SHRIMP WELFARE

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RECOMMENDED

Research Report:
Animal Welfare – Shrimp Welfare (2020 Recommended Idea)

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This is a summary report about improving whiteleg shrimp (*Litopenaeus vannamei*) welfare. In our five-step research process this report corresponds to step 4, the drafting of an in-depth, 80-hour report on a potential intervention. All the ideas considered for animal advocacy are listed in this spreadsheet. Other reports on animal welfare can be found here.

Thanks to Michael St. Jules, Karolina Sarek, Erik Hausen, and Daniela Waldhorn for reviewing the research, and to Antonia Shann, Nicoleta Faina, Bella Forristal, Patrick Stadler, and Urszula Zarosa for their contributions to this report. We are also grateful to the seven experts who took the time to offer their thoughts on this research.

For questions about the content of this research please contact Vicky Cox at vicky@charityscience.com. For questions about the research process, charity recommendations, and intervention comparisons please contact Karolina Sarek at karolina@charityscience.com.

Charity Entrepreneurship is a research and training program that incubates multiple high-impact charities annually. Our mission is to cause more effective charities to exist in the world by connecting talented individuals with high-impact intervention opportunities. We achieve this through an extensive research process and through our Incubation Program.

Research Process

Before opening the report, we think it is important to introduce our research process. Knowing the principles of the process helps readers understand how we formed our conclusions and enables greater reasoning transparency. It will also clarify the structure of the report.

Our research process incorporates elements that are well established in some fields but uncommon in others. This is partly because of the unique goals of our research (i.e. finding new areas for impactful charities to be launched) and partly because we incorporate lessons and methodologies from other fields of research, primarily global health and medical science. Below is a quick overview of some of the key elements.

Iterative depth: We research the same ideas in multiple rounds of iterative depth. Our goal is to narrow down our option space from a very large number of ideas (often several hundred at the start) to a more workable number for deeper reports. This means we do a quick 20-minute prioritization, a longer 2-hour prioritization, and finally an 80-hour prioritization. Each level of depth looks at fewer ideas than the previous round.

Systematic: The goal of our research is to compare ideas for a possible charity to found. To keep comparisons between different ideas consistent our methodology is uniform across all the different ideas. This results in reports that consider similar factors and questions in a similar way across different interventions, allowing them to be more easily compared. This is commonly used in other charity evaluations and encouraged in other fields.

Cluster approach: Comparing different intervention ideas is complex. We are not confident that a single methodology could narrow down the field, in part due to epistemic modesty. To increase the robustness of our conclusions, we prefer instead to look at ideas using multiple independent methodologies and see which ideas perform well on a number of them (more information here). These methodologies include a cost-effective analysis, expert views, informed consideration, and using a weighted factor model. We explain the merits and disadvantages of each method, as well as how we apply it, in the linked documents. Each methodology is commonly used in most fields of research but they are rarely combined into a single conclusion.

Decision relevant: Our research is highly specialized and focused. We only research topics that are directly related to the endline choice of what charity to found. Sometimes cross-cutting research is needed to allow comparison between different ideas, but all our research aims to be directly useful to getting new charities started. This level of focus on targeted practical outcomes is rare in the research world, but is necessary to our goal of generating more charity ideas with minimal time spent on non-charity idea related concepts.

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Improving shrimp welfare

Subsidizing farmers in Vietnam to improve water oxygenation is the approach we have modeled to improve shrimp welfare. However, we will also consider alternative interventions, countries, and approaches in the implementation report, and the entrepreneurs should be open-minded to pursuing any combination of these alternatives, or pivoting to them if our best guess doesn't work out. Ultimately, **the endline goal of this intervention is to improve the welfare of whiteleg shrimp** (*Litopenaeus vannamei*). We have done as much desk research as we can, but we are less certain that we have chosen the best intervention to improve shrimp welfare than we would be in other cause areas with higher levels of evidence, or than we would be if we could have visited a few farms in the most promising countries. We are most certain that we want to see an organization working on shrimp welfare, but less certain about what intervention this organization should work on, what approach they should take, and where this work should be done. The table below summarizes this.

Component	Certainty level	Notes
Whiteleg shrimp	Very high	This is the component of the intervention that we are most certain about: we would like to see an organization working for shrimp.
Dissolved oxygen	Medium-high	We have modeled this intervention in our 80h report as we think that this is a good bet at an intervention that will improve shrimp welfare.
Eyestalk ablation	Medium	This intervention seems a promising alternative to dissolved oxygen that we have not researched this year.
Vietnam	Medium-high	Working in Vietnam looks very promising when subsidizing aeration to improve dissolved oxygen levels. Even if not working on dissolved oxygen, Vietnam would be a good bet due to its high production of shrimp, but it might not be the most promising location for all intervention ideas.
Asia	High	Five out of seven of the top shrimp producing countries are in Asia, so it seems very likely that work on shrimp welfare will be done in Asia.
Subsidization	Medium	Subsidization has a direct path to impact, but it is less explored in the animal movement and has lower expected cost-effectiveness than other approaches. Subsidization looks promising in the short-term for improving dissolved oxygen as it has more potential for control than other approaches. However, another approach might be more promising in the longer term for dissolved oxygen or another intervention.

Training	Medium-low	This approach involves training farmers to appropriately aerate ponds to levels optimal for welfare, rather than subsidizing the cost of aeration. This seems less promising than subsidization.
Corporate campaign	Medium	A corporate campaign looks more promising for eyestalk ablation than for dissolved oxygen (due to the lack of control over stocking density increases for DO). A corporate campaign against the use of eyestalk ablation could be a good "foot-in-the-door" for shrimp welfare.
Governmental campaign	Medium-low	The main issue with government campaigns is the potential lack of enforcement and the lack of control over stocking density increases for DO.

Description of the intervention

The intervention explored in this report involves working with farmers to improve dissolved oxygen levels on their farms to levels that are optimal for shrimp welfare. Dissolved oxygen (DO) is simply the amount of oxygen dissolved in the water [1]. It is the most important aspect of water quality as non-optimal levels can cause high levels of stress to the shrimp who struggle to breathe, and can also result in lower survival [2]. We have modeled this intervention as training farmers on how to properly manage dissolved oxygen and subsidizing the cost of aeration (i.e. mostly the electricity costs of running aerators, as most farmers already have aeration equipment on their farms [3]). Other approaches will be explored in the implementation report.

Whiteleg shrimp (*Litopenaeus vannamei*) looks to be the most promising shrimp species for this intervention to focus on given the scale at which it is farmed [4]. Vietnam seems to be the best choice for the country of implementation as current dissolved oxygen levels on farms are likely below optimum due to farmer's poor technical controlling capability caused by rising temperatures. Farmers struggle as dissolved oxygen is especially difficult to manage during the hot weather and resulting salinity increases in earthen ponds. We believe that farmers would be willing to work with a new charity to improve the water quality standards on their farms as they are looking for assistance to strengthen their climate change resilience [3]. Managing dissolved oxygen is a part of this.

When thinking about starting this organization it is important to remember that this intervention still looks promising given *some* stocking density increases. We have modeled a stocking density increase that is 25% of the maximum possible increase given improved aeration. The intervention still looks promising under this assumption. We think that 25% is a reasonable assumption given that the potential reasons for not increasing stocking density to the maximum are quite compelling, but the intervention is quite sensitive to this parameter. Therefore it is important for the entrepreneurs that start this charity to keep this potential stocking density increase in mind. They may have to pivot away from this intervention if the stocking density increase is higher than we have modeled.

One potential intervention that should be considered if it is necessary to pivot away from water quality is preventing the use of eyestalk ablation to improve the fertility of shrimp.

Note: We are aware that Rethink Priorities is also researching shrimp and prawns. If they conclude that other interventions look as promising as (or more so than) water quality, we will further research their potential and either pivot to them or combine these interventions with a water quality ask.

Summary conclusion

Taking all of the information from the four methodologies into consideration, this intervention seems very promising. It scored well under all criteria, and it scored better relative to all other interventions we have considered this year in all areas.

The table below offers a step-by-step summary of our research process for this intervention and the main takeaways from each stage. Color-coding reflects how well the intervention performed at each stage. The idea sort, idea prioritization, supporting reports, and related reports involve background research prior to this report that will not be considered in the final decision on the promise of this intervention.

Report type	Summary results	Deeper reading
Idea sort	During the idea sort, this idea showed promise: it was in the top 22 of 395 total ideas, scoring well in all areas.	Full report Process
Idea prioritization	After two hours of researching improving dissolved oxygen levels of shrimp farms using the weighted factor model methodology, it was one of our highest priorities for more in-depth research as it was among the top eight ideas.	Full report Process
Prior view (section 1.)	This 80-hour report begins with a prior view, which summarizes the lead researcher's expectations before starting in-depth research. At this stage, we thought this intervention would be very promising if	Process

	we could find a country with high production where crustaceans are farmed in systems where water quality is currently poor and easy to affect.	
Informed consideration (section 2.)	Informed consideration occurs at two stages of our research process: the start and the end. Two sections in the report reflect this chronology. At this first stage, we explore what factors are likely to drastically affect the intervention (crucial considerations). We: i) considered which crustacean this intervention should focus on, finding shrimp to be most promising; ii) researched the production systems used in shrimp farming in the top five shrimp producing countries; iii) conducted a comparative analysis of the effects of different water quality parameters on shrimp welfare; iv) considered which of the top five shrimp producing countries this intervention should be implemented in; and v) evaluated the impact that COVID-19 will have on this intervention. Overall from this perspective, the intervention looked promising, mostly from an update on the most common production system used for shrimp farming.	Process
Expert view (section 3.)	After examining crucial considerations, we discussed the intervention with experts including ministry representatives, academics, and advocates. Broadly ~71% of experts thought working with farmers to improve dissolved oxygen levels on their farms looked promising and were interested in a charity being started in this field. Those who were concerned about this intervention were worried about whether this intervention could be net-negative as it may allow for increased stocking densities, and were uncertain about India as the country of implementation. As a result, Vietnam was chosen as the country of implementation.	Process
Weighted factor model (section 4.)	The next stage of our research involves a weighted factor model. We score the intervention based on preset criteria and weightings, and generate a causal chain. In this case, improving dissolved oxygen levels performed well, with an overall weighted score of 33/50. The score can be broken down as follows, with the weighting of each criterion in parentheses: 6/10 for strength of the idea (2), 7/10 for limiting factors (1.5), 7/10 for execution difficulty (1), and 7/10 for externalities (0.5).	Process

Cost-effectiveness analysis (section 5.)	In our cost-effective analysis, we quantify welfare in terms of dollar cost. Our findings suggest that improving levels of dissolved oxygen on shrimp farms is a cost-effective way to reduce suffering, even when accounting for a potential increase in stocking density. We expect to be able to affect more welfare points when subsidizing aeration as it seems likely that the probability of success will be higher. With subsidization, we expect this intervention to affect 87.8 welfare points per dollar (considering co-founder and funding counterfactuals).	Supplement A Process
Informed consideration (section 6.)	The second part of our informed consideration closes the report. This internal contemplation allows researchers to reflect on the data and evidence gathered throughout the process. In this writeup, the lead researcher and director of research summarize key conclusions and offer overall thoughts on working with farmers to improve dissolved oxygen as an intervention.	Process
Supporting reports	Three supporting reports are relevant for this intervention. Our weighted animal welfare indexes on big and small crustaceans (Supplement B) suggest that these are likely priority animals. The "Why focus on animals?" report details why we think animal advocacy is a high-impact area on which to focus.	Supplement B Why focus on animals?
Related reports	The 2019 report "Improving Environmental Conditions", which found improving management of dissolved oxygen levels for fish to be promising, is the reason we considered this similar intervention for crustaceans.	2019 report

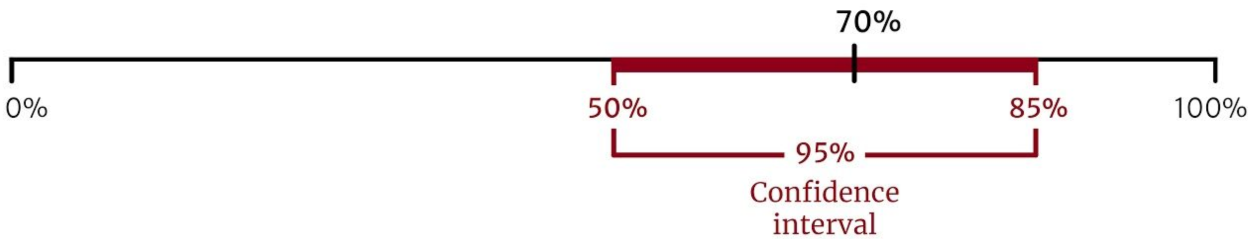
1 Prior view

This brief section summarizes our team's thoughts on this intervention before starting in-depth research.

This intervention is very promising in the abstract, but we are concerned about how promising it is in reality.

This intervention could be promising if we can find a good country to implement in (i.e., one with high production where crustaceans are farmed in systems where water quality is currently poor and can be easily affected). We are concerned that this might be difficult to find, though, as during the two-hour shallow research phase, it seemed as if most crustacean farming is performed in sea cages.

At this stage of the research, our subjective likelihood of recommendation was:



This probability estimate assumes that:

- Two animal advocacy ideas (from the 2020 research round) will be recommended at the end of the research process, so being recommended is equivalent to being in the top two ideas.
- With no prior information, each idea is equally likely to be recommended. Because we plan to consider 7 ideas in total, this means the prior probability is 2/7 * 100 = 29%.
- Because this intervention came out very promising in the previous stage of the research, we have updated the likelihood of recommendation to 70%.
- The 95% confidence interval represents how sure we are that there is a 70% chance this idea will be in the top two ideas. At this stage we had not done very much research in this area, though there are some strong indications that this is a good idea, such as how good of an intervention this is for farmed finfish.

1.1 Informed consideration

The impact of this intervention would rely on whether or not crustaceans are farmed in systems where water quality can be affected (i.e., not in systems such as sea cages) in the top producing countries.

1.2 Expert view

We expect experts to be positive about this intervention as it tackles chronic suffering, which experts tend to favor over interventions which tackle acute suffering. Experts may be more supportive of this intervention if it is directed at big crustaceans (crabs, lobsters, and crayfish) rather than small crustaceans (shrimps and prawns), as we are more certain that big crustaceans are morally significant.

1.3 Weighted factor model

The strength of the idea will be capped by the evidence base for the effect of water quality parameters on crustacean welfare, which is less strong than the evidence base for the effect of water quality parameters on finfish. Additionally, the right level for crustacean welfare of several key water quality parameters is not fully understood.

1.4 Cost-effectiveness

This intervention stands to be very cost-effective, as a similar intervention – improving water quality for farmed fish – is very cost-effective [5].

2 Informed consideration: Crucial considerations

After the prior view, we began the research process by identifying crucial considerations for this intervention. In this early phase, we considered:

- which species of crustacean to work on;
- what production systems these priority crustaceans are farmed in;
- which water quality parameter to work on;
- which of the top five producing countries has the worst water quality levels currently;
- how the COVID-19 pandemic will affect the promise of this intervention.

2.1 Which species of crustacean should we work on?

The groups of crustaceans we considered working on for this intervention were lobsters, crayfish, crabs, shrimp, and prawns. The decision of which group to prioritize was a trade-off between the higher probability of sentience and likely worse lives of the big crustaceans (lobsters, crayfish, and crabs) and the higher quantity of production of the small crustaceans (shrimp and prawns).

To make this decision we tried to model the total lifetime welfare points we could stand to affect when working with any of these groups. This measurement allows us to compare conditions for various animals so we can most effectively allocate resources. The calculation included the number of individuals farmed globally, the probability of sentience, and the welfare point score of these groups (categorized by "big" and "small" crustaceans). Even when accounting for a lower probability of sentience and a better quality of life, shrimp seems to be the most promising group to work on given the huge scale at which they are farmed. The total lifetime welfare points we could stand to affect by group, in descending order, are as follows [6]:

1. Shrimp* - 1.2 trillion welfare points
2. Crayfish - 270 billion welfare points
3. Prawns* - 220 billion welfare points
4. Crabs - 56 billion welfare points
5. Lobster - 470 million welfare points

With shrimp as the chosen crustacean, the species to prioritize is an easy choice. In 2017, whiteleg shrimp (*Litopenaeus vannamei*) made up ~59.9% of global shrimp aquaculture production [4] and ~95.4% of shrimp aquaculture production in the top five shrimp producing countries (China, India, Indonesia, Vietnam, and Ecuador) [7]. Therefore, this intervention will target whiteleg shrimp.

** Note that shrimp and prawn are sometimes used interchangeably. We categorize "shrimp" as any species with "shrimp" in their name on fishcount.org and "prawn" as any species with "prawn" in their name on fishcount.org.*

2.2 What production system is most commonly used to farm whiteleg shrimp?

We limit our scope for this consideration to the top five shrimp producing countries: China, India, Indonesia, Vietnam, and Ecuador. We use the following definitions of extensive, semi-intensive, intensive, and super-intensive from the FAO [8]:

- Extensive: 4–10 PL/m^2
- Semi-intensive: 10–30 PL/m^2
- Intensive: 60–300 PL/m^2
- Super-intensive: 300–450 PL/m^2

Country	Production type of whiteleg shrimp	Production system
China	Intensive [9]	Mostly earthen ponds, though liners made of plastic or concrete may be used in intensive systems [9]
India	Semi-intensive and intensive [10]	Pond-based brackish water farms [11]
Indonesia	Semi-intensive and intensive [12]	Concrete or polyethylene-lined ponds [13]
Vietnam	Intensive and super-intensive [14]	Intensive production can be found in earthen ponds and super-intensive production can be found in indoor ponds located in greenhouses [14]
Ecuador	Extensive and semi-intensive [15], and	(Coastal?) Ponds [15]

	there is some evidence that there is also intensive production [16].	

2.3 Which water quality parameter should we work on?

Unlike for finfish, there does not seem to be any comparative literature that considers what water quality parameter is most important for shrimp welfare. Instead we can only find studies considering the effects of dissolved oxygen on shrimp welfare, claiming that dissolved oxygen is the most important parameter for welfare; and studies considering the effects of salinity on shrimp welfare, claiming that salinity is the most important parameter for welfare. Therefore, we had to conduct our own comparative analysis. To do this we considered the effects of different water quality parameters on various indicators of welfare. The water quality parameters considered were dissolved oxygen, temperature, ammonia, pH, and salinity. The welfare indicators considered were cortisol, mortality rate, growth rate, disease rate, feed conversion ratio (FCR), and swim speed* [17]. It is important to note that we struggled to find many studies evaluating the effects of these water quality parameters on indicators that producers do not care about (e.g. cortisol levels). A summary of the estimated effect on each welfare indicator for all water quality parameters considered can be found in the table below.

	Welfare indicator					
Parameter	Cortisol levels	Mortality rate	Growth rate	Disease rate	Feed conversion ratio (FCR)	Swim speed
Dissolved oxygen	N/A	~14.8% decrease in mortality given a 1 mg/L increase in DO	Final weight increases by ~2.2g given a 1 mg/L increase in DO	N/A	FCR improves by 0.28:1 given a 1 mg/L increase in DO	N/A
Temperature	N/A	Increasing temperature between 20-25 °C decreases mortality by ~3.12% given a 1 °C increase in temperature. Past this, mortality increases by ~7.9% per °C	Growth rate increased by ~0.24 given a 1 °C increase in temperature	N/A	Small and medium shrimp do not seem to be affected, but large shrimp have their most efficient FCR at 23 °C, and temperatures higher and lower than this worsens FCR	Ucrit increased as temperature increased from 17 to 29 °C
Ammonia	N/A	Increasing the ammonia concentration between 13-19 mg/L increases	Shrimp weight and length were lowest under ammonia concentrations	There were no significant differences in various immune	N/A	N/A

		mortality by ~9.8% given a 1 mg/L increase in ammonia	of 13 and 19 mg/L. Maximum growth was observed at 0 and 6 mg/L	parameters in the range of 0.01 to 21.60 mg/L		
pH	N/A	Outside of the 5–9 pH range, a change in the pH level of 1 pH increases mortality by ~98.5%. Inside of the 5–9 pH range, a change in the pH level of 1 pH increases mortality by ~3.7%	The final weight remained fairly stable within the 5–9 pH range, but the growth rate increases as the pH increases within this range	N/A	Within the 5–8 pH range, the FCR improves by ~0.62:1 as pH increases by 1	N/A
Salinity	N/A	One study found a not statistically significant mortality effect from different salinities. However, other studies found that morality increases by ~0.9% with a 1% salinity increase	One study found a not statistically significant growth effect from different salinities. However, another study found that growth rates increase by ~0.6% as salinity increased from 4% to 32%	N/A	One study found a not statistically significant FCR effect from different salinities	N/A

From this analysis it seems that dissolved oxygen is most important for shrimp welfare as it has the most significant effects on the welfare parameters we have considered, though temperature seems like a close second. We have chosen to model managing dissolved oxygen for this report, but our implementation report will further explore whether we should recommend pairing this with another water quality parameter (e.g. temperature), or working on water quality more generally, not dissolved oxygen specifically, or working on another shrimp welfare ask. We are keeping this open as an option for two main reasons: 1) we are aware that all water quality parameters interact with one another, which could mean that working on dissolved oxygen in isolation is not the best approach; and 2) dissolved oxygen might currently look to be the most promising parameter to work on as it is the most studied, rather than because it is objectively the best. We will keep these limitations in mind, consider them further in the implementation report, and make the charity entrepreneurs aware of these issues such that they can pivot if new evidence moves away from a focus on dissolved oxygen in isolation.

**Note: In some cases active swimming is a sign of stress [18], so we must carefully analyze any studies considering swim speed as a welfare indicator.*

2.4 Which country should we work in?

To make this decision, we considered existing water quality standards in the top five shrimp producing countries and how far these standards are from optimal. This is summarized in the table below for adult individuals.

Parameter	Optimal	China	India	Indonesia [19]	Vietnam [20]	Ecuador
DO (mg/L)	4-9	N/A	N/A	3-6*	≥3.5	N/A
Temperature (ºC)	20-32	N/A	N/A	N/A	18-33	N/A
Ammonia (mg/L)	<0.03-1	N/A	N/A	N/A	<0.3	N/A
pH	6-9	N/A	N/A	N/A	7-9 fluctuating not more than 0.5 in a day	N/A
Salinity (ppt)	0-35	N/A	N/A	N/A	N/A	N/A

** Note: It does not seem like this is an actual enforceable standard of dissolved oxygen, but on the aquaculture agency's website it states "the dissolved oxygen requirement for optimal shrimp farming ranges from 3-6 ppm". However, we found a study which suggests that the mean dissolved oxygen levels on intensive farms in Indonesia is 4.84 mg/L [21]. It could very well be that many shrimp farmers are aware of this 3-6 mg/L recommendation and as such that dissolved oxygen is optimal on these farms.*

As shown in the table above, it seems as if most of the top five shrimp producing countries do not have enforceable water quality standards. We did find effluent water quality standards for all countries other than China and Indonesia, but these standards will likely not accurately represent water quality during production as wastewater is often treated before being discarded.

These findings may suggest that non-optimal dissolved oxygen is more of an issue in countries where we could not find existing water quality standards, or at least that dissolved oxygen is less of a neglected issue in those countries where we did find water quality standards. However, we remain uncertain as to which country seems best to work in, other than noting that India seems most promising to do animal advocacy work generally [22]. We will use experts to try and answer this question later in the process.

2.5 How will the COVID-19 pandemic affect the promise of this intervention?

Note: The considerations outlined below are not exclusive to this specific intervention and are likely to affect any intervention that places greater standards on shrimp production.

It is likely that the COVID-19 pandemic has negatively affected the promise of this intervention. It seems as if shrimp farmers will be less willing to make welfare improvements as they try to get back on their feet after being one of the hardest-hit sectors of the coronavirus outbreak [23]. Demand for shrimp has been volatile since the pandemic began, and the economic slowdown caused by the pandemic is likely to have affected "those [animal products] more commonly consumed outside (like fishes in some countries) and economically valuable crustaceans (i.e., lobsters, crabs, and shrimps)." [24] However, we expect that these effects are likely temporary.

In Vietnam, there is mixed messaging as to whether the pandemic has positively or negatively affected the shrimp sector. Some Vietnamese news sources have suggested that the pandemic could be a good thing as many markets have reduced shrimp imports from China, stating that this could be an opportunity for Vietnamese shrimp exports to grow in these markets [25]. Other sources have suggested that the pandemic has "resulted in multiple companies in China halting their purchases of Vietnamese products" which has "forced" Vietnamese products to seek new destinations [26], which does not look as positive as Vietnamese news sources are suggesting.

It is also important to note that it could initially be difficult for charity entrepreneurs to get onto farms to work with farmers with lockdown and social distancing rules in place. Again, we expect this to only be temporary and therefore will not have a relevant long-lasting effect.

3 Expert view

This section summarizes conversations between the lead researcher and a range of experts, including advocates, academics, and industry representatives.

Overall, the seven experts held mostly positive views about the promise of working with farmers to improve dissolved oxygen levels: ~71% had a positive view and ~29% a negative view. The concerns of these critics were the potential for increased stocking density as a result of better dissolved oxygen management making this intervention net-negative for shrimp welfare, and that Indian farmers would likely be unwilling to work with a new charity to improve the water quality standards on their farms.

The main update from this methodology is that Vietnam looks to be the most promising country for implementation. We went into these expert interviews without a real sense of which of the top five producing countries would be best to work in. After speaking with Zuridah Merican, we narrowed down from this top five to India and Vietnam, as Zuridah said that water quality is more of a constraint for shrimp farmers in these countries than in China, Indonesia, and Ecuador. Following this, we spoke with an agricultural scientist from India and a contact from the Ministry of Agriculture and Rural Development from Vietnam. Our conversation with an agricultural scientist in India updated us away from working in this country as it seems water quality is already well managed, and farmers may be unwilling to work with a new charity. This left Vietnam as our best option. We were also updated further towards working in Vietnam after our conversation with our contact from the Ministry of Agriculture and Rural Development. They reported that dissolved oxygen levels are often below optimum on farms and that farmers would be willing to work with a new charity to improve dissolved oxygen levels as this will help them overcome an issue caused by climate change, which lowers oxygen levels through increasing temperatures.

Phil Brooke

Profile: Phil works as Research Manager for Compassion in World Farming. He was contacted to get the opinion of an animal advocate on the promise of improving dissolved oxygen levels for farmed shrimp.

Summary: Phil mentioned that although providing aeration equipment might temporarily help the shrimp in the farm, it may also allow farmers to keep the shrimp at higher stocking densities to the overall detriment of their welfare.

Because of this, Phil thought that encouraging the purchase of humane stunning equipment would be more promising.

More information can be found in the conversation summary.

Olivier Decamp

Profile: Olivier is an academic who has written many papers on the effects of various water quality parameters on shrimp welfare. He is also a segment director at INVE Aquaculture, which develops technology and products to aid the aquaculture industry. He was contacted after reading his paper "Effect of salinity on natural community and production of Litopenaeus vannamei (Boone) within experimental zero-water exchange culture systems" to get his opinion on water quality as an intervention. We also wanted to ask whether effluent water quality is representative of water quality throughout production (as for some of our countries of interest we could find effluent water quality standards but not general water quality standards).

Summary: Olivier thinks that farmers know they need to maintain dissolved oxygen at an acceptable level as this message has been given to them by government agencies, consultants, opinion leaders, and private companies. For those farmers that are not managing dissolved oxygen, a new charity may need to help them analyze these parameters and advise them on ways to cost-efficiently maintain the required levels of dissolved oxygen. It is also important to note that farmers might not currently have aeration equipment as energy cost and/or access is a critical barrier in most countries.* Olivier also noted that effluent water quality standards are not representative of water quality during production as wastewater should be treated before being released.

More information can be found in the conversation summary.

** Note: This does not appear to be the case in Vietnam, our likely country of implementation, as most farmers already have aeration equipment* [3].

Zuridah Merican

Profile: Zuridah is editor and publisher of a prominent aquaculture magazine, AQUA CULTURE Asia Pacific. Olivier Decamp connected us with Zuridah as someone who would be able to answer questions about the promise of working on water quality in Asia specifically.

Summary: Zuridah suggested working in Vietnam or India as water quality is an important constraint for shrimp farmers in these countries, more so than in China, Indonesia, and Ecuador. She stated that farms that do not have optimal levels of water quality likely have problems because of poor knowledge or the costs of maintaining optimal water quality levels.*

More information can be found in the conversation summary.

** Note: Here Zuridah was commenting on shrimp aquaculture in Asia in general. In Vietnam, it seems that dissolved oxygen is reducing below optimum due to farmer's poor technical controlling capability* [3].

An anonymous agricultural scientist from India

Profile: This agricultural scientist did not want to be named or their conversation summary shared. They were contacted to learn about shrimp farming in India. We were particularly interested in current conditions on farms.

Our team's major updates after this conversation: Dissolved oxygen levels in India appear to be optimal for welfare, so this intervention may not be necessary. It also seems as if farmers would be unwilling to work with a new charity, as the aquaculture sector in India is self-reliant and self-sustaining.

An anonymous contact at the Ministry of Agriculture and Rural Development

Profile: A warm introduction was made to a contact at the Ministry of Agriculture and Rural Development as we wanted to learn about shrimp farming in Vietnam. We were particularly interested in current conditions on farms.

Summary: Dissolved oxygen often ranges from 2 to 4mg/L, but dissolved oxygen is becoming increasingly hard to manage due to climate change which, for example, decreases the levels of dissolved oxygen by increasing the temperature of the water. Farmers in the Mekong Delta region would be especially interested in working with an NGO that can help them strengthen their climate change resilience. Managing dissolved oxygen is a part of this.

More information can be found in the conversation summary.

Claude Boyd

Profile: Claude is a professor at the International Center for Aquaculture and Aquatic Environments who has been involved in many studies concerning water quality and welfare. He was contacted to learn more about the interaction between aeration and stocking densities.

Summary: Claude stated that stocking densities will increase by 400-500 kg/ha for every 1 hp/ha of aeration. At a harvest weight of 18g per shrimp, this increase in yield would require an additional 22,222-27,778 PL/ha or 2.2-2.8 PL/m^2 (independent of current survival rates on farms).

More information can be found in the conversation summary.

Andrew Ray

Profile: Andrew is an Associate Professor at the Kentucky State University Aquaculture Research Center. He was contacted to get his opinion on water quality as an intervention.

Summary: Andrew stated that water quality is the most important factor for shrimp welfare, both in the abstract and in practice on shrimp farms (i.e. water quality is a big concern for shrimp farmers).

More information can be found in the conversation summary.

4 Weighted factor model

In this stage of research, we scored this intervention based on preset criteria and weightings. We also generated a causal chain.

Overall, the weighted factor model suggests that improving dissolved oxygen is likely to be one of the top interventions we have considered as it performs well across all criteria of the weighted factor model.

This graphic shows the score of the intervention in each area:

4.1 Strength of the idea

Score: 6/10

The evidence base for the effects of 'non-optimal' dissolved oxygen levels on shrimp welfare (where optimal is defined as 4 to 9mg/L, the level we believe to be best for whiteleg shrimp welfare) is similar in quality and quantity to the evidence base for the effects of other water quality parameters [17]. The evidence base was more consistent for dissolved oxygen than for other parameters, however. Of the studies that we could find on evaluating dissolved oxygen, all suggested that whiteleg shrimp are sensitive to 'non-optimal' dissolved oxygen levels. The evidence base is more mixed for other parameters. With respect to salinity, for instance, we found four studies suggesting that whiteleg shrimp are sensitive to low levels of salinity, but also found evidence suggesting no significant differences in mortality rates, feed conversion ratio (FCR), or growth rates at different salinities.

We were able to find studies exploring the effects of differing levels of dissolved oxygen on mortality rates, FCR, and growth rates of farmed whiteleg shrimp. However, we were unable to find studies exploring the effects of differing levels of dissolved oxygen on welfare indicators that farmers would have less interest in, such as cortisol levels, disease rate*, and swim speed. We would like to see more research on these indicators to increase our confidence in improving dissolved oxygen levels as an intervention to improve shrimp welfare.

This intervention is likely to be cost-effective (discussed further in the following section, Cost-effectiveness analysis). We expect improving dissolved oxygen levels to affect a large number of welfare points (12 to 22 welfare points per year [27]), and due to the large number of individual shrimp that can be found on any given farm in Vietnam - we have estimated that there are approximately ~1.5M shrimp per farm [28].

** Note: we do not know to what extent farmers care about disease rates in themselves, but certainly farmers care about disease rate insofar as it affects production (e.g. disease outbreaks have been a major problem in shrimp aquaculture, especially in Asia [29]).*

4.2 Limiting factors

Score: 7/10

Talent, counterfactual replaceability, and the size of the problem are unlikely to be limiting factors in the short or long term.

We are currently unsure whether this intervention would be easy or difficult to fundraise for. OpenPhil and the EA animal welfare fund have previously given funding to crustacean interventions. OpenPhil gave the Humane Slaughter Association funding to "support research to improve the welfare of farmed... decapod crustaceans (crabs, lobsters)" [30], and the EA animal welfare fund gave Crustacean Compassion funding to extend the legal protections of the UK Animal Welfare Act to decapod crustaceans like crabs and lobsters [31]. Although this could be taken as a positive update for funding availability, these grants have been focused solely on "big" crustaceans, or both "big" and "small" crustaceans, not just "small" crustaceans. We cannot be sure that funders would be willing to fund a charity focused on shrimp as they are generally considered less morally significant than bigger crustaceans like lobsters. It is important to note, however, that very few organizations currently work on shrimp welfare.

We should not take this lack of funding as a very serious update, as it could be the case that these interventions would be well funded if they existed. This seems to be the case given a recent request for proposals from the EA animal welfare fund. The request aims to solicit applications that its fund managers feel particularly excited about, listing areas and subareas of particular interest to the fund managers. One of these areas is "Efforts that aim to improve the welfare of neglected farmed animals such as fish, or invertebrates, especially shrimp and prawns" [32].

The biggest limiting factors we expect this intervention to face are logistical bottlenecks and the barriers of (likely) Western co-founders working in a non-native country. The main logistical bottleneck is that it is a long and difficult process to register a nonprofit organization in Vietnam. This could slow down or inhibit the charity's progress [33], especially if farmers are less willing to work with the entrepreneurs without registration. The main barrier that arises when running an organization in Vietnam with non-native co-founders is that English proficiency is low in the country [34]. We expect that to make significant progress here the entrepreneurs will need accessibility to Vietnamese, which will likely come from a local hire. Other barriers including the potential lack of cultural knowledge can also be overcome by making a local hire early on.

4.3 Execution difficulty

Score: 7/10

The nonprofit registration process in Vietnam could be a barrier that prevents the intervention from starting well.

The main challenge that this organization could face in running well is a low uptake of the intervention from farmers. We think it likely that farmers would be more interested in working with a new charity if the charity offered to subsidize the costs of aeration. These subsidization costs seem reasonable, so the charity should have little difficulty fundraising enough money to cover this. We have also recommended this intervention be started in Vietnam as it seems as if Vietnamese farmers would be open to working with NGOs on welfare improvements [3].

The feedback loops should be fairly quick in most cases. Metrics of success are easy to measure: for example, mortality rates and cortisol levels are informative even if taken only once (although dissolved oxygen should be controlled daily, and measured at least twice daily). It is also important to remember that mortality rates and cortisol can fluctuate due to factors other than the oxygen level, so these measures might not be perfect.

4.4 Externalities

Score: 7/10

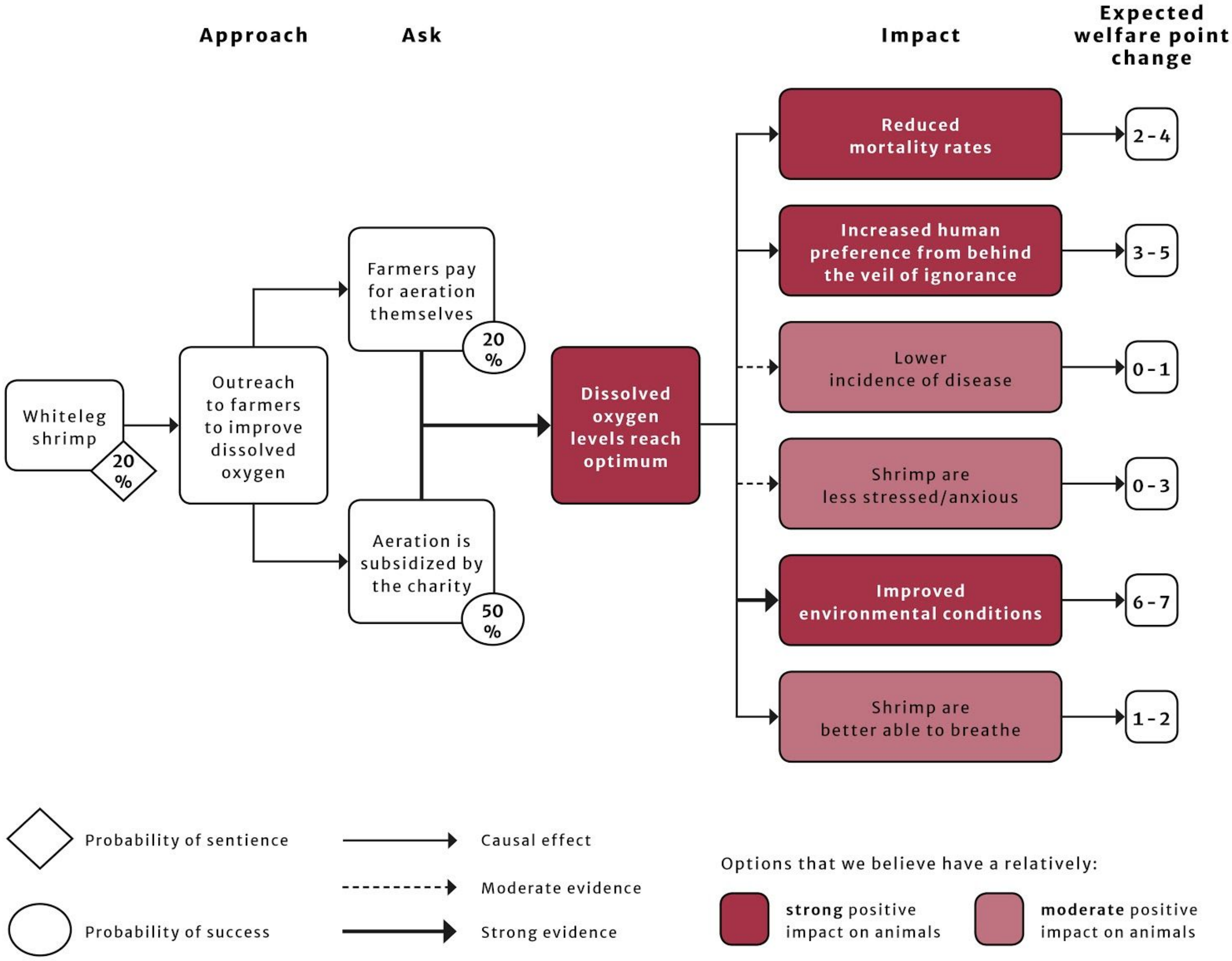
Skills and lessons gained through this intervention would be transferable to outreach and cooperation in other industry-type interventions. Although the nonprofit field for shrimp welfare is currently non-existent, it seems it would be relatively easy to establish. Also, as this intervention will likely be implemented in Vietnam it could positively contribute to building the animal advocacy movement in an important neglected country.

One of the most important indirect effects for this intervention is that since improved dissolved oxygen levels decrease mortality, farmers need to stock fewer shrimp in their ponds at the beginning of production to get the desired tonnage of shrimp at the end of production. Therefore, this intervention could spare shrimp lives. However, better dissolved oxygen management in intensive systems could also facilitate even more intensive farming. If water is reliably oxygenated, you can keep the shrimp at higher stocking densities to the overall detriment of their welfare. We have estimated that there will be a 100% likelihood that farmers will increase stocking densities by 25% of the maximum possible given improved aeration as a result of this intervention. It might intuitively seem as if increasing stocking densities by the maximum possible would be the obvious choice for farmers as it could increase profitability. However, there are some good reasons farmers might not choose to increase stocking density:

- More feed will be necessary. At a typical feed conversion ratio of 1.5, an additional 600-750 kg feed/ha/crop would be necessary for 400-500 kg/ha more shrimp [35]. On top of this, feed is expensive in Vietnam, where the feed price is 10-15% higher compared to other countries [36].
- The costs of other inputs, maintenance, and labor may also rise. Since most farms are owned by families rather than corporations, farmers might not be able to make this kind of investment [37].
- Fears of disease rate increasing, which becomes more of a problem as stocking densities increase [38].
- Stocking density also influences the size of the shrimp at harvest. That is, in more crowded farms, shrimp typically grow smaller [39]. So when adjusting stocking density farmers will have to consider the shrimp sizes required by the market.
- Difficulty managing dissolved oxygen levels is only one of the many challenges farmers have to deal with. Better dissolved oxygen management thus does not mean that farmers can just increase stocking densities as increased stocking densities could exacerbate other existing issues. Find out more about the other issues faced by Vietnamese farmers in this conversation summary.

Although this intervention still appears to be cost-effective when modeling possible stocking density increases, it is also worth it for the entrepreneurs to consider making subsidization conditional on a maximum stocking density increase. For example, the charity would only subsidize aeration if stocking density is not increased, or the level of subsidization could depend on the stocking density increase. We will consider this point further in the implementation report, and will likely recommend the entrepreneurs keep this as an option to consider once they have more experience on farms, and with whether farmers hope to increase stocking density. Another option that the entrepreneurs should keep in mind and be prepared to do if need be is pivot away from this intervention (or shut down the organization entirely) if it turns out that farmers are increasing their stocking densities by too much.

4.5 Causal chain



5 Cost-effectiveness analysis (CEA)

This section summarizes our CEA, which weighs the likely cost of this intervention against the likely good accomplished. To quantify impact for animal welfare interventions, we use a system of welfare points (adjusted for probability of sentience and expected lifespan). Our cost-effectiveness analyses quantify the number of such welfare points we expect to affect per dollar spent.

This CEA models the impact of improving dissolved oxygen levels for farmed whiteleg shrimp in Vietnam. This approach is not necessarily recommended as a path forward for entrepreneurs, but was chosen to provide a rough sense of the cost-effectiveness of working on shrimp welfare. Entrepreneurs may pivot based on their own research: for example, they may instead work to prevent eyestalk ablation, another potentially promising intervention for shrimp welfare.

Detailed discussion of the CEA is laid out in Supplement A.

5.1 Overview

Improving dissolved oxygen levels for farmed whiteleg shrimp may affect a total of ~87.8 welfare points (WP) per dollar when subsidizing aeration (considering co-founder and funding counterfactuals).

Without subsidization, this intervention looks less promising. It is less likely to succeed and entails a greater risk that farmers increase stocking densities, which could harm shrimp welfare in aggregate. We have nonetheless included the figures in this section for reference.

Model		WP without subsidization	WP with subsidization
Google Sheets	With counterfactuals	-36.2	87.8
	Without counterfactuals	117.8	207.3

We took into account the following factors in our CEA:

- Probability of success
- Affecting factors
- Direct effects
- Indirect effects
- Costs

- Counterfactuals
- Years operating
- Where our CEA could go wrong

Our considerations for these issues are laid out in the sections below. Further discussion can be found in Supplement A.

5.2 Probability of success

These percentages are an average of the probabilities of success given by our team for each scenario:
Without subsidization: 20%
With subsidization: 50%
We expect it to be easier to convince farmers to work with a new charity if the costs of aeration are subsidized.

5.3 Affecting factors

Affecting factors are the variables that could change cost-effectiveness the most. The table below shows the impact of affecting factors in each scenario.

The r^2 value used here for each factor shows how much of the variance in cost-effectiveness is explained by variance in that factor. That is, using an example from the table below, if the total WP loss is changed, this will change the cost-effectiveness of the intervention by a moderate amount when subsidizing farmers to make these welfare improvements. Factors are color-coded to reflect the extent to which they alter cost-effectiveness, from red (does not change cost-effectiveness) to green (significantly changes cost-effectiveness).

	Total WP affected (r^2)	Total WP loss (r^2)	Charity costs per year (r^2)
Without subsidization	0.33	0.31	0.25
With subsidization	0.17	0.51	0.16

5.4 Direct effects

Detailed figures for the following considerations (including ranges) can be found in our Guesstimate model.

To calculate the direct effects of improving dissolved oxygen levels, we took into account:

- The lifespan of a shrimp on a Vietnamese farm
- Welfare points affected when improving dissolved oxygen levels
- Average number of shrimp per farm
- Number of farms a charity can work with in its first year
- Number of farms a charity can work with each additional year

Putting these all together, we estimate that we could affect 2.8 billion welfare points when improving the dissolved oxygen levels for 640 million shrimp. All of the welfare points gained for this intervention come from these direct effects.

5.5 Indirect effects

Detailed figures can be found in our Guesstimate model.

To calculate the indirect effects of improving dissolved oxygen levels, we focused primarily on the welfare point loss from the potential increase in stocking density that comes with better dissolved oxygen management. We took into account:

- The probability that farmers would increase stocking density
- Increase in stocking density as a fraction of the potential stocking density increase
- Welfare point score of a shrimp with optimal dissolved oxygen levels (as this intervention could result in more shrimp being farmed)
- Current stocking density
- Difference between current and optimal dissolved oxygen levels
- Horsepower needed to increase dissolved oxygen by the desired amount
- Maximum stocking density increase due to better dissolved oxygen management

Putting these all together, we estimate that increased stocking density could result in a loss of ~142 million welfare points (~602K welfare points per farm worked with).

5.6 Costs

Detailed figures for the following components (including ranges) can be found in our Guesstimate model. We calculated:

- Staff costs: $104K
    - Based on: number of founders; founders' salaries; number of other staff; other staff's salaries.
- Logistics & administration costs: $13K
    - Based on: travel (international & domestic); office space; subscription costs.
- Subsidization costs: $165K across the whole ten years of operation
    - Based on: the cost of aeration per lb of shrimp, the weight of a shrimp, the number of farms worked with, and the average number of shrimp per farm.

Using these numbers, we estimate the following costs:

- First year costs: $77K without subsidization, $79K with subsidization
    - Based on: co-founder salaries; international and in-country travel; office costs; subscription costs; and the cost of subsidization (scenario dependent).
- Charity costs per year: $120K without subsidization, and an average of $280K with subsidization
    - Based on: staff costs, logistics and administration costs, and the cost of subsidization (scenario dependent).

5.7 Counterfactual costs

Detailed figures and ranges for counterfactual costs can be found in our Guesstimate model. We calculated:

- Co-founder counterfactuals: 38M WP without subsidization, 74M WP with subsidization
    - Based on the value co-founders could contribute at other high-impact organizations or through earning to give.
- Funding counterfactuals: 7M WP without subsidization, 18M WP with subsidization
    - Based on the amount of funding diverted per year from high- and medium-impact charities, and the estimated impact of high- and medium-impact charities.

5.8 Years operating

We have assumed that this charity will operate for roughly ten years. Figures can be found in our Guesstimate model.

5.9 Where our CEA could go wrong

We considered how our CEA could go wrong in each step. Some general potential issues include:

- Best guesses and value judgments: certain figures are estimates by Charity Entrepreneurship staff. Another person could look at the same evidence and come to a different conclusion. Those with different judgments should copy our models and insert their own estimates. These best guesses and value judgments include:
    - Probabilities of success
    - Probability that farmers will increase stocking density
    - Number of welfare points affected by improving dissolved oxygen levels
    - Welfare point score of a shrimp with optimal dissolved oxygen
- Other factors: with an 80-hour summary report, it is impossible to exhaust every angle. There are likely factors that may affect the CEA in ways we cannot predict. Equally, factors inherent to our modeling may influence the results of the CEA.

For further discussion of our CEA, please see Supplement A.

6 Informed consideration: Internal contemplation

In this stage, we analyzed all the data and insights gathered through previous steps in the research process. The most important conclusions from each are summarized here, as are our team's overall thoughts on improving dissolved oxygen levels for farmed shrimp as an intervention.

6.1 Crucial considerations

Summary: Overall this intervention looks positive under the informed consideration methodology. Our review found that dissolved oxygen appears to be the most important water quality parameter for shrimp welfare. The main update at this stage was a positive update toward the promise of this intervention, after deeper research into shrimp specifically found that production mostly occurs in ponds (not caged systems as we had initially thought). The main remaining uncertainty at this stage was the country of implementation, as for most of the top producing countries we could not find water quality standards to base this decision on.

At the idea prioritization stage we were concerned that while improving water quality seemed promising in the abstract, we would be unable to have a meaningful impact on water quality in practice as we thought that most production took place in cages. This concern was overcome after we chose shrimp as the crustacean to focus on, as deeper research found that shrimp production occurs mostly in ponds where water quality is easily modified. Since at the 2-hour stage we had not narrowed down which crustacean we wanted to focus on yet, we were broadly researching "crustacean production". These results must have been skewed mostly by results of lobster farming, which appears to most commonly occur in cage systems. Crucial considerations research thus updated us positively towards the promise of this intervention.

6.2 Expert opinions

Summary: Overall this intervention looks promising under this methodology. A contact from the Ministry of Agriculture and Rural Development said that dissolved oxygen is currently below optimal on Vietnamese farms, and that farmers would be willing to work with a new charity to improve this. Our conversations with experts led us to two big updates. We learned that Vietnam seems to be the most promising location for this intervention. This is based on the scale of production, current dissolved oxygen levels on farms, and the fact that our contact in Vietnam believes that farmers would be open to working with a new charity to improve their dissolved oxygen levels. Although better management of dissolved oxygen may result in increased stocking densities on farms, it seems unlikely that this will be net-negative for shrimp welfare. As a result, working with farmers to improve water quality to optimal levels still looks to be promising. We had few remaining uncertainties after speaking with experts.

We initially planned to contact experts from all of the top 5 shrimp producing countries, but we quickly narrowed our scope after hearing from Zuridah Merican. She stated that water quality was the biggest bottleneck in shrimp farming in India and Vietnam.

Our contact in India was an agricultural scientist. Our conversation with them negatively updated us on the promise of working in India. It seems that water quality levels are already optimal, and that farmers would be unwilling to work with a new charity as the aquaculture sector in India is self-reliant and self-sustaining.

Our contact in Vietnam was from the Ministry of Agriculture and Rural Development. Our conversation with them positively updated us on the promise of working in Vietnam. They said that dissolved oxygen levels are commonly between 2 and 4 mg/L, which is below the optimal levels of 4 to 9 mg/L. Furthermore, they stated that dissolved oxygen is becoming increasingly hard for farmers to manage due to climate change. They thought that this would mean that farmers in the Mekong Delta region would be especially interested in working with an NGO that can help them strengthen their climate change resilience. Managing dissolved oxygen is a part of this.

Our conversation with Phil Brooke from Compassion in World Farming was the first time we seriously considered the potential that this intervention could be net-negative for shrimp given possible stocking density increases. This negatively updated us on the promise of this intervention. Whether or not stocking density would increase, and if so whether this increase would make the intervention look net-negative, became a crucial consideration to answer before we could confidently recommend this intervention. We were lucky enough to get in contact with Claude Boyd who helped us get a better sense of how aeration can affect stocking density. This conversation helped us to answer our questions concerning whether this intervention would be net-negative, and updated us away from this concern.

6.3 Weighted factor model

Summary: Overall this intervention performed well under the weighted factor model methodology, scoring 6 or 7 on all criteria. This is the most promising animal advocacy intervention idea of those we have considered this year under this methodology. The main update at this stage was a slight negative update against the promise of this intervention due to the logistical bottleneck of a long and difficult registration process to become a non-profit organization in Vietnam. The main remaining uncertainties are also around this logistical bottleneck, as it is still unclear how this will affect the intervention in practice.

The difficulty of registering as an organization in Vietnam only slightly negatively updates us on the promise of this intervention. We still have some remaining uncertainties as to how this will affect the intervention in practice:

- Is it possible to work under organizations that are already registered in Vietnam rather than having to spend the time and resources to register as a new organization? This is possible in India, but we are currently unsure if the same is true in Vietnam. If it is possible, registration is less of a barrier to beginning implementation in Vietnam.
- Will farmers be less willing to work with the entrepreneurs if they are not registered as their own organization? We are uncertain on this, though our intuition is that farmers will be unlikely to worry about this as long as we work under another organization. If this is not possible, then this becomes more of a worry. Perhaps the entrepreneurs can start the registration process and farmers would be happy in the knowledge that the organization is at least registering to become an official organization.

6.4 Cost-effectiveness analysis

Summary: This intervention looks promising under this methodology, being one of the most cost-effective that we have considered. The cost-effectiveness analysis brought no big updates to the promise of this intervention. We decided not to model the impact that this intervention would have on the costs of production as we thought that the time it would take to do this well would be unjustifiable given the 20-hour time cap for this section of the research, and our assumption that the effect on prices would likely be quite small, anyway. Also, we have modeled this intervention using the individual farmer outreach approach as other common approaches - corporate or governmental outreach - do not seem best for Vietnam. The main remaining uncertainties after modeling this intervention is how likely it is that farmers will increase stocking densities. We have currently modeled this as a very wide confidence interval, 30%-90% probability, and it would improve the cost-effectiveness estimate if we had a better sense of what the true probability would be.

There were no big updates from the cost-effectiveness analysis, though we were surprised by how inexpensive aeration looks to be.

One indirect effect that we could have modeled in the cost-effectiveness analysis is the effect on the costs of production for shrimp farmers, and the resulting effects on supply and demand of shrimp. We decided not to model these effects for two reasons. Firstly, there are a lot of interconnecting factors to consider. For example, improving dissolved oxygen levels will improve the feed conversion ratio (FCR) but the potential increase in stocking density will mean that an additional 600-750 kg feed/ha/crop would be necessary. We expected that the time taken to fully understand and accurately model all of the effects would not be worthwhile given that we would only work with ~10 farms each year, too small a percentage of total farms in Vietnam to impact the price of shrimp. Secondly, we believe that the "foot-in-the-door" benefits of this intervention (or a similar one, such as working to prevent eyestalk ablation) are more important than the effect on supply and demand. The immense scale of shrimp farming dwarfs the ~10 farms we could work with, but by spotlighting shrimp welfare this intervention could have important flow-through effects. Even so, we plan to conduct future research on the costs of production and on supply and demand.

We have modeled individual farmer outreach as the approach for this intervention. Note that this approach was selected based on the choice of Vietnam as the country of implementation. Farmer outreach seems to be the best approach in Vietnam as corporate outreach and governmental outreach seem either inappropriate or slow. Most shrimp farmers are small in scale (even those in intensive production [40]). Fish Welfare Initiative notes that "Most of the production within Vietnam is from small-scale producers. It is important to understand their incentives. For example, they often do not sell their produce to corporations, and so are isolated from corporate systems that are often utilized by animal protection organizations." Additionally, "most fish farming systems in Vietnam seem to be small-scale and for sale at local markets." [41] Therefore, corporate outreach seems inappropriate. Although governmental outreach seems common in Vietnam (and has been successfully utilized by HSI/Vietnam), it is very slow.

6.5 Overall thoughts

This intervention looks to be the most promising of those we have researched this year as it scores well under all criteria. It is also one of the most cost-effective interventions considered. As the cost-effectiveness of an intervention is the criteria that we weight most heavily, this is one of the main reasons for its recommendation.

It is important to note that we have modeled a 100% probability that this intervention will increase production by 25% of the maximum possible given improved aeration. Though it still looks overall net-positive as the stocking density increase is expected to be quite small, we could see this being a problem under certain moral frameworks. Moreover, entrepreneurs who start this charity must keep this potential stocking density increase in mind. They may have to pivot away from this intervention (or shut down the organization entirely if there are no promising alternatives*) if the stocking density increase is higher than we have modeled. Though this might seem worrying, we could see there being potential to decrease the likelihood of a stocking density increase. For example, the entrepreneurs could make subsidies conditional on the promise that farmers will not increase stocking density. It is also worth noting that the potential reasons for not increasing stocking density are quite compelling, and could convince farmers without the need for this conditional offer.

** Note: If improving dissolved oxygen levels proves to unavoidably increase stocking densities to the overall detriment of shrimp welfare, another potentially promising ask is preventing the use of eyestalk ablation to increase fertility in shrimp. We will try to consider this intervention further, and will also be open to considering any other interventions that Rethink Priorities find promising in their research.*

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