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Stakeholder perceptions of the impacts from salmon aquaculture in the Chilean Patagonia

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ABSTRACT

We review stakeholder perceptions in Chile regarding socioeconomic impacts of salmon aquaculture in the Chilean Patagonia. This is one of the fastest growing industries in Chile that developed with very limited regulation, which has resulted in significant effects on the ecosystem and local communities. After the Infectious Salmon Anemia (ISA) virus struck the industry in 2007, aquaculture companies helped to craft new legislation in an effort to create a sustainable industry. Nevertheless, some of the impacts remain and a new and small outbreak of the ISA virus struck in 2013. During this period, we conducted a series of workshops to evaluate stakeholder concerns regarding the impacts generated by aquaculture. Stakeholders from the government, NGOs, local communities, fishermen and aquaculture companies participated in a series of workshops, where they shared their different views about the impacts of the salmon industry in Chile. The analysis of this information provides an overview of the main issues from salmon aquaculture, a guide for regulators and firms about where negative perceptions exist, and recommendations on how the salmon industry can become more sustainable. We found that *regulatory institutions* and *governance* are the most important concerns of stakeholders to achieve a sustainable aquaculture industry in Chile.

1. Introduction

The United Nations has urgently called upon member nations to restore depleted fish stocks back to levels that enable them to produce maximum sustainable yield no later than 2015 (United Nations, 2002). Marine fish stocks have, however, continued to decline. In 2011, 61.3% of assessed stocks were fully fished and could no longer be harvested at a biologically sustainable level (FAO Fisheries and Aquaculture Department, 2012). However, demand for protein and seafood has continued to increase. Ways need to be found to increase the yield of the oceans while protecting wild stock. The primary method by which this has been pursued over the past several decades has been to expand the aquaculture industry by a variety of marine species ranging from shrimp to Atlantic salmon (Abdallah and Sumaila, 2007; Garcia and Rosenberg, 2010; van Vliet et al., 2010; Islam, 2014).

Aquaculture already accounted for 47 percent of total global food fish supply in 2010, outpacing even human population growth (FAO Fisheries and Aquaculture Department, 2014). The per capita supply of animal protein from aquaculture has also increased, from 0.7 kg in 1970 to 7.8 kg in 2008, reflecting an average annual growth rate of 6.6 percent (Kalikoski et al., 2010). The aquaculture sector is therefore one of the fastest-growing food producing sectors in the world and is likely to be the sector that will contribute the greatest future growth to the global food supply (Cunningham, 2005; Lem et al., 2014). This is important because global human population passed the 7 billion mark in 2012 and is on track to reach 9 billion by 2050 (Garcia and Rosenberg, 2010).

Commercial salmon farming has become a key aquaculture industry. In 1980, wild commercial fisheries produced more than 500,000 tons (99%) of salmon consumed worldwide, but by 2009 demand for salmon increased to over 3 million tons and farmed salmon accounted for 60% of the market demand (Falk-Petersen et al., 2011; Oug et al., 2011).

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The historical and projected increases in demand for aquacultured salmon create a powerful incentive for the salmon aquaculture industry to increase production substantially. The industry, however, has a history of volatility and, according to many, a mixed environmental record. Effective management of the industry will be essential in ensuring that the industry is both profitable and sustainable. Effective management in turn needs both natural science data (such as baseline information for monitoring environmental changes), but input from stakeholders is also important for understanding how the industry impacts human communities and whether regulatory efforts will have the desired impact. Knowing how groups of key stakeholders in a given issue area perceive potential management changes is also essential to understanding how they anticipate and react to change, and in identifying potential conflicts and addressing them before they can undermine management efforts. Mapping perceptions also allows managers to compare stakeholder perceptions to scientific analysis of impacts, allowing them to respond to both stakeholder concerns and scientific evidence. In short, how people perceive the interactions that they have with natural resources, as well as with other stakeholders, has great influence on their behavior. Human behavior in turn impacts the dynamics of natural systems. *Human interaction* is changing natural rhythms, a fact that is observable in the atmosphere, fisheries and in forestry (De Jouvenel, 2000; Ostrom, 2009). Because managing aquaculture is about managing highly complex and interacting human and natural systems, issues of governance are critical.

The following article explores governance issues in the world's second largest producer of aquacultured Atlantic salmon, Chile.[1] It presents and analyses stakeholder perceptions regarding salmon aquaculture in the Chilean Patagonia, based on a series of seven workshops incorporating key stakeholders in April 2013. Three workshops were held in Chile's current and historical center of the aquaculture industry (Puerto Montt in the Los Lagos region); two were in an area of the country where the industry seeks to move (Punta Arenas in the Magallanes region). These workshops included a range of local stakeholders, including the aquaculture industry, other economic sectors seen as directly affected by it (artisanal fishing and tourism) and local experts, activists and community leaders. Two additional workshops engaged governmental managers and other experts on the industry (Santiago and Concepción).

At the workshops, we employed a methodology developed by the South East Queensland Climate Adaptation Research Institute (SEQ-CARI) which combines two participatory modeling techniques (Richards et al., 2013) "systems thinking" (ST) and "Bayesian Belief Network" (BBN). Taken together, the effect of these techniques is the identification at the group and individual level of the factors that a given stakeholder group considers to be most important in how their socio-ecological system (SES) functions. This approach allows exploration of a complex system at the local scale based on the expertise of the stakeholders themselves. Replication of this methodology in a series of workshop with different stakeholder groups creates a series of maps and facilitates comparisons among them.

The article first introduces salmon aquaculture in Chile and then explains the methodology employed in the stakeholder workshops. The article then presents the principal findings of each workshop before offering an analysis of the material. Key findings are that there is notable agreement among Chilean stakeholders on the need to produce better regulations and to enforce them. While many local stakeholders were concerned with how aquaculture already impacts their livelihoods and environment, and were anxious about the future, most imagined solutions ran aground on a cluster of concerns about governance and state capacity. While the industry reports self-improvement, monitoring and reporting, a lack of mutual trust between critics of the industry on the one hand and the industry on the other suggests that it is the state that must exercise these functions, a conclusion supported by the comments made by many stakeholders throughout the workshops. Building trust in both the industry and the government's ability to drive the industry in a sustainable direction – and the trust required for stakeholders to want to engage in what can be long and tedious processes of information exchange, planning and assessing results – will require attention to not just what regulations are made but how they are made. Finally, the workshops together illustrated that in a globalized world, the state remains a critical ingredient in developing sustainable enterprises.

2. Salmon aquaculture in Chile

In the current article, the term *aquaculture* refers to the farming of Atlantic Salmon (*Salmo salar*) within the framework of the production process of placing produced smolts in sea cages for saltwater growing until the fish reaches the size that is suitable for market purposes. Commercial farming of Atlantic Salmon began in Norway, Chile, US, Scotland and Canada in the 1970s (Liu et al., 2011). By 2011, the market demand had grown dramatically to about 1.93 million metric tons (FAO Fisheries and Aquaculture Department, 2014). Though the demand for salmon is high, areas suitable for salmon farming are few. Farm locations require excellent water quality, a regular cold temperature to ensure low mortality and maximum profitability; they also require adequate currents to disperse nutrients and pollutants added to the natural system in order to minimize the environmental impact of the farms. This specialized cluster of requirements explains why most countries do *not* produce farmed salmon and why future growth is likely to come from countries where the industry is already established.

Natural conditions meant that Chile had the potential to become a major producer of salmon; government policy promoted and fostered its development and growth. The industry was originally one of a group of non-traditional exports promoted by the government in the late 1970s in order to diversify the economy; it was one of the few activities that were intended to promote economic development in the southern part of the country. The industry first developed in the region of Los Lagos, where the city of Puerto Montt and Chiloé Island are located, and it grew rapidly there between roughly 1980 and 2007. By 2005, production was only a few thousand metric tons shy of Norwegian production which at that time led the world (Asche et al., 2009). In 2007, however, the industry was struck by an outbreak of infectious salmon anemia (ISA), which resulted in the loss of 20,000 jobs and reported to range from 34 million to 3 billion USD between 2008 and 2011. One company alone reported losses of around 15 million USD (Battista et al., 2012; Bustos-Gallardo, 2013).

The salmon aquaculture industry has since rebounded, in part by expanding production into new areas with a lower risk of disease. By 2009, the industry was the fourth largest contributor to the Chilean economy, with farmed salmonoid accounting for over 73% of aquaculture production (Buschmann et al., 2009). In the first three months of 2014, farmed Atlantic salmon was still the most

[1] This research was carried out as a part of a Norwegian Research Council (NRC) funded project known as CINTERA (A Cross-disciplinary Integrated Eco-systemic Eutrophication Research and Management Approach) (NRC Project 216607). The goal of that project is to improve knowledge of knowledge of ecosystem response to eutrophication and management of eutrophication in different marine fjord systems in Chile and Norway.

exported farmed marine species from Chile, having increased by over 20% in terms of quantity to the same period in 2013 (Globefish.org 2014).

The rejuvenated industry has been moving to the Aysén region (to the immediate south of Los Lagos) and finally started its flight towards the fjord ecosystem of the Magallanes region of the far south. These areas are suitable for industry growth because they satisfy the environmental requirements for raising salmon and they are relatively pristine, offering an almost pollution-free environment. In terms of socio-economic conditions, however, the picture is more mixed. These areas are sparsely populated. They have only small, isolated communities and the lowest population density in the country. Aysén and Magallanes region have only 0.9 and 1.2 pop/km^2, compared to the national average of 22 pop/km^2 and the capital city of Santiago with 434 pop/km^2. Although this means that pollution from land sources will be less of a problem, it also means a lack of infrastructure and workers, which in turn suggests the further development of the area. In addition, as our workshops suggested, the location of facilities in such a distant region may also complicate the monitoring and enforcement of regulations. While the low population level suggests that locating aquaculture facilities in this area might occasion few conflicts with existing user groups, it is important to note that both Aysén and Magallanes are home to significant artisanal fisheries that land seaweed, shellfish and fish (Gallardo Fernandez, 2008: table 4.6). Tourism is a relatively small but still significant sector in both the Los Lagos and Magallanes regions and is a direct competitor for use of ocean resources in both places.

The ISA crisis resulted in the creation of new regulatory measures by Chilean authorities and that were subsequently adopted by the Chilean industry. These include important regulations concerning the permitted densities of fish in the farms, the coordination of nearby companies in "neighbourhoods" and the implementation of monitoring processes. Furthermore, the issuance of permits has been frozen in the Magallanes area until the operation of the industry can be shown to be more environmentally sustainable. However, disagreements still exist as to the legitimacy of these new regulations and whether they will be effective in achieving sustainability (Aquaculture Management and Conservation Service, 2009; Bustos, 2010; Gelcich et al., 2010).

With the memory of the 2008 collapse of salmon production still fresh, the recent launching of new regulations, the reinvigoration of industry, and the persistence of doubts about the sustainability of the industry, the spring of 2013 was a propitious time to examine stakeholder's views as to how sustainability can be achieved. The good timing of this work was underscored by another, minor, outbreak of ISA just as the first workshop was being organized.

3. Methodology

This project required that researchers get an in-depth understanding of how local stakeholders in key communities viewed their SES and what they understood to be the factors needed to build a sustainable industry. Participatory workshops have become a broadly accepted way for researchers and others to engage with local stakeholders and solicit their input. Such workshops are used particularly in search of sustainable practices in a wide variety of issue areas, and the practice is growing in Chile as well (Ostrom, 2009a,b; Schumann, 2010; O'Ryan and Pereira, 2015).

A total of seven participatory workshops were held for stakeholders around Chile during April 2013. Three workshops involved groups of stakeholders local to the area that has been the center of the aquaculture industry since its beginning (Puerto Montt, Los Lagos). The marine areas around Puerto Montt have been thickly populated by aquaculture facilities and the city and region experienced both the "boom" of the industry in the 1980s and 1990s and the effects of its "bust" as a result of the 2007 ISA virus crisis. Two workshops were held in Punta Arenas, in the Magallanes Region, a mostly pristine area into which the salmon aquaculture industry is now attempting to move in the search for clean and healthy waters. Workshops were held in central locations in Puerto Montt and Punta Arenas in order to make these as easy to attend as possible.

Researchers identified specific stakeholder groups and the workshop team actively recruited participants from each group. Groups in Puerto Montt and Punta Arenas were selected because of their direct involvement in the salmon aquaculture industry or because their livelihoods or communities were (or are will likely be) directly impacted by it. Local stakeholder groups targeted for invitations included owners, managers and workers in the aquaculture industry, artisanal fishermen and their representatives, representatives of the tourist industry and representatives from the local community and regional government. Researchers from the Universidad de Concepción, which is affiliated with Chile's Interdisciplinary Center for Aquaculture Research (INCAR), advertised widely among the relevant communities for participants for the workshop, and directly contacted the many industry and local leaders they have worked with over the years to spread the word and find participants. In Punta Arenas, a local TV channel ran an interview with our primary Chilean investigator (Salgado); it advertised the event, invited participants and underscored the issues at stake (if a bit dramatically). In all cases, it was made clear that the meeting with the community was open to all who wanted to attend and no one was refused admittance.

The workshops were, however, organized along group or economic sector lines to the extent possible so that we could identify as clearly as possible the concerns of that sector or group. We actively channelled those interested who expressed an interest in attending the workshops to the most relevant workshop. For example, in Puerto Montt, we held one workshop for artisanal fishermen and a separate workshop for those associated with the aquaculture industry. While this strategy for the most part worked, some workshops were more mixed than others and the workshop for the industry ended up with a vocal representative of groups in opposition to the industry. We found, however, that this mixture of participants did not have the effect of derailing or destroying the discussion. Instead, particularly in the latter case, the ensuing confrontation helped draw out participants in the dominant group and stimulate discussion. In this context, the neutrality and conciliatory attitude of the workshop facilitator (Salgado) emerged as the critical factor ensuring the success of the workshop: participants stayed for both sessions and participated in a constructive way. Whether the results would have been substantially different without these few incongruous participants is of course difficult to say. Table 1 presents a detail of the type and number of stakeholders that participated in each workshop and Fig. 1 shows a map of Chile with the different locations where the workshops were hold.

In order to compare the views of local stakeholders with those of government representatives as well as academic experts, researchers also held workshops targeting their views. A workshop was held for Chilean natural and social scientists with direct knowledge of the industry (here called "Chilean experts") in order to tap their assessments as to where potential problems areas with respect to aquaculture lie. The Chilean experts' workshop was held at Universidad de Concepción, in Concepción, Chile and drew upon a wide variety of experts associated with INCAR. A workshop was held in Santiago for government officials charged with regulating the industry. This workshop also drew upon and environmental groups that have worked on the issue of salmon farming. These

Table 1
Type and number of participants in each workshop.

	Workshop location	Key stakeholder groups represented	Number of participants	Notes
1.	Santiago	Governmental managers: (SERNAPESCA[a], SUBPESCA[b]); consultants, Environmental NGO.	8	Some last minute cancellations because of reports of new outbreak of ISA
2.	Concepción	Chilean Experts: Academics associated with Interdisciplinary Center for Aquaculture Research (INCAR), which includes biologist, oceanographers, environmental economists, aquaculture engineers, sociologists and political scientists)	8	
3.	Puerto Montt 1st workshop	Artisanal fishermen: Union representatives, fishermen, consultants to artisanal fishermen	7–11	The session started with 7 participants but others arrived after the session began.
4.	Puerto Montt 2nd workshop	Industry and critics: Aquaculture industry representative, service providers to the aquaculture industry, one opposition/environmental NGO, university experts and interested advanced students	8–9	
5.	Puerto Montt 3rd workshop	Tourism and Community Tourism and community: representatives from tourist industry, community activists and representatives, artisanal fishermen's union representative	12–15	The number fluctuated; 15 were present before break, 12 afterwards
6.	Punta Arenas 1st workshop	Artisanal Fishermenfishermen (two unions)	4	Many confirmed participation but few showed up. However, those who did attend were well connected and highly informed. Two unions were represented
7.	Punta Arenas 2nd workshop	Local Tourism and community: NGOs, community representatives, tourist industry representatives, academic experts	7–12	7 began the workshop but more arrived during the ST phase (before the break)

[a] Servicio Nacional de Pesca y Acuicultura.
[b] Subsecretaría de Pesca y Acuicultura.

groups were combined because of resource constraints.

In running the workshops, we used a combination of two participatory modeling techniques to access and capture stakeholders' knowledge and perceptions, and to test the consistency, value and validity of this information: **System Thinking (ST)** (Forrester, 1968; Checkland, 1981; Senge, 1990; Sterman, 2000) and

Fig. 1. Map of Chile with location of stakeholder workshops.

Bayesian Belief Networks (BBN) (Charniak, 1991; Varis and Kuikka, 1997; Kjaerulff and Madsen, 2008). Although these two techniques have been individually used for a long time, combining them to build stakeholder-driven scenarios was first done in the context of climate change and adaptation strategies by the South East Queensland Climate Adaptation Research Initiative (SEQ-CARI) (Richards et al., 2013). The use of this methodology has grown rapidly and other applications include studies on the impact of jellyfish on coastal fishermen, offshore aquaculture in California, and migration effects in local communities (Tiller et al., 2012; Tiller, Richards et al., 2014; Tiller, Mork et al., 2014; Tiller et al., 2015).[2]

The method is based on the identification of stakeholder-driven scenarios using two consecutive stakeholder workshop sessions. In the first session, the ST technique is used to generate a discussion among stakeholders that allows them to identify key variables, relationships and priorities of the group with regard to a main research question being asked by the facilitator. The discussion takes approximately sixty to ninety minutes, allows the stakeholders to generate common knowledge, and lays the foundation for the second session. This first session begins with the posing of a question and the introduction of a number of pre-determined "drivers" (factors that may impact the system without being impacted by the system). The drivers are written out at the top of a whiteboard (or electronic medium projected on a screen), and the workshop facilitator then asks the participants to discuss each driver individually. Participants are free to focus on the drivers or to introduce other elements they feel impact their SES. This ensuing discussion yields "determinants" that participants believe affect their SES, which the facilitator then adds to the white board. The facilitator then draws lines indicating the connections among these as well as to the original drivers. This exercise yields a complex pictorial representation of the group's shared conceptual model of how their SES works.

In our workshops, participants were asked how the salmon aquaculture industry has impacted in their area and what would be

[2] To build the system-thinking map, a board and sticky-notes were employed while this was immediately transcribed to a computer using the VENSIM software. The BBNs were built and analyzed using the NETICA 5.12 software. Both are available on-line and are free for academic use.

required for a sustainable industry. Eight drivers, chosen earlier by an experts' workshop held in Trondheim, Norway, as a part of the larger CINTERA project, were presented to stakeholders as the starting point for the discussion. These were: 1) Net construction; 2) Production waste (nets, actual trash, lost buoys, etc.); 3) Coastal area taken up by aquaculture industry; 4) Jobs created/lost; 5) Animal welfare (focusing on salmon, escapees, diseases, etc.); 6) Feed waste (including excess feed and feces); 7) Maritime traffic; and 8) Use of chemicals and antibiotics. Interestingly, the topic of fish feed only came up with respect to issues of eutrophication[3] and pollution and not as a sustainability issue in its own right. While the production of adequate amounts and quality of feed for carnivorous salmon is indeed a central issue to the industry as a whole, the CINTERA workshops focused in particular on local issues, perhaps explaining the absence of this topic. In our workshops, these discussions generated what the stakeholders believed to be important determinants as to whether and how aquaculture affects socio-economic sustainability in the Chilean Patagonia.

While this session was underway, the workshop team worked simultaneously to enter the variables mentioned into a free download version of Vensim® which creates an enduring graphic representation of the map charted out on the whiteboard and provides an easily accessible display of the links among them. This can be useful because the ST session can produce a whiteboard map that is very untidy and highly complex map, leading some pioneer users to call these "horrendograms". Both the whiteboard and Vensim versions are useful in providing visual cues as to which factors the discussion revealed the group held to be most central. Such visual cues are useful for both the participants and facilitator in the next phase of the workshop. In these workshops, however, the facilitator did not need to call upon the Vensim version of the whiteboard because the connections were clear. The Vensim program here provided a check on the whiteboard version and a way of recording the results that can be easily accessed and used in the future. In addition, the discussions that took place during the ST session were recorded. These provide a "narrative" which serves as a further check on the records produced during the meeting and also serve as a rich source of information beyond the words and phrases recorded on the whiteboard or in Vensim. Here is information not just about what factors were identified as critical but why: Participants explained the rationale behind their views and the actions of their group.

After a short break a second session is held in which one priority issue is analyzed to build a Bayesian Belief Network. The priority issue is chosen by the stakeholder group interacting with the facilitator; as noted both draw upon the preceding ST discussion. This BBN consists of a series of causal relationships and binary scenarios for a number of important variables related to the main scenario being analyzed. In building this network a backward procedure is followed. Each group is first asked to identify the priority issue based on a list of problems identified in the ST discussion and the conceptual map developed from that session, which was presented to them during the break.

Then two scenarios, one desirable and its opposite, are identified for this problem. For example, in one of the workshops the main issue was the "effects of aquaculture activities on the resources being used by artisanal fishermen". In this case the two scenarios were "large impacts" and "small impacts". Once these two scenarios are defined by the group, the three most important determinants of this scenario are identified. These are defined as the variables that will have the most important effect on flipping the main scenario between one of the two possible states previously defined. Once again, two possible states are identified for these three determinants by the group of stakeholders. The procedure is then repeated for each one of the second-level nodes and a third level of determinants is built. The results of this session are entered into Netica software, which produces a computer-generated graphic display of the BBN tree of the type illustrated in Fig. 2.

Once the BBN tree has been constructed, a combination of conditional scenarios is conducted for each one of the four bases nodes (the main issue and the three first-level determinants). For this, the combination of the scenarios of determinants is used to build four conditional probability tables (CPTs). The tables are generated automatically by an excel spreadsheet. In each one of these tables, stakeholders are asked to state how likely they think it is that scenario A will happen, conditional on the combination of scenarios given for its three main determinants (parent nodes). A similar CPT is constructed for nodes Determinant 1, Determinant 2 and Determinant 3. By assigning probability to outcome, stakeholders prioritize the importance of their selected key factors, allowing researchers to identify what each individual believes to be the key determinant factor. Notice that as these probabilities are conditionals on the scenarios, there is no correlation between them. In that way, a stakeholder could consider a high probability of a second-level scenario and conditional on that, a lower probability of the first-level scenario. For example, as it happens in some of the workshops, even when the Determinants 1, 2 and 3 could have a high probability of a positive scenario, the stakeholders could still consider that the Main Problem's positive scenario has a low probability of occurrence (Table 2).

The same team ran all of the workshops, and the same facilitator led all of the discussions. This enhanced the comparability of the workshops and reduced the chance that facilitator style and attitude would be a factor in generating different results in the workshops. Filling out the CPTs is the most difficult part of the workshop, and participants often require further assistance in completing them. The facilitator was in all cases present for this part of the workshop and answered questions as they came up.

The results we obtain are conditional on a number of things whose effects we cannot anticipate. For this reason, we cannot ensure that all the results are robust to changes in those conditions and the external validity of the results cannot be completely ensured as in any non-representative sampling method. One of the most important elements that condition the results is who participates in the workshop. Nevertheless, the methods employed are designed to avoid that one or a few participants to manipulate the results. For example, all participants are invited and asked to publicly express their opinion during the ST session and to reach agreements about the most important scenario and the structure of the BBN. But after that, stakeholders are required to individually respond about their beliefs of the different scenarios. In this part, research assistants help them understand and answer the question and they are expressly instructed to not influence the responses. Stakeholders are also asked not to talk during this part to avoid influencing each other. Therefore, we could anticipate that the average perception of probabilities might be more sensible to a change in the number of participants, particularly when this number is small. Nevertheless, some results, such as the issues identified as important in several workshops, are much more robust. For this reason, the selection of stakeholders is crucial because it is important that they are informed and represent the

[3] Eutrophication is the continuous addition of excessive and inorganic nutrients to water bodies which can cause high phytoplankton growth beyond the natural level, thus accumulating biomass, increasing bacteria respiration and then lowering dissolved oxygen through the water column. It is one of several issues that can arise where aquaculture (fish and mussel farms) is carried out but it can have a mixture of causes, such as upwelling from deep waters and drainage into the ocean from a variety of sources across river basins.

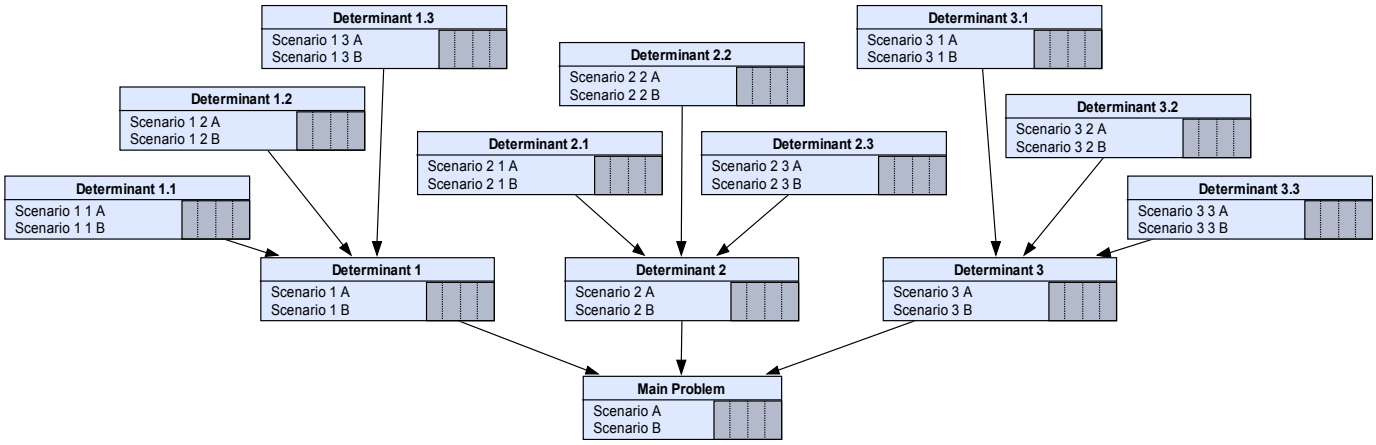

Fig. 2. Structure of the BBN used in stakeholder workshops.

Table 2
Conditional Probability Table, depicting how the different scenarios are illustrated to the stakeholder. The individual stakeholder then assigns a 0–100% probability in the fourth column for that given scenario is likely to happen. Scenario B, which is the opposite, it is assigned the remaining probability.

Determinant 1	Determinant 2	Determinant 3	Probability of Scenario A
Scenario 1A	Scenario 2A	Scenario 3A	
Scenario 1A	Scenario 2A	Scenario 3B	
Scenario 1A	Scenario 2B	Scenario 3A	
Scenario 1A	Scenario 2B	Scenario 3B	
Scenario 1B	Scenario 2A	Scenario 3A	
Scenario 1B	Scenario 2A	Scenario 3B	
Scenario 1B	Scenario 2B	Scenario 3A	
Scenario 1B	Scenario 2B	Scenario 3B	

views of a given group. They therefore need to have some kind of leadership position among the sector they represent. We consider that this was accomplished in every workshop even those with a limited number of participants.

4. Results

The workshop discussions were as a rule lively and wide-ranging. As a rule the discussions began slowly but as the sessions continued, participants engaged more willingly. While strong feelings were expressed, at no time did discussions take on an unproductive, destructive character. The systemic drivers selected beforehand did serve to start the conversation, but participants were clearly not bound by them. Participants in all cases considered the original drivers, but ranged far beyond these to pull out factors they felt to be important. The facilitator encouraged participants to nominate their own suggestions as to what might produce a sustainable aquaculture industry in Chile. The discussions covered environmental, socio-economic and political factors.

The results presented here focus on the BBNs generated by the seven workshops and the probabilities stated by each participant. It is in this phase of the workshop that stakeholders are compelled to choose the factors or determinants they feel will be most decisive in creating a sustainable aquaculture industry. The BBN process, then, yields results that allow for the clearest comparisons among groups. However, the key points of the workshop discussions are also presented in summary form in order to provide an understanding of the discussions that ultimately led to the selection of these priority issues. In addition these summaries also provide a snapshot of the world view of the participants in April 2013.

In this section we divide the presentation of the results in two parts. The first subsection presents general results related to what issues arose during the workshops, the most important issue chosen by each stakeholder group and how they relate to each other; these show some interesting trends. In a second subsection, we present more detailed results associated with the building of scenarios and the corresponding probability assigned by each stakeholders. The results give us more specific insights regarding what different groups have on mind in the salmon aquaculture industry in Chile.

4.1. General results

The workshops were originally conceived as a part of the CINTERA research project that was initiated by natural scientists interested on improving baseline (and basic) environmental knowledge of regions that host or are likely to host the aquaculture industry, particularly Norway and Chile. Its initial focus was the phenomenon of eutrophication to which the aquaculture industry can contribute. Not a single Chilean stakeholder mentioned the issue of eutrophication directly, so indicating even an indirect link to eutrophication among their concerns is difficult. Interestingly, the experts' workshop in Trondheim, Norway, where the project is anchored, selected the initial drivers for the workshops, but did not select eutrophication as one of the system drivers that were to be used to initiate discussions. Two drivers identified by the Norwegian experts workshop occasioned little interest in Chile, even on the part of Chilean experts: animal welfare and marine traffic. On the other hand, the difficulties posed by the feed required by carnivorous Atlantic salmon, a widely-discussed constraint on production and burden on wild fish stocks (see for example Pinto and G, 2006; Olsen, 2011), were not much discussed by any of the groups. Even when this is known to be a very important issue in the technical discussion of global sustainability of the aquaculture industry, our results show that local stakeholders are not much concerned with this issue and they are more focused on local effects instead. These workshops provide a good example of how concerns can vary from place to place and how experts' concerns are not always foremost on the minds of local stakeholders.

Local stakeholders were concerned about the impact of aquaculture on the environment but significantly, these concerns primarily manifested themselves as concern for the impact aquaculture was having or would have on their livelihoods. Other socio-economic impacts of the aquaculture industry were also highlighted in most workshops. These included the industry's effects on local culture (including indigenous culture), the situation

of artisanal fishermen and indigenous peoples and generation of conflicts among users of marine space. Labor conditions within the industry also came in for comment: jobs were important but so were working conditions. As expected, different groups ranked these concerns differently. Only in the groups in which union representatives were present, for example, did the issue of how conditions affected the role and efficacy of unions come up (see Table 3).

It was striking, however, that although salmon aquaculture in Chile is highly controversial, there was remarkably wide agreement on what the main issues were. Opinions differed primarily with respect to the degree to which the problems connected with the industry had been or were being corrected – or could be corrected. Perhaps the most striking result was the broad agreement among participants in all workshops as to the importance of good public institutions. In one way or another, discussions led back to the lack of adequate laws and regulations, the ability of the state to enforce existing laws and regulations and the process by which existing laws and regulations had been formulated.

Issues related to governance dominated most of the discussions, however, even when carrying capacity or biodiversity was identified at the priority issue (Table 4). In the ST session, stakeholders explain their views as to how their socio-economic systems work. In so doing, they choose the determinants of the system and how these relate to one another. In our workshops, these discussions revealed that stakeholders often attributed environmental and socio-economic problems to deficiencies in public institutions and their outputs. For example, the inability of the state to monitor existing and planned facilities (the lack of required equipment and boats on the part of local authorities) was a common theme. This inability meant that the isolation of aquaculture facilities and the difficulties of gaining access to the places where the aquaculture concessions were located – factors that in some situations might be a positive development because of the lack of other users in such remote marine area – became barriers to enforcement of regulations. This effect was particularly important in the Aysén and

Table 3
Most Relevant Issues for Stakeholders in each Workshop.

Workshop	Relevant issues, ordered by frequency in each workshop (*) indicates the priority issue chosen by the stakeholder group
Santiago: Governmental managers, consultants, Environmental NGO	Public institutions and regulation (*)
	Quantity and quality of jobs
	Effects on indigenous people
	Competition with other activities
	Effects of antibiotics on native species
	Research needed
	Animal health
	Infrastructure
Concepción: Chilean academic experts.	Public institutions (*)
	Quantity and quality of jobs
	Cultural impact
	Effect on marine ecosystem
	Governance (*)
	Impact on local development
	Uncertainty and lack of information
	Market dynamics
Puerto Montt 1: Artisanal fishers representatives.	Regulations
	Jobs
	Local culture
	Effect on native species (*)
	Research
Puerto Montt 2: Industry and critics.	Regulations
	Job quality
	Effects on other activities
	Technical assistance to industry
	Carrying capacity (*)
	Impact on pelagic fisheries
	Firms influence on regulations
	Intensive production system
Puerto Montt 3: Tourism and community.	Regulatory framework (*)
	Conflicts of use of land and marine space
	Effects of antibiotics
	Densities and carrying capacity
	Governance and stakeholders participation
	Effect on local development
Punta Arenas 1: Artisanal fishers.	Regulation and Enforcement (*)
	Limited labor availability
	Damage to marine ecosystem
	Effects of antibiotics on natural species
	Carrying capacity
	Impacts on artisanal fisheries
Punta Arenas 2: Local community.	Regulation and enforcement
	Labor conditions
	Impact on local culture
	Effects on biodiversity (*)
	Impact on artisanal fisheries
	Impact on Tourism
	Territorial planning
	System for evaluation of environmental impacts

Table 4
Most important issue in each workshop.

Workshop	Most important issue	Belief of sustainability
Santiago	Regulatory institutions	54%
Concepción	Governance and regulatory institutions	42%
Puerto Montt 1	Effect on native species	56%
Puerto Montt 2	Carrying capacity	48%
Puerto Montt 3	Regulatory framework	36%
Punta Arenas 1	Resources for artisanal fishermen	33%
Punta Arenas 2	Effects on biodiversity	61%

Magallanes regions where accessing concessions requires taking a boat trip that can take several hours. The impacts of aquaculture on carrying capacity and biodiversity, similarly, were in part attributed to inadequate regulation in the past (and, more controversially, today). Stakeholders who were concerned with poor labor conditions also attributed these to the lack of ability (or will) on the part of the state to enforce existing laws and regulations; increased conflicts among users of marine space were also attributed at times to a regulatory framework that did not provide for conflict resolution.

In relation to each of these issues during the BBN session, stakeholders built a network of scenarios and expressed the conditional probabilities of each scenario, based on the scenarios on which they in turn depend. The detail of these Bayesian belief networks for each session and a discussion of these results are presented in the next subsection. Nevertheless, in Table 4 we present the final result associated with the belief of the positive scenario related to each issue. We interpret this result as the average probability that the group of stakeholders assign to the possibility that the salmon aquaculture industry can become a sustainable activity. We observe that the results fluctuate between 33% and 61% showing a big variation between stakeholder perception among groups and issues. It is relevant to mention that the groups that involved the government in Santiago, the artisanal fishermen in Puerto Montt and the general community (also including government) in Santiago were the ones who were the most optimistic (with probabilities of 54%, 56% and 61%, respectively) while the groups associated with artisanal fishermen in Punta Arenas and the community in Puerto Montt were the least optimistic (with probabilities of 33% and 36%).

Issues related to governance dominated most of the process of developing new laws and regulations, in particular, the need for the participation of local stakeholders in creating such measures (particularly with respect to the Aysén and Magallanes regions). The lack of such involvement, it was frequently argued, was the reason why new regulation was too limited in scope: it focuses on avoiding the spread of diseases and parasites, such as the ISA virus, SRS and sea lice. While these goals are important, the regulations have prioritized promoting the productivity of the industry, without taking into account the effects this would have on local interest groups and communities.

The inability of the state to enforce existing laws and regulations (about aquaculture and more generally), and the lack of regulations that adequately address larger ecosystemic and socio-economic issues, means that individual companies are for the most part self-reporting and self-enforcing and that they must step up and take responsibility in areas were laws and regulations are lacking. The industry's record leading up to the 2007 crisis has clearly left a legacy of mistrust of the industry along with other damages, however. Many local stakeholders did not believe that what perceive in effect as the privatization of the monitoring and enforcement functions would result in an industry that was environmentally or socially sustainable. While the industry argued that improved, more sustainable management was in its own best interest, some stakeholders were unwilling to trust the industry to fill in these regulatory and legal gaps (Table 5).

4.2. Detailed results for each workshop

4.2.1. Stakeholder workshop in Santiago: Government managers, consultants and environmental NGO

The debate between NGO and government representatives was heated during this workshop. All participants recognized that the collapse of the industry in 2007 was in part due to inadequate regulation, but they disagreed on the degree to which the new regulations had corrected these shortcomings and would produce a sustainable industry.

NGO representatives argued that the regulatory framework was only designed to promote the fast growth of an introduced species, and that strategy based on this goal could never be considered sustainable. NGO representatives used data indicating the high amount of antibiotics used by the salmon industry in Chile to illustrate their point that the salmon could not survive in Chilean waters without external help. Neither the industry nor the species could therefore be sustained naturally. They were also critical of what they considered to be weak sanitary regulations, and the capacity to enforce regulations particularly in the extended and remote Patagonia region. They also argued that the aquaculture industry had failed to accomplish what it had promised 30 years ago: 1) to supply a source of protein widely available for human consumption, and, 2) to provide a sustainable activity that reduced pressure on wild fish, while 3) generating stable and high quality

Table 5
Most repeated relevant issues during the 7 workshops.

Relevant issue	Number of workshops in which the issue was considered relevant
Institutions and regulations	7
Labor conditions	6
Effects on local culture	4
Effects on marine environment	4
Conflicts with other activities	3
Use of antibiotics	3
Research and knowledge needed	3
Carrying capacity	3
Effects on pelagic fisheries	3

jobs to local communities.

The government representatives explained that institutions can only use the existing regulatory framework but that good work had been done within this framework. It became clear as the discussion progressed that government representatives acknowledged that the current regulatory framework does have some limitations.

All participants did agree, however, that after the 2007 ISA crisis, the industry and the government had worked together to change their sanitary standards, regulations and controls, and that these had therefore been more effective in the recent years. Participants then went on to discuss how Chile was in the midst of a process of changing aquaculture institutions and regulations to improve the sustainability of the industry. These stakeholders felt strongly that information distribution was critical for effective policy and decision making.

The importance of stakeholder participation in the decision-making process was another issue that generated an interesting discussion between stakeholders. All agreed that stakeholder participation is almost nonexistent in the current decision-making processes. Related to that, it became clear that the Mapuche and other indigenous and local communities are not consulted when salmon aquaculture concessions that might affect their interests and culture are decided. Additionally, new concessions usually have an effect on local communities, but information about the new concession is nevertheless not effectively provided to the community. It was generally perceived that there was no monitoring process after the actual distribution of licenses. This, it was agreed, creates conflict among the aquaculture companies and local communities, tourism interests and artisanal fishermen. All of this promotes negative perceptions of the industry and distrust by local communities of external regulations and institutions, it was argued. Stakeholders agreed, however, that most of these problems were related to a limited framework of action for the regulatory agencies and a weak regulatory framework. They also agreed that improving the institutions with stakeholder participation and good information would be the most important way to achieve a sustainable industry.

Following these discussions, the priority issue identified by participants in the BBN session was the achievement of "*Strong and coordinated Institutions*", with the three most important determinants of this being a "*Government focused on sustainability*", "*High stakeholder participation*" and "*Relevant and available information*".

In the second stage, when stakeholders were asked to assign a probability to each scenario, they answered that there was a 61.9% probability that government will focus on sustainability, a 77.2% probability that stakeholder participation will be considered and a 73.3% probability that relevant information will be available. Nevertheless, they only awarded 54.0% probability to the scenario in which institutions will be strong and coordinated, assigning a small probability to the concept that they consider most important for the sustainability of the salmon aquaculture industry in Chile. These results are presented in Fig. 3.

4.2.2. Stakeholder workshop in Concepcion: Chilean academic experts

The ST discussion in the experts' workshop covered much ground, but factors associated with the regulation of the industry made up the dominant theme throughout. In the participants' opinion, the new regulatory framework and institutions are still inadequate to generate sustainable activity in the country. Although they do recognize that a number of important changes have been introduced in recent years, they believe that these changes are not adequate and that the actions available to the regulatory agencies are still too limited, particularly given the lack of funding for the enforcement of the new regulations. They also argued that there is an important source of uncertainty regarding the environmental, economic and social impacts of the new regulations. Finally, they agreed that funding for research and action is needed to prevent and control diseases that have a significant impact on salmon aquaculture are urgently needed.

Stakeholders also identified a series of other factors related the goals of the regulating agency and other governance issues. In the view of these experts, regulation has prioritized the economic

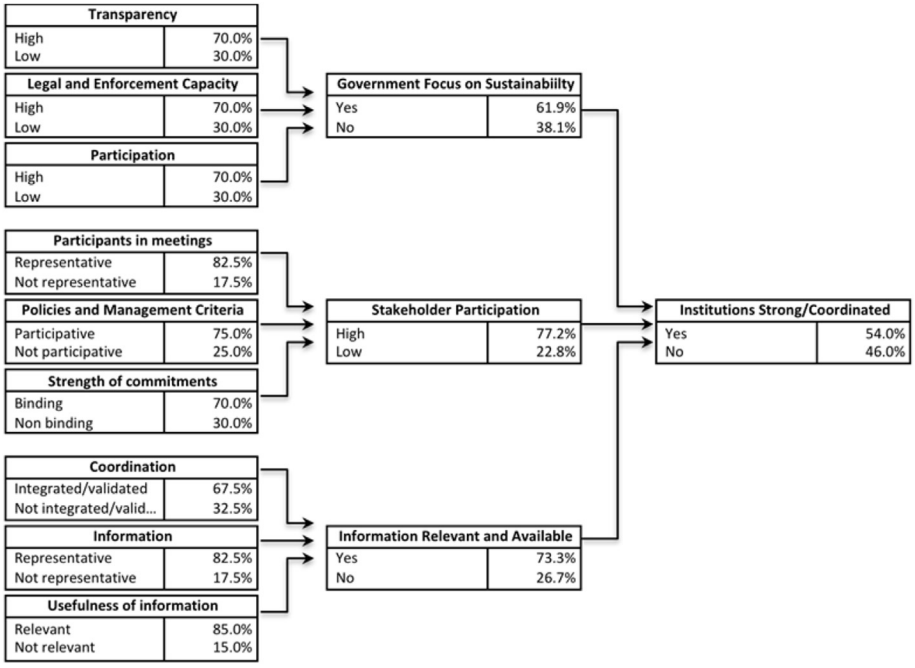

Fig. 3. BBN 1, Santiago workshop.

development of the Chilean Patagonia through salmon aquaculture promotion. The environmental and social impacts of this activity, however, have not received the required attention. As a result, regulations have been developed as response to crisis instead being designed to anticipate and avoid crisis. The scientists then discussed these environmental impacts of the aquaculture industry and how they are measured, detected and mitigated. In their view, there was a lack of clear information about and regulation dealing with the amount of antibiotics that could be used, or about the fecal and other wastes generated by salmon farms, whether on land or in water. Additionally, they argued that these factors could potentially have an important effect on both biodiversity and tourism but these potential impacts were not being sufficiently studied or quantified. Finally, the group of scientists agreed that a sustainable aquaculture industry requires better information and institutions that will allow better governance of the industry. This must include information about the socioeconomic and environmental impacts of the aquaculture sector in Chile.

Workshop participants also discussed and considered a wide range of other factors. The competition between the large producers and artisanal fishermen and small scale aquaculture over the use of the space was noted. Factors brought up in this workshop, but not in any others, were the importance of the international market, volatility in prices and how costs affect the profitability of the industry. These, it was noted, will have a direct impact on the capacity of the industry to face restrictive regulations, to attract international investment, to generate jobs, to pay high salaries and to contribute to local communities with resources and financial assistance. It was also the perception of the group that the national industry was still adjusting to lower prices, higher costs and indebtedness resulting from the 2007 ISA crisis and the new regulations that were created in its wake. The academics also mentioned the impact that the industry has had in the past on the culture of local communities relating to the impact of markets and economic activity in the areas where the aquaculture industry is operating, particularly in Puerto Montt. In their view, aquaculture has changed the way in which local workers relate to ocean resources; instead of harvesting the oceans, they are now seeding them. The industry has also brought changes in labor conditions, strict time schedules and higher salaries. Adapting to this change has taken time: workers in the aquaculture industry are still not well accepted by artisanal fishermen.

In the wake of the ST discussion, the participating natural and social scientists chose the achievement of a “Sustainable Governance” as their priority issue. The three most important determinants were identified as “Effective Rules”, “High Trust in Government” and “Adequate decision making process”.

Stakeholders considered that there was 49.1% probability that formal and informal rules will be effective, 49.8% probability that there will be high trust in government and 52.2% probability that the decision making process will be adequate. All of this implies that in their opinion, there is 42.4% probability that the governance of the salmon aquaculture industry will be sustainable (Fig. 4).

4.2.3. First stakeholder workshop in Puerto Montt: Artisanal fishermen

The participants in this workshop were all artisanal fishermen from the area. These fishermen reported that the stocks that they fished were in a poor state, a situation that they attributed in part (but not exclusively) to the aquaculture industry. They had very strong views about what they perceived to be the negative environmental impact of salmon aquaculture on the ecosystem. They assigned the responsibility for escaped fish and pollution to the salmon aquaculture industry exclusively, which they claimed must be a cause of the decline in naturally occurring species of the internal waters of the fjords of the Puerto Montt region, including fish, algae and other benthic species. They also believed that the extensive use of antibiotics by the industry was also a reason for the decline in native stocks. These views are well represented by an observation made by one of the fishermen. He reported that algae grow slower now than it did before the aquaculture industry arrived. According to this fisherman, 15 years ago algae could be harvested within a month of being put in the water, and could be cut twice during the season. Now they needed to wait four times

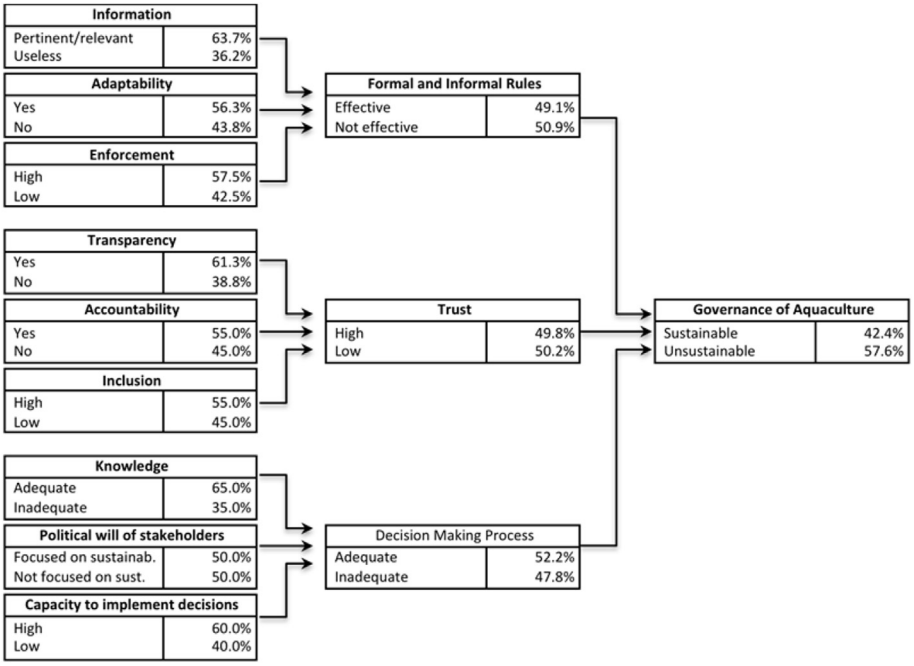

Fig. 4. BBN 2, Concepción workshop with academics.

longer to have the same production. He attributed this change to pollution by the salmon aquaculture activities in the area.

These fishermen's high unemployment rates and low level of fishing activity contrasted pointedly with the fast growth of the aquaculture activity in the past two decades. For these reasons they identified a clear conflict between aquaculture and traditional small-scale fishing.

The artisanal fishermen see themselves as the stakeholders most impacted by the aquaculture industry, and feel that they are the ones that have to pay the costs of the pollution from the aquaculture industry. Furthermore, they claim that they have not benefited at all from the industry: they have requested action and compensation from the industry, but feel that their voices are not heard.

These stakeholders also brought up an array of intertwined governance and related socio-culture issues. They said that laws and enforcement activities are insufficient, and that a lack of funding for enforcement makes achieving sustainable salmon farming unlikely. They said that the focus of the government has been on the development of the industry rather than taking care of the native ecosystem and the local culture. The impact of the industry on local culture was an important issue for this group: in their view, the salmon industry has brought “modernity” to the Patagonia region and that traditions are being lost due to this economic activity. They argued that information and relevant research is needed to have a sustainable activity and reduce the impact of the industry on both local communities and native species.

The priority concern identified by this group of stakeholders in the BBN session was to have aquaculture with “Low impact on native species and communities”. The three most important determinants of this were identified as “Relevant and transparent studies”, “Responsible businesses” and “Strong regulations”.

Stakeholders assigned an average probability of 49.4% to the scenario in which aquaculture companies are socially responsible, a 32.2% probability to the research being relevant and transparent and a 47.9% probability to the regulations being strong, implying a 56.4% probability of aquaculture having a low effect on the native species they fish (Fig. 5).

4.2.4. Second stakeholder workshop in Puerto Montt: the industry related stakeholders and its critics

This workshop was the most potentially contentious of the seven workshops held. The original objective of this third workshop was to identify the views of those in aquaculture industry or closely related industries. In the event, these were joined by local researcher and also by a former aquaculture worker who was now working for an NGO and leading an important campaign against the aquaculture industry.

This meant that this workshop was dominated by an intense discussion between people against the industry and people defending the industry's actions. This could have had a negative impact on the discussion, but proved here to be a vehicle of understanding and an illustration of the need for clear communication. Both sides presented arguments for and against every point discussed, presenting arguments and numbers to support their side.

The at times intense discussion brought out the main complaints made by activists against the industry. They argued that the industry requires a high level of external inputs, such as fishmeal and fish oil from wild fish and antibiotics. In addition, oxygen has to be injected directly into the water because the low levels of oxygen in the water endangered the salmon in the cages. For the harshest critics, such problems mean that salmon aquaculture will never be sustainable in these waters and that the business venture should be removed completely from the Chilean Patagonia region. Critics also point out the ongoing conflicts over ocean space with indigenous people and artisanal fishermen, and the complete lack of dialog between the industry and the affected groups. They complain that the central government issues concession permits to the industry without any consultations with local stakeholders and the legal rights of artisanal fishermen and indigenous peoples are routinely violated. This in turn creates conflicts between the local traditional users and the new modern users of the marine space. Weak enforcement of existing regulation was another topic that the

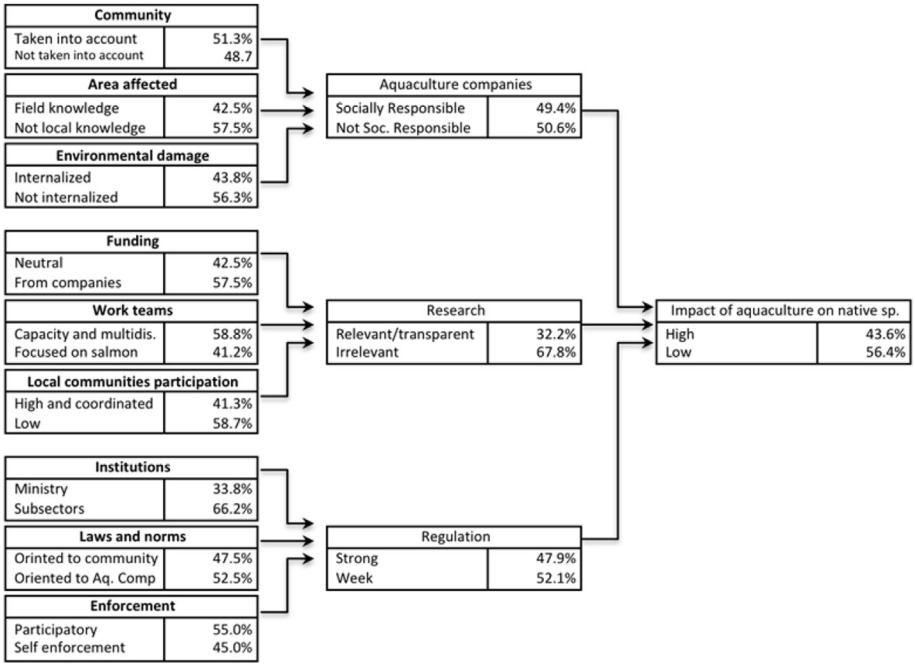

Fig. 5. BBN 3, Puerto Montt, 1st workshop.

opponent claim requires attention.

The people closest to the industry generally responded to their critics by saying that the industry had developed its activities in accordance with Chilean laws. The problem, they said, was that the laws were not designed to address the social impacts of aquaculture; the industry itself was not at fault. If the necessary regulations were to be put in place and well-enforced, the aquaculture companies would adapt. They also argued that many perceptions about the harm caused by the industry are based on wrong conceptions of the industry or on experiences dating back to the early 1980s when the industry actually grew without much in the way of regulation. However after the 2007 ISA virus, they argued, the regulatory framework improved. Industry recognizes that nature places limits on what the industry can do and that an effective industry requires a better use of resources. The industry believes it is now prepared to control this virus and other sanitary diseases. In addition, they argued that the industry had become more conscious of its corporate social responsibility.

It was in assessing the laws and regulatory framework that the strongly divided participants in this workshop found some common ground. Although it was noted by some that the government had dedicated many hours to meeting with the public in fashioning the new laws and regulations, workshop participants generally agreed that the information that was used in the process of designing and deciding on the allocation of aquaculture concessions was far too limited: In most cases the carrying capacity of the area is unknown and spatial effects are completely ignored. Also, regulations provide for the monitoring of the health of the fish within the cages but not the monitoring of industry impacts on ecosystem processes or services. They also agreed that there is an important need to improve the design, application and enforcement of aquaculture regulations.

Most participants also recognized that the aquaculture industry has been an important provider of income, education, employment and economic activity to Chile in many high poverty regions and that this socio-economic development came at a time when traditional fishing activities were collapsing. They also agreed that it is important to make the changes required to build a sustainable industry because aquaculture is now the base of the economic system in the region, with many families depending directly or indirectly on this activity.

The workshop was long and reaching a consensus was difficult. However, participants did finally come together to agree upon a priority issue after the Systems Thinking session. Encouraged to identify a single priority issue, they agreed on the importance of achieving an aquaculture industry "based on carrying capacity of the ecosystem", with the three most important determinates of this identified as "Pertinent and scientific knowledge availability", "Responsible businesses" and "Adequate regulations".

When assessing their beliefs, stakeholders say on average that there exists only a 38.5% probability that knowledge will be based on science, a 45.8% probability that aquaculture companies will behave responsibly and a 46.5% probability that regulation will be adequate. Still, they consider that there exists a 48.4% probability that aquaculture activity will be based on carrying capacity (Fig. 6).

4.2.5. Third stakeholder workshop in Puerto Montt: Tourism and community

The third workshop was held in Puerto Montt, where representatives of the tourism industry and other active community actors were invited. Most of the discussion focused on the interactions of aquaculture with the tourism sector and the labor conditions in the former.

The stakeholders in this workshop believed that the aquaculture industry had negatively affected the natural ecosystem and native species, which in turn had a negative impact on the tourism sector and opportunities for artisanal fishermen. They therefore associated the operation of the aquaculture industry with the current poor conditions for artisanal fishermen. It was also their belief that the excessive use of antibiotics and the high densities of salmon in the cages were responsible for environmental pollution and these negatively affected native species and benthic habitat.

Much of the discussion focused on labor conditions and related issues. The participants believed that the conditions at most

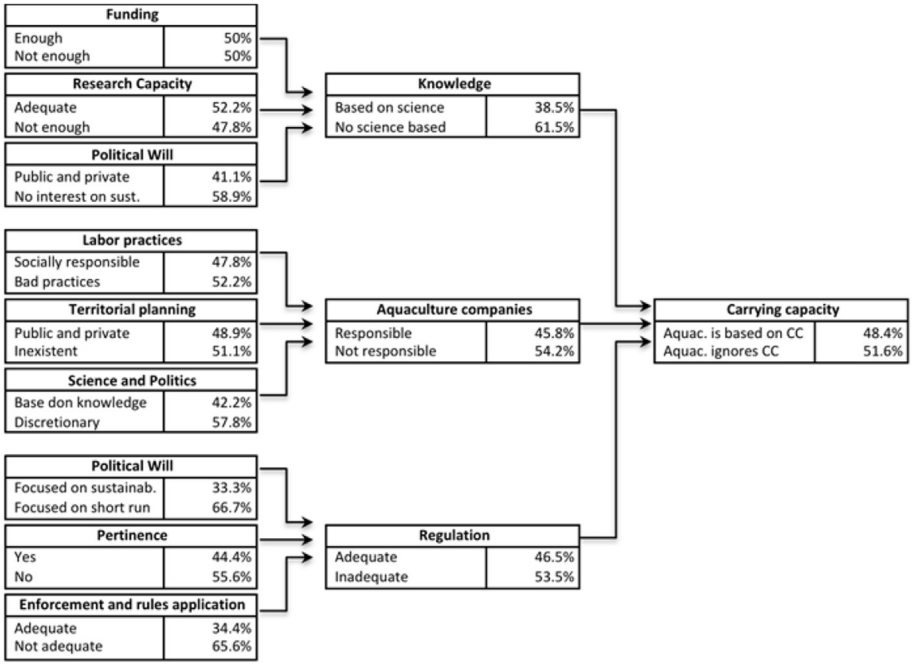

Fig. 6. BBN 4, Puerto Montt second workshop.

aquaculture operations were not optimal and that the industry had degraded the culture of local workers. Additionally, specialized workers were brought in from other regions, taking good labor opportunities away from local people in a region where jobs were already scarce. They also mentioned that in most companies the conditions for workers' unions were not adequate, and that the only task left to unions was salary negotiations. The results of these limitations on unions became clear during the 2007 ISA crisis which led to poor labor conditions and high unemployment rates. The stakeholders believed that the regulatory system and the weak enforcement of the regulations were mainly responsible for these poor labor conditions. In their views, the aquaculture industry was consistently given priority because of its importance to the economy of the country and the region, and regulations were therefore adapted to allow their operations to continue on this path. Although they recognized that the aquaculture industry was very important for the regional and national economy, they argued that only small economic benefits were seen by the communities in which the industry was located.

The priority issue for this group of stakeholders after the ST session was the achievement of aquaculture with an "Adequate and efficient regulatory framework", with the three most important determinants of this identified as being "Participation and Stakeholder Inclusion", "Availability of pertinent information" and "Efficient monitoring". Stakeholders in this group consider that there exists a 25.8% probability that stakeholders will be included in the regulatory framework, a 66.9% probability that information will be pertinent and a 65.2% probability that enforcement will be effective. With that in mind, they consider that there exists only a 36% probability that the regulatory framework will be adequate and efficient (Fig. 7).

4.2.6. First stakeholder workshop in Punta Arenas: Artisanal fishermen

Only four representatives of artisanal fishermen attended this workshop but those who did attend were well-informed and active members of the community. They have been involved in organizing local fishermen and the dialog concerning fisheries law. It is important to keep in mind with respect to the Punta Arenas workshops that salmon aquaculture is new to the Punta Arenas region and just a few companies operate there. The region was also not affected by the 2007 ISA crisis.

The stakeholders in this group believe that important technological developments in the aquaculture industry, such as automatic feeding procedures, could greatly reduce the impact of the industry on the ecosystem. They acknowledge that most technological developments would be designed to increase the efficiency and profitability of the industry, which might reduce the need for labor and might mean higher production costs and generally lower benefits from the industry. They nevertheless feel that technological investment and innovation would be required to reduce the environmental impact of the industry.

The participants furthermore believe that where aquaculture exists, the effects on the native species can be seen. They believe that the waste from aquaculture together with the extensive use of antibiotics has already caused a reduction in the availability of native species for artisanal fishermen. They also feel that most of the problems with the aquaculture industry relate to the lack of resources on the part of regulatory bodies that can accordingly not carry out the required tasks of monitoring and enforcing regulations.

The priority issue this group of stakeholders identified after the Systems Thinking session was that aquaculture should have a "Low impact on the artisanal fishermen", with the three most important determinants of this understood to be "Adequate monitoring", "Minimal waste in the water" and "High participation of artisanal fishermen". The stakeholders estimate that there is a 37.3% probability that enforcement will be adequate, a 30.4% probability that water pollution will be minimal and a 31.4% probability that local participation will be high. This implies that they consider that there is a 33.3% of probability that the effects of aquaculture on resources of artisanal fishermen will be low (Fig. 8).

4.2.7. Second stakeholder workshop in Punta Arenas

This workshop was attended by a variety of local stakeholders, including regional government representatives, researchers, NGOs

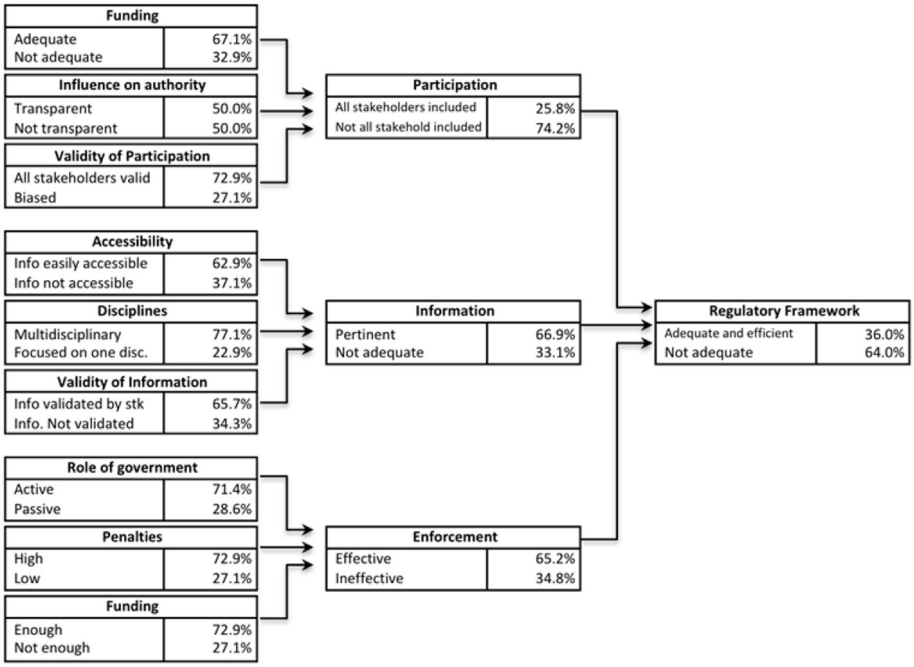

Fig. 7. BBN 5, Puerto Montt third workshop.

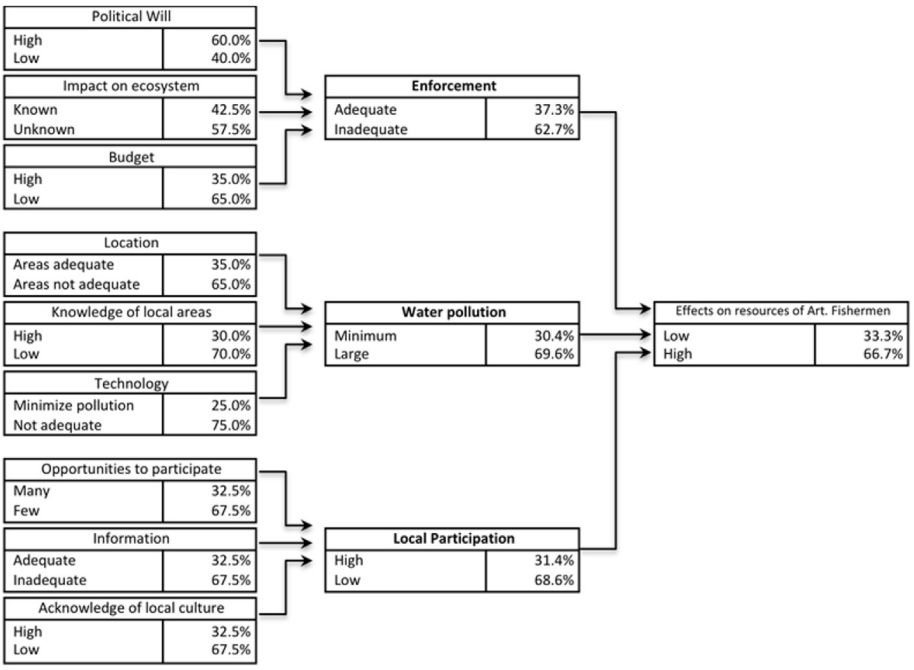

Fig. 8. BBN 6, Punta Arenas first workshop.

and other members of the local community. One of the main concerns of this group was the impact that the aquaculture industry might have on the indigenous people and on local culture. They said that the aquaculture industry creates conflicts by using some coastal areas for concessions or transportation that has traditionally been part of the indigenous territory.

These marine space conflicts also affect the tourism industry and other groups and local communities, because other uses are excluded where aquaculture concessions are present. They argued that the existing regulations are not able to deal with these conflicts, and that the various institutions that might be expected to manage the area have very limited powers. For example, responsibilities are divided among the army, the regulatory body and the enforcement agencies, resulting in their dilution. Additionally, the long distances from big cities to the places where the aquaculture facilities were in fact located were understood to make adequate enforcement impossible. Some stakeholders also argued that the regulations do not take into consideration the different uses of the territory, overlooking in particular conservation and tourism activities. They argued that conservation activities should

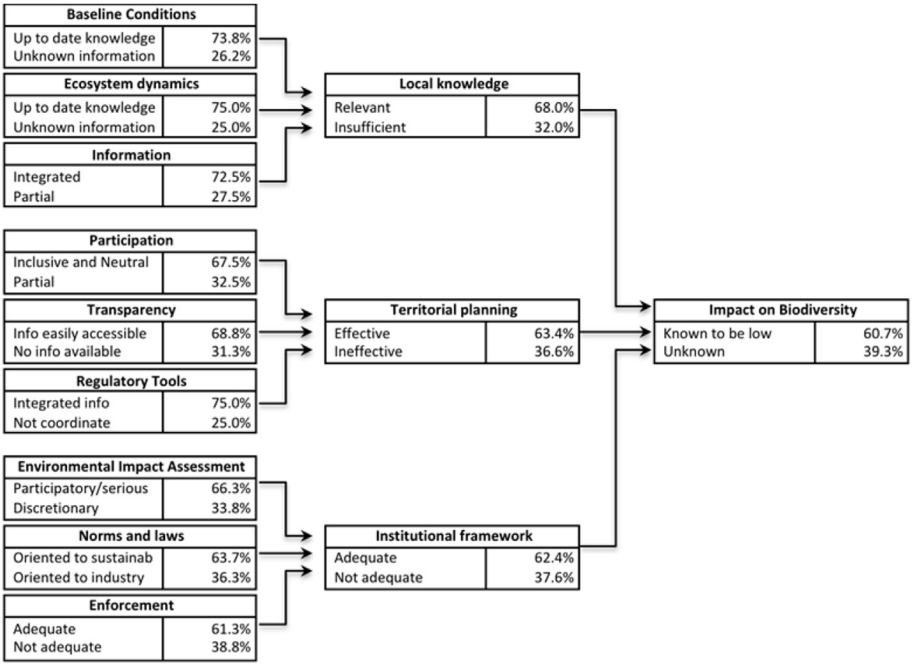

Fig. 9. BBN 7, Punta Arenas second workshop.

be recognized as important because they attract tourism to the area, an important economic activity there. They felt that both tourism and conservation have been negatively affected by salmon aquaculture. They also considered territorial planning to be fundamental for the correct integration of the different users currently present in the Patagonia region, and that all users should be allowed to develop in a balanced way. In their view, this is at present difficult because the regional government has defined the aquaculture sector to be a priority economic activity to bring economic development to the region.

The priority issue this group of stakeholders identified in the BBN session that followed the ST summarized above was that aquaculture should have a *"Low effect on the artisanal fishermen"*, with the three most important determinants of this understood to be *"Adequate monitoring"*, *"Minimal waste in the water"* and *"High participation of artisanal fishermen"*. After analyzing the responses to the Conditional Probability Tables and averaging them, we observe that participants consider there to be a 68.0% probability that local knowledge will be relevant, a 63.4% probability that territorial planning will be effective and a 62.4% probability that institutional framework will be adequate. All of this leads to a perception that there is a 60.7% probability that the impact on biodiversity will be known to be low.

It is interesting to notice that this group has by far the most positive perception of the most relevant issue chosen by them to determine sustainability and that this group of stakeholders is representative of the general community where there is new development of t "Aquaculture 2.0", which is the new industry development after the regulations post-ISA outbreak. This contrasts with the view of the agents in the area of Puerto Montt who have more negative views of sustainability of the salmon aquaculture industry due to the negative impact that the ISA outbreak had on their community. The aquaculture industry and the regulations have a good opportunity to build a sustainable industry in this region and to keep up with the expectations of local stakeholders (Fig. 9).

5. Conclusions

We have analyzed information collected in seven participatory workshops where we asked stakeholders to consider the impacts that salmon aquaculture has had and will have in selected locations in the Chilean Patagonia, and whether and how they consider this level of activity might be sustainable. The results from this exercise suggest the following main conclusions:

- An important difference exists among the technical perception of the most important issues of sustainability for aquaculture in the mind of the experts and local stakeholders, particularly in relation with issues as eutrophication, food quality, marine transportation and other drivers of sustainability that local stakeholder did not consider to be among the most relevant issues.
- In the case of Chile, there is a major consensus about the main issues that need to be addressed for achieving a sustainable aquaculture industry, the most relevant being the need to have strong institutions-regulations-enforcement. Even in the cases when this issue was not chosen as the most important, it always appeared as one of the main determinant of the principal focus being analyzed, and was always much present in the discussions.
- The average perception of the future sustainability of the industry among stakeholder groups ranges between 33% (artisanal fishermen in Punta Arenas) and 61% (general community in Punta Arenas). The fact that these two cases are both in Punta Arenas is interesting. This result suggests that the low information available to these fishermen combined with a perceived lack of control over the industry on the part of artisanal fishermen could create a perception of vulnerability higher than the perception of the community and government officials who could feel more in control of the situation.

All workshops showed that important conflicts exist among different stakeholders, including traditional small-scale fishermen, the tourism industry, workers in the industry and the industry itself. Most of the conflicts revealed in the workshop were based on beliefs about how the SES functions that cannot be independently evaluated or confirmed. Some local stakeholder concerns seemed to date from the pre 2008 period, before the collapse of the industry and the new government reforms and improved practices; industry and government representatives complained that their recent efforts had not been adequately taken on board by critics. Attribution of problems to aquaculture, such as the decline in the resources that artisanal fishermen rely upon, may well be misplaced. Nevertheless, such perceptions are strongly embedded in many stakeholder groups. The workshops clearly indicate what concerns and issues must be addressed in order to increase the legitimacy of the industry, if not its sustainability. Information sharing and dialog among all interested groups can help ensure that such concerns are addressed either by improving knowledge on the part of stakeholders or by adequate research and regulation, as it has in other contexts (Ostrom, 2009a,b; Havice and Iles 2015).

The workshops also reveal widespread concern with governance and state capacity issues: stakeholders broadly agreed that the institutional framework that governs the salmon industry needs urgent attention. Many believe that is important that the framework reach far beyond what happens in the aquaculture pens. Among the greatest needs are the improvement of information about the impact that the activity has on the fjord ecosystem, the inclusion of impacts of the industry on the ecosystem and local communities into the regulatory framework and the incorporation of affected stakeholders into the decision-making process. Importantly, there was a widespread sentiment that the state lacked the capacity and will to monitor even existing regulations. While many local stakeholders were concerned with how aquaculture already impacts their livelihoods and environment, and were anxious about the future, most imagined solutions ran aground on this cluster of concerns about governance and state capacity.

Mutual trust among critics of the industry on the one hand and the industry and sometimes governmental managers was conspicuously lacking. Building trust in both the industry and the government's ability to drive the industry in a sustainable direction – and the trust required for stakeholders to want to engage in what can be a long and tedious processes of information exchange, planning and assessing results – will require more attention to not just what regulations are made but how they are made. All will have to work hard to overcome a legacy of mistrust and real grievances, and stakeholders make it clear that the state has an important role to play in this process. Finally, the workshops together illustrated that in a globalized world, the state remains a critical ingredient in developing sustainable enterprises.

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