obviously, SSF have the longest experience with scallop culture and have built a lot of place-based knowledge on its production in Sechura Bay. However, their capabilities and financial means to acquire scientific knowledge from the outside or to build scientific knowledge about the production process in the bay are far more limited. Larger producers have the possibility to employ marine biologists, who have top edge scientific knowledge and who can systematically optimize the production conditions and harvest decisions through scientifically monitoring environmental conditions and scallop growth (observation of the first author). Since larger firms also work with SSF, they have access to both knowledge systems.

The huge *uncertainties due to the natural conditions* lead to high fluctuations in returns from year to year, ranging from years with extremely high profits to years of high losses. For example, El Niño events, occurring in the area every couple of years, affect immensely the production and require quick adaptation. As the world scallop production for export markets only takes places in few locations of the world, the variability in the production of one place leads to huge variability in prices in other places. Those price changes are not necessarily linked to the current production process in Sechura. Both aspects lead to high risks of production, which are extremely difficult to handle for SSF, who do not have access to insurance or credit markets. The larger producers can cope with a year of losses, can wait for a good year to come and can even profit from taking over production capacities for a good price, from those, who went bankrupt (7, 12).

Most of those natural materialities have largely influenced the governance in the market sphere. Contracts have been altered so that an ever-growing part of the production process has been taken over by larger producers. Particularly the materiality of El Niño events, which let to plummeted incomes, has shaped the contracts governing the businesses (12).

Hybrid materialities

Scallops have *high hygienic requirements*, particularly if one wants to operate on the export market. This requires a lot of knowledge and investments for building the supply chain, which is obviously asymmetrically distributed. Ever since the opening of Sechura Bay's culture areas to international (mainly European, i.e. 77.1% of all exports in 2018; PRODUCE, 2019a) markets, respectively, imposed sanitary requirements are a constant concern of producers, shaping different governance outcomes. Those producing in suspended culture (i.e. larger producers) have an advantage on that matter because water conditions are typically better in the water column than on the sea bottom. Additionally with their closed production cycle (i.e. incorporating all steps from hatchery to harvest), sanitary standards are easier controllable. However, larger producers receive, process and then export SSF's harvest, and therefore need to also account for the conditions of SSF's production, especially if they are the ones exporting (7). This is particularly demanding as sanitary conditions within Sechura Bay are much more exposed to external influences (e.g. pollution through river run-off) than suspended cultures, since the latter are typically positioned further away from shore (i.e. in deeper waters). Once harvested, the *product needs to be processed* (cleaned, shucked and frozen) *quickly*, i.e. within a timeframe of 24 h. This creates a crucial bottleneck in the actor controlling the processing plants (i.e. the larger producers) who has a strategic advantage over SSFs being disproportionally dependent from this step. This has shaped the institutions in their favour. For example, the rules and procedures, when a particular plot is harvested, are determined by the processors (9). This asymmetry becomes even more apparent when considering that these larger actors also control the export to international markets, which provides them with price setting power. This leads to human-made interdependencies. Certain institutional structures lead to distinct elbow rooms for different actors, which yet again shape other institutional solutions, following an interdependent path. Relatedly, the fact that *supply chains for foreign market require big production units* (13) has additionally favoured those larger producers controlling scallop processing and the export.

Anthropogenic climate change and *environmental pollution* stemming from river runoffs creates the risk to experience harmful algae blooms and then oxygen depletion within the bay. Particularly in the summer season (January–March), when temperatures increase and oxygen declines in the natural environment, scallop die-offs occur frequently on different spatial scales (Badjeck et al., 2009). This materiality led to path dependencies in the institutional development, i.e. the creation of a patron-client system (12). Overall, those producing scallops in suspended cultures are less prone to experience such environmental disturbance due to the better environmental conditions in the water column but also due to their higher financial capital and the controlling role in the processing chain, allowing quick responses in case of a disturbance. For small-scale producers, a single disturbance event, e.g. an algae bloom causing the loss of a year's harvest, has more devastating implications. Though in many bigger businesses savings for compensating bad harvests are common practice, this has as yet to be incorporated into the routines of SSF. More important than routines is that small-scale producers simply have lower financial means to cope with such an event, creating dependencies. However, some means to finance scallop bottom cultures emerged over time, also to cope with potential losses: SSF organization members may organize to each bring in a given share for the biggest initial investment (for scallop seed), while others acquire a loan from a bank or a private investor (who are private persons or larger producers from within the aquaculture sector). The latter may only provide the credit and be paid back with interests or attach certain conditions to it: pre-arranged contracts (Span. *Convenios*) are common, in which the share of profits after harvest is specified (30:70, 40:60, 50:50).

The *high costs to produce seeds in hatcheries* have shaped different dependencies. On the one hand, it forced SSF to continue extracting scallop seed from the natural banks – at the cost of the environment and their own health (as described above). On the other hand, this facilitated larger, financially powerful producers to gain exclusive access to markets of certified seafood, since these certifications typically require hatchery-produced seed. Still, small-scale producer's output is (illegally) incorporated into these lucrative value chain, a fact that has facilitated power accumulation on the side of larger actors (15).

Human-made materialities

The fluidity between open-access (scallop) fishery and mariculture has shaped the way bottom culture is conducted in Sechura Bay until today: *compressor diving* is still the main way SSF collect scallop seed on natural banks, and monitor and harvest their product within own (bottom) culture concessions. Those who cannot – or do not dare to – dive, will not be able to control this step of the production chain. While associated with considerable health risks, divers are part of the social culture, of the social reproduction of the community. As such, compressor diving is indivisibly linked to the discourse of small-scale producers, to Peruvian scallop mariculture being an artisanal activity providing economic opportunity to the poor. This discourse is progressively being diluted by the recent changes in Peruvian aquaculture legislation aiming to regulate the activity through the institution of (medium- or large-scaled) firms, rather than SSF. However, it is constantly used by SSF to oppose exactly that development of power accumulation by (larger) firms. Here, it is also important to consider that suspended culture does not necessarily depend on diving, favouring larger producers in the sense that even though suspended culture is generally labour (and technology) intensive, it is less risky for its workers – a fact that creates a 'cleaner' image for critical (international) consumers. This discourse is also being promoted by the discussion on prohibited scallop seed extraction on the island ILT – criminalizing SSF for an activity that they believe is simply their right. Nevertheless, also larger producers receive scallop seed collected by SSF (while diving) in the wild, creating and shaping important inter- and goal-dependencies of both actors.

Two human-made materialities have created path dependencies in the favour of larger producers: The high *technological/machinery* associated with suspended culture requires high investments for producers that SSF largely have no access to. This is particularly important, as materials needed for suspended culture are not produced within Peru, but have to be imported (Mendo & Quevado, 2020), creating additional constraints. In addition, the *high demand for scallops from rich distant markets* and the requirements needed to ship the harvested product to those consumers (e.g. continuous cooling chain, transparency of product's origin) have favoured those in control of processing plants to establish a constant, reliable avenue for scallops as an important export commodity.

Discussion and conclusions

This paper focused on the materialities of the scallop production process in Sechura Bay shaping contrasting but also intertwined goals of the two main actor groups involved and creating different path dependencies in the emerging governance processes and outcomes. As such, we realized the utility of combining the view on natural, hybrid and human-made materialities for disentangling the different dependencies. We have argued that the combination of exigent natural (high environmental variability requiring quick responses), hybrid (high sanitary requirements of the scallops) and human-made (export-oriented production) materialities have rather favoured the intentions and goals of the larger producers than those of the SSF. Goals are necessarily human-made. From our analysis, it becomes apparent, that goal dependencies have largely influenced the institutional structure of the scallop production for our study case. The demands of the European Union (and international markets in general), i.e. the (sustainability) certifiers in conjunction with the European consumer, for which the entire business of Sechura Bay is basically operating, has a clear understanding and is rather exigent on what a healthy product would be. Those goals shaped the rules. As a side effect, they exclude small-scale farmers, operating in the bottom culture. This was accompanied with a discourse of a less transparent and reliable production line when compared to suspended culture, again favouring big producers. Both also shaped substantially the rules in relation to traceability of the product, especially the seed. Particularly the de facto rules in relation to traceability are indeed a bread between societal goals and material structures. The latter sets clear limits to traceability, opening up substantial loopholes for both actors involved.

The natural risks associated with scallop bottom culture have enabled financially powerful agents to gradually take over the control of the sector in Sechura Bay, with the former cooperative owners becoming piece wage labourers. Though according to the first aquaculture law (2001, *cf.* section 2), only small-scale fisher organizations were allowed to conduct scallop bottom culture (sea ranching) within the bay. This formally institutionalized cooperative ownership created a human-made material path dependency: Ownership of concessions by financially more potent actors could only emerge via informal pathways. Financially powerful actors wanting to conduct (cheaper) scallop bottom culture could (i) control SSF organizations and their scallop production by bribing the respective leaders to expel unwanted members or to replace the entire membership by dummies (12), (ii) rent a concession area (illegally) for a particular time (typically 1–2 years) (4) or (iii) buying such a concession (which is also illegal) (Schlüter et al., 2021). These types of tunnelling, as a well-known form of privatization or ownership change in the former communist states, took place, which allowed potent owners, to informally take over the control about the valuable concessions. With the new law (2015, *cf.* section 2) altering the nature of concessions within Sechura Bay (from that of concessions for bottom culture owned by SSF to that of concessions owned by medium and larger firms), many informants have argued that this will allow for an even further power accumulation of larger producers (5, 7, 12, 16).

In the intertwined realities of SSF and larger firms, the use of materialities in one's favour – and adoption of formality – is only realized up to the point at which it is favourable to the respective actor. Coming back to the extraction of the resource, scallop seed as the main input for mariculture in Sechura Bay, being a largely informal or even illegal process. Larger producers have used this fact as an argument for the reproduction of their own image as clean, reliable producers, even though these illegally extracted scallops often end up in their own formalized, certified scallop production lines (15); larger firms clearly benefit from lower costs associated and the transfer of (health) risk to SSF. That way, both actors have shaped a hybrid institutional system in which the first production step is allowed to remain informal. And although one may think that this informality may also be a way of maintaining a bit of independence from dependence (with SSF controlling, in a way, the first production step), the informality lays on the side of small-scale fishers. Moreover, the informal way of extracting seeds is (potentially) damaging the environment (i.e. reducing scallop stocks, altering biodiversity and thus ecosystem functioning), by not being monitored or managed. In the long durée, the practice might be to the cost of the small-scale producers themselves. This is so because SSF do not have the necessary capital to build hatcheries in case scallops were to be extinct in the natural environment. And thus, the externalities of the extraction are put on the side of the poor, while reducing the purchasing prices for both the bigger on-site producers and the final consumer in Europe or elsewhere.

It remains an open question if under the present material conditions, it would have been possible to reach an outcome that favours more SSF. Likely only with strong governance, supportive for small-scale holders, path dependencies and the effects of materialities could have been reshaped. Governance structures, like insurance or credit schemes for SSF, could have helped them to cope with the existing materialities. Another way to support small-scale holders could have been the construction of communal hatcheries (something also requested by Mendo & Quevado, 2020). This would have decreased input prices and thereby reducing the dependency of SSF on natural sources of seed. Additionally, this would have improved the image of small-scale producers and reduced health risks (due to avoiding deep dives), but also available (dangerous) jobs. These thoughts remain speculative, of course, as the counterfactual is missing for this context-specific process of institutional change. Also, the evaluation of whether the observed outcome – or the one just theorized about – would be more or less desirable, positive or negative for the different actors will necessarily depend on societal and governance preferences and discourses.

We have argued that from a social science perspective, those material conditions, might they be naturally given or human-made, are often forgotten. From this perspective, it is well justified to put a particular focus on those materialities in this contribution. However, not only with a social scientist's eye, one realizes that such an approach takes another blind eye on social non-material aspects shaping the process (Epstein et al., 2015). These could be many things, ranging from discourses, institutional or social structures that at the end create power asymmetries enabling or limiting the intention of one or the other actor group (Van Assche et al., 2014). For example, the global discourse on equity, conservation and in particular around community based territorial use rights for fishers have largely helped small-scale fishers to establish in the first aquaculture law of 2001 that only SSF could get the right for a concession to conduct sea ranching (bottom culture) at the sea floor. Through a subsequent marine spatial planning process, only this type of concession was granted within

Sechura Bay, while big producers have been locked out. Later, the discourse on formalization required for professional economic development has largely fostered the locking out of fisher organizations who had mainly due to limited capabilities difficulties to formalize their prior semi-informal business.

In the end, it seems extremely important to consider natural, hybrid and human-made materialities for understanding the evolution of governance in such a case as Sechura. But of course, central social processes shaping the views and practices of involved actors are not to be neglected.

Notes

1. Available at http://www2.produce.gob.pe/RepositorioAPS/1/jer/PROPESCA_OTRO/marco-legal/1.2.%20Ley%20Acuacultura%20l27460.pdf
2. Available at http://www2.produce.gob.pe/RepositorioAPS/3/jer/VUANORMA/D.S.%20N%C2%BA%20030-2001-PESQUERIA.pdf
3. Available at http://www2.produce.gob.pe/dispositivos/publicaciones/2006/abril/rm102-2006-produce.pdf
4. Available at http://www2.produce.gob.pe/dispositivos/publicaciones/2006/agosto/rm204-2006-produce.pdf
5. Available at http://extwprlegs1.fao.org/docs/pdf/per67134.pdf
6. Available at http://www2.produce.gob.pe/dispositivos/publicaciones/2009/mayo/ds016-2009-produce-reglamento.pdf
7. Available at http://www.sanipes.gob.pe/archivos/biblioteca/N_8_DL_1195_Ley_General_de_Acuicultura.pdf
8. Available at https://busquedas.elperuano.pe/normaslegales/aprueban-el-reglamento-de-la-ley-general-de-acuicultura-apr-decreto-supremo-n-003-2016-produce-1360384-1/
9. Available at https://cdn.www.gob.pe/uploads/document/file/134909/79191_1.pdf
10. Available at https://cdn.www.gob.pe/uploads/document/file/310259/Resoluci%C3%B3n_Ministerial_N__157-2019-PRODUCE20190425-8900-1p7z9mz.pdf
11. Available at https://cdn.www.gob.pe/uploads/document/file/510723/421173188826657220320200204-11250-12f9m2c.pdf
12. Available at http://www2.produce.gob.pe/portal/portal/apsportalproduce/dispositivoslegalespopup?id = 8516&codigo = 10

Acknowledgements

All authors would like to express their deepest gratitude to all people who have taken their time to talk with us in relation to this research.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This manuscript was prepared as part of the bilateral project 'Social-Ecological Tipping Points of the Northern Humboldt Current Upwelling System, Economic Repercussions and Governance Strategies' (Humboldt Tipping, https://humboldt-tipping.org/) funded by the Federal Ministry of Education and Research (BMBF) [grant number 01LC1823D], [grant number 01LC1823E]. The base funding of Leibniz Centre for Tropical Marine Research (ZMT) and Kiel University (Christian-Albrechts Universität zu Kiel, CAU), therewith the German tax payer, is gratefully acknowledged. This was also supported by Bundesministerium fur Bildung und Forschung.

Notes on contributors

Lotta Kluger Since January 2021, Lotta C. Kluger leads the research theme 'Marine Food Security' at the Center for Ocean and Society. After studying biology, Lotta C. Kluger complemented her profile with an interdisciplinary master's degree in tropical marine ecology (MSc International Studies in Tropical Marine Ecology) at the University of Bremen. In 2016, she completed her doctorate at the Leibniz Centre for Tropical Marine Research (ZMT) Bremen and University of Bremen working on the social-ecological sustainability of aquaculture, taking as a case study the Peruvian bay scallop. This was followed by several years of postdoctoral research at the ZMT and the artec Sustainability Research Center (University of Bremen), where she expanded her research on understanding social-ecological dynamics of marine food production (small-scale fisheries,

aquaculture). Since 2010, Lotta C. Kluger has carried out field research in Brazil, Ecuador, Peru, Colombia, and Panama, and she further collaborates on projects in Indonesia, Ghana, and Mexico.

Achim Schlüter Achim Schlüter is an institutional economist focussing on institutional change in the marine environment. He is particularly interested in issues about the blue economy and changes in property rights to marine resources. As he is working at the Leibniz Centre for Tropical Marine Research (ZMT, Bremen Germany) his main focus is on tropical regions. At ZMT he is leading the working group of institutional and behavioural economics and is currently the social science department leader. He holds a professorship of social systems and ecological economics at Jacobs University, Bremen.

María Garteizgogeascoa is an environmental scientist currently writing her PhD in the University of Bremen on the topic of social change, with a special focus on gender, in relation to ocean crisis and mariculture development through a feminist political ecology lens. She is currently working in the German-Peruvian project "Social-Ecological Tipping Points of the Northern Humboldt Current Upwelling System, Economic Repercussions and Governance Strategies" (https://humboldt-tipping.org/en).

Gerardo Damonte Valencia holds a PhD in anthropology from Cornell University. He is a Professor of the Department of Social Sciences at Pontificia Universidad Católica del Perú (PUCP). He is also a Senior Researcher at the Analysis Group for Development (GRADE). Currently he is the Director (PUCP) of trAndeS-Postgraduate Program on Social Inequalities and Sustainable Development in the Andean and has been a visiting professor at the Free University of Berlin and visiting researcher at the Ibero-Amerikanisches Institut. His research addresses socio environmental issues in Latin America, particularly the social dynamics linked to global extractive developments. Gerardo has published his work in several journal articles and book chapters.

ORCID

Lotta Clara Kluger http://orcid.org/0000-0003-1433-4477
Achim Schlüter http://orcid.org/0000-0002-0046-7263
Maria Garteizgogeascoa http://orcid.org/0000-0001-8357-4357
Gerardo Damonte http://orcid.org/0000-0002-0529-2124

References

Arnason, R. (2012). Property rights in fisheries: How much can individual transferable quotas accomplish? *Review of Environmental Economics and Policy*, *6*(2), 217–236. https://doi.org/10.1093/reep/res011

Asche, F., Roheim, C. A., & Smith, M. D. (2016). Trade intervention: Not a silver bullet to address environmental externalities in global aquaculture. *Marine Policy*, *69*, 194–201. https://doi.org/10.1016/j.marpol.2015.06.021

Badjeck, M. C., Mendo, J., Wolff, M., & Lange, H. (2009). Climate variability and the Peruvian scallop fishery: The role of formal institutions in resilience building. *Climatic Change*, *94*(1–2), 211–232. https://doi.org/10.1007/s10584-009-9545-y

Barange, M., Merino, G., Blanchard, J. L., Scholtens, J., Harle, J., Allison, E. H., Allen, J. I., Holt, J., & Jennings, S. (2014). Impacts of climate change on marine ecosystem production in societies dependent on fisheries. *Nature Climate Change*, *4*(3), 211–216. https://doi.org/10.1038/NCLIMATE2119

Bear, C. (2013). Assembling the sea: Materiality, movement and regulatory practices in the cardigan Bay scallop fishery. *Cultural Geographies*, *20*(1), 21–41. https://doi.org/10.1177/1474474012463665

Beunen, R., Van Assche, K., & Duineveld, M. (2015). *Evolutionary governance theory*. Springer International Publishing: Imprint: Springer.

Bivand, R. S., Pebesma, E., & Gomez-Rubio, V.. (2013). *Applied spatial data analysis with R* (2ed.). Springer. https://doi.org/10.1007/978-1-4614-7618-4

Bromley, D. W. (2006). *Sufficient reason: Volitional pragmatism and the meaning of economic institutions.* University Press.

Bromley, D. W. (2016). Rights-based fisheries and contested claims of ownership: Some necessary clarifications. *Marine Policy*, *72*, 231–236. https://doi.org/10.1016/j.marpol.2016.07.002

Brownrigg, R. (2018). Maps: Draw geographical maps. R package version 3.3.0.

Campling, L., & Colas, A. (2021). *Capitalism and the sea: The maritime factor in the making of the modern world*. Verso Books.

Cashion, T., Le Manach, F., Zeller, D., & Pauly, D. (2017). Most fish destined for fishmeal production are food-grade fish. *Fish and Fisheries*, *18*(5), 837–844. https://doi.org/10.1111/faf.12209

Duineveld, M., Van Assche, K., & Beunen, R. (2017). Re-conceptualising political landscapes after the material turn: A typology of material events. *Landscape Research*, *42*(4), 375–384. https://doi.org/10.1080/01426397.2017.1290791

Edwards, P. (2015). Aquaculture environment interactions: Past, present and likely future trends. *Aquaculture*, *447*, 2–14. https://doi.org/10.1016/j.aquaculture.2015.02.001

Epstein, G., Morrison, T. H., Lien, A., Gurney, G. G., Cole, D. H., Delaroche, M., Villamayor Tomas, S., Ban, N., & Cox, M. (2020). Advances in understanding the evolution of institutions in complex social-ecological systems. *Current Opinion in Environmental Sustainability*, *44*, 58–66. https://doi.org/10.1016/j.cosust.2020.06.002

Epstein, G., Pittman, J., Alexander, S. M., Berdej, S., Dyck, T., Kreitmair, U., Rathwell, K. J., Villamayor-Tomas, S., Vogt, J., & Armitage, D. (2015). Institutional fit and the sustainability of social–ecological systems. *Current Opinion in Environmental Sustainability*, *14*, 34–40. https://doi.org/10.1016/j.cosust.2015.03.005

Epstein, G., Vogt, J. M., Mincey, S. K., Cox, M., & Fischer, B. (2013). Missing ecology: Integrating ecological perspectives with the social-ecological system framework. *International Journal of the Commons*, *7*(2), 432–453. https://doi.org/10.18352/ijc.371

Fairbanks, L. (2019). Policy mobilities and the sociomateriality of US offshore aquaculture governance. *Environment and Planning C: Politics and Space*, *37*(5), 849–867. https://doi.org/10.1177/0263774X18809708

Flick, U. (2013). *The SAGE handbook of qualitative data analysis*. Sage.

Food and Agriculture Organization. (2020). *The state of world fisheries and aquaculture 2020*. Sustainability in action. https://doi.org/10.4060/ca9229en

Freeth, R., & Caniglia, G. (2020). Learning to collaborate while collaborating: Advancing interdisciplinary sustainability research. *Sustainability Science*, *15*(1), 247–261. https://doi.org/10.1007/s11625-019-00701-z

Garlock, T., Asche, F., Anderson, J., Bjørndal, T., Kumar, G., Lorenzen, K., Ropicki, A., Smith, M. D., & Ragnar Tveterås, R. (2020). A global blue revolution: Aquaculture growth across regions, species, and countries. *Reviews in Fisheries Science and Aquaculture*, *28*(1), 107–116. https://doi.org/10.1080/23308249.2019.1678111

Garteizgogeascoa, M., Gonzales, I. E., Kluger, L. C., Damonte, G., & Flitner, M. (2020). Institutional context and governance of Peruvian fisheries and aquaculture. Artec paper Nr. 226, ISSN: 1613-4907. https://doi.org/10.26092/elib/557. https://media.suub.uni-bremen.de/handle/elib/4760?locale=de

Gentry, R. R., Froehlich, H. E., Grimm, D., Kareiva, P., Parke, M., Rust, M., Gaines, S. D., & Halpern, B. S. (2017). Mapping the global potential for marine aquaculture. *Nature Ecology and Evolution*, *1*(9), 1317–1324. https://doi.org/10.1038/s41559-017-0257-9

Hagedorn, K. (2008). Particular requirements for institutional analysis in nature-related sectors. *European Review of Agricultural Economics*, *35*(3), 357–384. https://doi.org/10.1093/erae/jbn019

Holmer, M., Argyrou, M., Dalsgaard, T., Danovaro, R., Diaz-Almela, E., Duarte, C. M., Frederiksen, M., Grau, A., Karakassis, I., Marbà, N., Mirto, S., Pérez, M., Pusceddu, A., & Tsapakis, M. (2008). Effects of fish farm waste on *Posidonia oceanica* meadows: Synthesis and provision of monitoring and management tools. *Marine Pollution Bulletin*, *56*(9), 1618–1629. https://doi.org/10.1016/j.marpolbul.2008.05.020

Kluger, L. C. (2013). *First cost benefit analysis of Scallop cultures under present conditions*. SASCA Report – Milestone 1. p. 23. https://mosetip.files.wordpress.com/2020/05/kluger_2013_first-cost-benefit-analysis-of-scallop-culture-in-sechura_sasca_milestone1.pdf

Kluger, L. C., Alff, H., Alfaro-Córdova, E., & Alfaro-Shigueto, J. (2020). On the move: The role of mobility and migration as a coping strategy for small-scale fishers after abrupt environmental disturbances – the empirical example of the coastal El Niño 2017. *Global Environmental Change*, *63*, 102095. https://doi.org/10.1016/j.gloenvcha.2020.102095

Kluger, L. C., & Filgueira, R. (2021). Thinking outside the box: A call to embrace social complexity into aquaculture carrying capacity estimations. *ICES Journal of Marine Science*, *78*(1), 435–442. https://doi.org/10.1093/icesjms/fsaa063

Kluger, L. C., Taylor, M. H., Wolff, M., Stotz, W., & Mendo, J. (2019). From an open-access fishery to a regulated aquaculture business: The case of the most important Latin American bay scallop (*Argopecten purpuratus*). *Reviews in Aquaculture*, *11*(1), 187–203. https://doi.org/10.1111/raq.12234

Knott, C., & Neis, B. (2017). Privatization, financialization and ocean grabbing in New Brunswick herring fisheries and salmon aquaculture. *Marine Policy*, *80*, 10–18. https://doi.org/10.1016/j.marpol.2016.10.022

Kompas, T., & Che, T. N. (2005). Efficiency gains and cost reductions from individual transferable quotas: A stochastic cost frontier for the Australian south east fishery. *Journal of Productivity Analysis*, *23*(3), 285–307. https://doi.org/10.1007/s11123-005-2210-1

Kooiman, J., & Bavinck, M. (2013). Theorizing governability – the interactive governance perspective. In M. Bavinck, R. Chuenpagdee, S. Jentoft, & J. Kooiman (Eds.), *Governability of fisheries and aquaculture* (pp. 9–30). Springer.

Kuckartz, U. (2019). Qualitative text analysis: A systematic approach. In G. Kaiser & N. Presmeg (Eds.), *Compendium for early career researchers in mathematics education*. Springer.

Laínez Del Pozo, D., & Jones, P. J. S. (2021). Governance analysis of two historical MPAs in northern Peru: Isla Lobos de Tierra and Isla Lobos de Afuera. *Marine Policy*, *127*, 104096. https://doi.org/10.1016/j.marpol.2020.104096

López de la Lama, R., de la Puente, S., Sueiro, J. C., & Chan, K. M. A. (2021). Reconnecting with the past and anticipating the future: A review of fisheries-derived cultural ecosystem services in pre-Hispanic Peru. *People and Nature*, *2021*(3), 129–147. https://doi.org/10.1002/pan3.10153

López de la Lama, R., Valdés-Velasquez, A., Huicho, L., Morales, E., & Rivera-Ch, M. (2018). Exploring the building blocks of social capital in the Sechura Bay (Peru): insights from Peruvian scallop (*Argopecten purpuratus*) aquaculture. *Ocean and Coastal Management*, *165*, 235–243. https://doi.org/10.1016/j.ocecoaman.2018.08.030

Majluf, P., de la Puente, S., & Christensen, V. (2017). The little fish that can feed the world. *Fish and Fisheries 18*, 772–777. https://doi.org/10.1111/faf.12206

Mansfield, B. (2004). Neoliberalism in the oceans: "rationalization," property rights, and the commons question. *Geoforum Journal of Physical, Human, and Regional Geosciences*, *35*(3), 313–326. https://doi.org/10.1016/j.geoforum.2003.05.002

Mendo, J. (2015). Diagnostico de la acuicultura marina en la región Piura. Informe final de consultoría. DIREPRO – Dirección Regional de la Producción. Gobierno Regional Piura, 77 pp.

Mendo, J., & Quevado, I. (2020). La cadena de valor de la concha de abanico. Report series: Estudio Prospectivo N°1, Programa Nacional de Innovación en Pesca y Acuicultura – PNIPA, 68 pp. https://www.pnipa.gob.pe/ … /2020/09/cadena-de-valor-de-la-concha-de-abanico-PNIPA.pdf

Mendo, J., Wolff, M., Mendo, T., & Ysla, L. (2016). Scallop fishery and culture in Peru. In S. E. Shumway & J. Parsons (Eds.), *Scallops – biology, ecology, aquaculture, and fisheries* (3rd ed., pp. 1089–1109). Elsevier Science.

Mendo, J., Wolff, W., Carbajal, W., Gonzáles, I., & Badjeck, M. (2008). Manejo y explotacion de los principales bancos naturales de concha de abanico (*Argopecten purpuratus*) en la costa peruana. In A. Lovatelli, A. Farias, & I. Uriarte (Eds.), *Estado actual del cultivo y manejo de moluscos bivalvos y su proyeccion futura: Factores que afectan su sustentabilidad en America latina* (pp. 101–114). *Taller técnico Regional de la FAO. 20-24 de agosto de 2007, Puerto Montt, Chile. FAO actas de Pesca y acuicultura. No. 12.* FAO.

Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., Lubchenco, J., Shumway, S. E., & Troell, M. (2021). A 20-year retrospective review of global aquaculture. *Nature*, *591*(7851), 551–563. https://doi.org/10.1038/s41586-021-03308-6

North, D. C. (1981). *Structure and change in economic history.* Norton.

Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, *104*(39), 15181–15187. https://doi.org/10.1073/pnas.0702288104

Partelow, S., Schlüter, A., Manlosa, A. O., Nagel, B., & Octa Paramita, A. (2021). Governing aquaculture commons. *Reviews in Aquaculture*, *14*, 729–750. https://doi.org/10.1111/raq.12622

Pebesma, E.. (2018). Simple features for R: Standardized support for spatial vector data. *R Journal*, *10*(1), 439–446. http://dx.doi.org/10.32614/RJ-2018-009

Pebesma, E. J., & Bivand, R. S.. (2005). Classes and methods for spatial data in R. *R News*, *5*, 9–13.

PRODUCE – Peruvian Ministry of Production. (2019a). *Anuario estadístico pesquero y acuícola 2018*. Governmental report (p. 200). https://ogeiee.produce.gob.pe/index.php/en/shortcode/oee-documentos-publicaciones/publicaciones-anuales/item/901-anuario-estadistico-pesquero-y-acuicola-2018

PRODUCE – Peruvian Ministry of Production. (2019b). PRODUCE decomisa más de 9 toneladas de conchas de abanico en Piura. Press release. https://www.gob.pe/institucion/produce/noticias/50890-produce-decomisa-mas-de-9-toneladas-de-conchas-de-abanico-en-piura

R Core Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. at: https://www.R-project.org/

Said, A., Tzanopoulos, J., & MacMillan, D. (2016). Bluefin tuna fishery policy in Malta: The plight of artisanal fishermen caught in the capitalist net. *Marine Policy*, *73*, 27–34. https://doi.org/10.1016/j.marpol.2016.07.025

Sanchez, L. (2015). Análisis de la cadena de valor de la concha de abánico en la bahía de Sechura. Thesis, Faculty of Fisheries, Universidad Nacional Agraria La Molina (p. 93). https://repositorio.lamolina.edu.pe/handle/20.500.12996/3273

Schlüter, A. (2001). *Institutioneller wandel und transformation*. Shaker.

Schlüter, A., Bavinck, M., Hadjimichael, M., Partelow, S., Said, A., & Ertör, I. (2020). Broadening the perspective on ocean privatizations: An interdisciplinary social science enquiry. *Ecology and Society*, *25*(3). https://doi.org/10.5751/ES-11772-250320

Schlüter, A., Kluger, L. C., Damonte, G., & Garteizgogeascoa, M. (2021). *From securing rights for small-scale fishers to property for "efficient" producers: the privatisation of scallop production in Sechura Bay, Peru*. http://ssrn.com/abstract=3994780

Schlüter, A., Partelow, S., Torres Guevara, L. E., & Jennerjahn, T. C. (2019). Coastal commons as social-ecological systems. In B. Hudson, J. Rosenbloom, & D. Cole (Eds.), *Handbook of the commons.* (pp. 170–187). Routledge.

Schreier, M. (2012). *Qualitative content analysis in practice*. SAGE.

Van Assche, K., Beunen, R., & Duineveld, M. (2014). *Evolutionary governance theory: An introduction*. Springer.

Van Assche, K., Duineveld, M., Beunen, R., Valentinov, V., & Gruezmacher, M. (in press). Only material dependencies: Hidden underpinnings of sustainability transitions. *Journal of Environmental Policy and Planning.*

Van Assche, K., Hornidge, A.-K., Schlüter, A., & Vaidianu, N. (2020). Governance and the coastal condition: Towards new modes of observation, adaptation and integration. *Marine Policy*, *112*. https://doi.org/10.1016/j.marpol.2019.01.002

VERBI Software. (2019). *MAXQDA 2020 [computer software]*. maxqda.com

Vogt, J. M., Epstein, G. B., Mincey, S. K., Fischer, B. C., & McCord, P. (2015). Putting the "E" in SES: Unpacking the ecology in the Ostrom social-ecological system framework. *Ecology and Society*, *20*. Artn 55. https://doi.org/10.5751/Es-07239-200155

Wolff, M. (1987). Population dynamics of the Peruvian scallop *Argopecten purpuratus* during the El Niño phenomenon of 1983. *Canadian Journal of Fisheries and Aquatic Sciences*, *44*(10), 1684–1691. https://doi.org/10.1139/f87-207

Wolff, M., Taylor, M. H., Mendo, J., & Yamashiro, C. (2007). A catch forecast model for the Peruvian scallop (*Argopecten purpuratus*) based on estimators of spawning stock and settlement rate. *Ecological Modelling*, *209*(2–4), 333–341. https://doi.org/10.1016/j.ecolmodel.2007.07.013