The Cumulative Pain Framework for SWP

Executive Summary

What is this report?

This report is an attempt to understand a framework which can be used to quantify the different amounts of suffering that shrimps experience due to different farming techniques. Due to the difficulty of this task, much of this report is taken up in the discussion of the framework itself, and only a few example experiences of farmed shrimp are examined in moderate detail.

As I am not a shrimp expert, the quantitative estimates I have come up with will almost certainly be very inaccurate and so should not be thought of as very meaningful, but merely as a first attempt, of which the main value comes from being a helpful starting place for shrimp experts to critique and improve. To jump straight to these quantitative estimates, go to the section Using the Cumulative Pain Framework for Shrimp

What are the main findings?

The main finding is that the Cumulative Pain Framework can be used to compare between different painful experiences for shrimps, and to demonstrate this I have done exactly that for four experiences that farmed shrimps are unfortunately subjected to: eyestalk ablation, slaughter by asphyxiation, stunning via ice, and stunning via electrical shocks.

I definitely do not want to overstate the confidence I have in the specific quantitative estimates that I came up with, but their results lead me to tentatively think that the method of slaughter for shrimps is a more significant factor than whether or not shrimps experience eyestalk ablation.

What are the implications for the SWP?

The Cumulative Pain Framework (adjusted for our purposes) could be an extremely valuable tool to compare between different painful experiences for shrimp, and thus inform SWP's decisions on prioritising certain interventions over others.

Supplementary Reports

For a discussion of how results from the Cumulative Pain Framework can be used to compare across species, including between shrimps and humans, read: Rethink Priorities' Welfare Estimates for SWP

For speculative discussion on the weightings different pain intensities might have and why those weightings might be logarithmic, read: Logarithmic Pain Weightings for SWP

For appendices, read: Appendices for SWP

The Cumulative Pain Framework

The Cumulative Pain Framework is a tool designed by the Welfare Footprint Project, a research effort aimed at measuring the impact on welfare of different farming practices and associated interventions. In short, it is a metric designed to quantify the pain of individuals across a period of time.

The CPF does not assign a negative value to death, only to pain. Thus, the CPF is not a rights-based metric, but purely a welfarist, utilitarian metric.

The CPF divides pain into four distinct categories, and the amount of time the individual spends in each of these pain-categories is estimated. The framework does **not** attempt to aggregate the time spent in these four pain categories into one number, for reasons discussed near the end of this summary (however we only need to assume some weights to aggregate the results into one number, and we shall adjust the framework to do exactly this).

Of course, this approach still requires us to estimate which of the four pain categories the individual is experiencing. In fact, in the Cumulative Pain Framework, the individual is not said to be definitely in any one state, but to have a probability distribution over all four states. To estimate these probabilities, the framework uses the following forms of evidence: observations of the behaviour of the individual, as well as more quantitative indicators using physiological measurements (e.g. concentrations of certain hormones, brain activity, immune system response). The main form of evidence that the paper discusses is the observation of the individual's behaviour. The reason for this, is "*If the adaptive value of pain is to prompt protective and adaptive behavioural responses, the use of behavioural indicators of pain seems to be the particularly suitable way to interpret the intensity of the pain experienced.*"

The four pain categories are summarised below in increasing order of severity:

- Annoying
    - **Definition:** Annoying pain is experienced as aversive, but not intense enough to deter an individual from behaviours it is motivated to do.
    - **What to look for:** The pain can be ignored most of the time, and performance of cognitive tasks are only mildly affected. Vocalisations and other overt expressions of pain should not be exhibited.

- Hurtful
    - **Definition:** Experiences in this category disrupt the ability of individuals to function optimally. As opposed to Annoying pain, the ability to draw attention away from the sensation of pain is reduced: awareness of pain is likely to be

present most of the time, interspersed by brief periods during which pain can be ignored depending on the level of distraction provided by other activities.
    - **What to look for:** Individuals can still conduct routine activities that are important in the short-term (e.g. eating, foraging) and perform cognitively demanding tasks, but an impairment in their ability or motivation to do so is likely to be observed. Although animals may still engage in behaviours they are strongly motivated to perform (i.e., exploratory, comfort, sexual, and maintenance behaviours), their frequency or duration is likely to be reduced

- Disabling
    - **Definition:** Pain at this level takes priority over most bids for behavioural execution, and prevents all forms of enjoyment or positive welfare. Pain is continuously distressing.
    - **What to look for:** Individuals affected by harms in this category often change their activity levels drastically (the degree of disruption in the ability of an organism to function optimally should not be confused with the overt expression of pain behaviours, which is less likely in prey species).

- Excruciating
    - **Definition:** all conditions and events associated with extreme levels of pain that are not normally tolerated even if only for a few seconds. In humans, it would mark the threshold of pain under which many people choose to take their life rather than endure the pain.
    - **What to look for:** Behavioural patterns associated with experiences in this category may include loud screaming, involuntary shaking, extreme muscle tension or extreme restlessness. Another criteria is the manifestation of behaviours that individuals would strongly refrain from displaying under normal circumstances, as they threaten body integrity (e.g. running into hazardous areas or exposing oneself to sources of danger, such as predators, as a result of pain or of attempts to alleviate it).

The descriptions given above (and the more detailed descriptions given in the paper itself) are used to categorise the level of pain that the individual is feeling. As already said, this framework can be used in a probabilistic sense to convey uncertainty, with each of the 4 states above (actually 5 including the state of no pain) being assigned a probability to estimate the individual's state.

	i. Wound infliction Point of tissue rupture	ii. Hemostasis (coagulation)	iii. Acute inflammation	iv. Inflammation + proliferation
Excruciating				
Disabling	60%	20%		
Hurtful	40%	80%	70%	20%
Annoying			30%	60%
Duration	**0.5 - 2 min**	**5 - 15 min**	**0.5 - 2 days**	**7 - 14 days**

An example of a Pain-Track table with estimates for the state of the individual at different time lengths. This example is for a skin wound in an egg laying hen. When the percentages

do not add up to 100% in a time slot, the remaining percentage is attributed to no pain. See the paper for a detailed explanation for this example, including the ranges in duration.

As already stated, simple visual observation should not be the only method of pain intensity attribution when possible. Other forms of evidence include the concentrations of stress hormones, the activation of the immune system (indicating bodily harm), and specific kinds of brain activity. Obviously these forms of evidence are much more difficult and costly to collect, so in practice behavioural observations will usually be the main form of evidence.

To understand how the actions of species correlate with their hedonic experiences, the paper suggests measuring the relative strength of motivation to obtain a resource or enter a different environment. e.g. by seeing that a chicken makes a greater effort to get to an environment which has space to perch, than to an environment that has better ventilation, we can infer that space to perch is more important to a chicken than the ventilation is.

As animals in intensive farming typically have very similar lives to each other within a given species, we only need to analyse the lives of a few representative examples of individuals, e.g. broodstock shrimp, shrimps who die due to disease, shrimps who survive up to being slaughtered etc.

Ordinal Scale

The Cumulative Pain Framework is an ordinal (ranked) scale, not a cardinal (numerical) scale. Therefore, the Framework does **not** involve aggregating the time spent in different intensities of pain to reduce the experience down to one number because the authors have not been able to find a rigorous method for doing so. This does not mean that all comparisons are impossible, as the framework can be used to compare between different pain events, specifically, when one event has lower (or equal to) time-in-pain across all intensities. I have seen it reported as: “Event 1 has x% lower time in pain for Excruciating pain, y% for Disabling pain, etc”.

In fact, the framework can be used to compare between more events than just those which fit the above criteria. This is because even though we don’t know the weightings between the different intensities, we do know that the badness of the pain increases with the intensities, i.e. we know the weighing from a higher intensity to a lower intensity is greater than 1, even if we don’t know exactly what it is.

This means that if Event B is the same as Event A except that an amount of time from a high intensity pain has been shifted to a lower intensity pain, then we know that Event B must be better than Event A. An example of this situation is shown below.

To illustrate this, imagine an Event B is the same as an Event A, but B has X less time in a high intensity pain, and X more time in a low intensity pain. As we know that a certain amount of time in a high intensity pain is worse than that same amount of time in a lower intensity pain, we can know that Event A is worse than Event B.

Event A

		Total
Excruciating	75%	45 mins
Disabling	25%	15 mins

Hurtful		
Annoying		
Time:	1 hour	

Event B

		Total
Excruciating	50%	30 mins
Disabling	35%	15 mins
Hurtful	15%	15 mins
Annoying		
Time:	1 hour	

Even if we don't know the what the weighting should be between Excruciating and Hurtful pain, we know that Excruciating pain is worse than Hurtful pain (although we don't know **how much** worse), and so if Event A has 15 fewer minutes of Excruciating pain than Event B and Event B has 15 more minutes of Hurtful pain, we still know that Event B is preferable to Event A. However, if Event A had 15 minutes more Excruciating pain but 16 fewer minutes of Hurtful pain then we could no longer be certain that Event B is preferable (as it is possible, but incredibly unlikely) that the weighting between Excruciating and Hurtful labelled w is $1<w<(16/15)$).

This means that in practise the framework can often be used as intended, and it's only when things become ambiguous e.g. Event B has 1 less hour of Disabling pain, but at the cost of 10 more hours of Hurtful pain than Event A, which is better?

How can this framework be used in practice when there are more complicated tradeoffs?

I contacted the authors to ask how animal advocates can use this framework in practice without having some sort of weighting across the pain categories, and Wladimir J. Alonso explained that they originally hoped that the framework would be able to incorporate some kind of inter-category weighting, but that they eventually decided to abandon this due to the difficulty of the problem. Some of the difficulties:

- The inter-category weightings might be species-specific, i.e. how many times worse Excruciating pain is than Annoying pain might be different for different species. See this supplementary report for more discussion on comparisons between species: Rethink Priorities' Welfare Estimates for SWP
- This is a long debated problem in philosophy with no clear conclusion as to whether these sorts of comparisons are even possible, "How many people need to experience the slightest amount of discomfort (having a speck of dust land in their eye) to equate to one person experiencing the worst suffering imaginable?"

He sent me the beginning of the paper on this topic before it was abandoned. It discusses the surprising paucity of published papers on this topic, with only two relevant papers being found by their search.

In the absence of a better solution, I have used their preliminary speculative estimates as the weights for the framework for our purposes. So what follows is the Cumulative Pain Framework, with some weights which should not be taken too seriously.

A very speculative discussion of comparing across different intensities of suffering

"To investigate the equivalence of intermediate categories of pain intensity, we used the results of Dixon and colleagues (Dixon et al., 2011), who assessed various chronic diseases using a time trade-off approach (whereby participants identified the time in good health that was equivalent to ten years with each chronic disease state).

Finally, the equivalence between Disabling and Excruciating pain was subjectively assessed by ourselves, with Excruciating pain estimated to be 3,000 times worse than Disabling pain (in this case, 1 hour of Disabling pain is equivalent to 1.2 seconds of Excruciating pain). "

These numbers are shown in the table below (taken from the since abandoned paper):

Level*	**Category**	**Conversion Factor - relative to one hour in disabling pain (HDP)**	**Time Equivalence - num. hours equivalent to 1 HDP**
1	Annoying	0.00201**	496 hours (1 month***)
2	Hurtful	0.03125	32 hours (2 days***)
3	Disabling (Reference)	1	1 hour
4	Excruciating	3000	1.2 sec

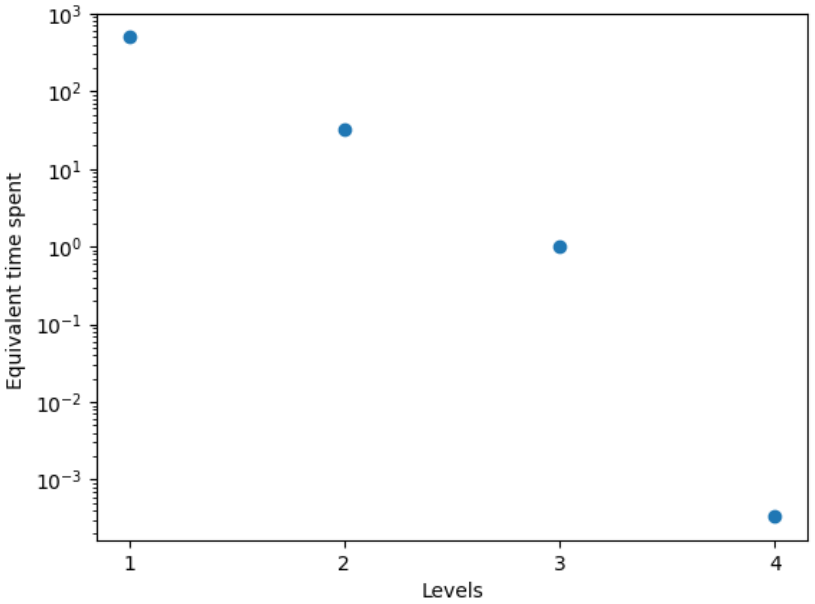
Note: The reference level of pain is 1 hour in disabling pain (HDP)

*The levels have no inherent numerical value, they are only ordinal (arbitrarily numbered 1 to 4).

**The equivalence between the Annoying and Disabling categories is based on the function $y = 0.99x^{2.99}$ (Wallenstein et al 1980), where *x* is the pain category, and *y* is total distress.

***The equivalence in days considers only active hours (16h/d), hence assuming no suffering during sleep.

These estimates place a very large weighting on Excruciating pain and a very low weighting on Annoying pain. This reflects research indicating that experiences often follow a logarithmic scale. My summary and discussion of a website post on this topic can be found here: Logarithmic Pain Weightings for SWP



This is a graph of the relative amount of time needed to be spent in the 4 pain levels to achieve equivalency according to the table above, plotted with a logarithmic y-axis. The three points in levels 1, 2, and 3 appear linear, meaning that the relationship is exponential, while the point corresponding to the 4th level is lower than would be expected, meaning that the relationship there is super-exponential.

However, in their tentative study, the authors made it clear that they don't trust these numbers very much:

"It is important to bear in mind that, even if guided by empirical evidence and adjusted progressively by increasing consensus, the conversion factors shown in Table 1 will always be highly subjective. Importantly, some categories of pain may not be even comparable: for example, in the case of Excruciating pain, it is not unreasonable to suppose that many would choose a permanent state of Annoying pain over a few minutes of torture-like pain (i.e. these categories would not be comparable numerically)[1]. Also, there is a deep philosophical and ethical puzzle regarding the validity of balancing levels of suffering among different individuals (Singer, 2015): would it be possible to equate the suffering of one sentient being who endures a state equivalent to 500 hours of disabling pain (HDP) to 500 people enduring only 1 HDP? For our purposes, however, the value behind estimates of equivalence comes down as a choice between making explicit and implicit valuations. By making our valuations explicit, a black-box is opened for public scrutiny and progress. Here, the assessment was guided by data pointing to the temporal equivalence between harms of different intensities (measured by the time trade-off approach; Dixon et al 2011) and between the equivalence of categorical and numerical ratings (Wellenstein et al 1980)."

Complications to this theory:

[1] Pedantic note from Cian: I don't see why a lifetime in Annoying pain being preferable to a few minutes in Excruciating pain shows that these are incomparable numerically, as a lifetime is finite. Maybe if the same people were asked whether they would want to live **three** lifetimes in Annoying pain rather than a few minutes in Excruciating pain they would switch to the torture, indicating that there is a conversion factor, albeit one that is extremely large.

- The effects of different welfare harms are not necessarily independent of one another, e.g. a piglet whose tail is docked may suffer from additional anxiety during other painful experiences when compared to a pig who has not had its tail docked.
- Prey species have evolved to mask their pain, so this makes it even more difficult to gauge their hedonic states.

Using the Cumulative Pain Framework for Shrimp

What follows is my quick (two working days by me, someone who has next to no knowledge about shrimp) attempt at a cumulative pain diagram for a few different kinds of farmed shrimp experiences. Due to the limited time I spent on these examples, they should be thought of as examples of how we could use the framework, and so do not take the results to be very meaningful. Many of the numbers are just guesses, and I have displayed these in red. I would love for some shrimp experts to critique my attempt and refine it to make it more meaningful and accurate.

The calculations are done in this spreadsheet: Cumulative Pain for Shrimp Spreadsheet

I used Guesstimate, a free web tool for making probabilistic events, to incorporate my uncertainty of the weighting between the pain intensities, the length of time of the time ranges, and the probabilities of the shrimp being in different intensities of pain. The links for the Guesstimate pages are at the end of each of the four kinds of farmed shrimp experiences I examined.

Eyestalk Ablation

All of the information I have used below relating to eyestalk ablation was taken from the paper *Minimizing the effects of stress during eyestalk ablation of Litopenaeus vannamei females with topical anesthetic and a coagulating agent (10.1016/j.aquaculture.2003.09.034)*

The paper notes that “all shrimp reacted to eyestalk ablation by displaying a recoil reaction, or ‘‘flinching’’, when the incision was made. This suggests that eyestalk ablation is traumatic”. I will take this to mean that the shrimps are experiencing excruciating pain during the first few seconds, let’s say 10 seconds.

80% of shrimp which experienced eyestalk ablation (without any medication) “exhibited lateral, erratic, or ‘‘spiral’’ swimming behavior”. “One hour after ablation, some of this type of behavior was still evident, but had ceased within 2-h post-ablation”. So I take this to mean that initially 80% of shrimp are in Disabling pain and 20% are in Hurtful pain, and this changes linearly until 2 hours later when all shrimp are only experiencing Hurtful pain. This is equivalent to 2 hours of 40% of shrimp experiencing Disabling pain and 60% of shrimp experiencing Hurtful pain.

The behaviour of the shrimps was not discussed after the 2 hour mark. For the sake of this example I’m going to assume that the shrimps were experiencing Hurtful pain for an additional 48 hours, and Annoying pain for an additional 4 weeks.

Eyestalk ablation						
Comment:	10 seconds of excruciating pain	Linearly changing from Disabling to Hurtful over 2 hours	48 additional hours of hurtful pain	4 weeks of annoying pain	**Weighting (constant)**	**Total (HDP) by pain intensity***
Excruciating	100%				3000	8.3
Disabling		40%			1	0.8
Hurtful		60%	100%		0.03125	1.5
Annoying				100%	0.00201	1.4
Time in state	10 seconds	2 hours	48 hours	4 weeks	**Total HDP:**	**12.0**
Total (HDP) per time period:**	8.3	0.8	1.5	1.4		

*Formula = Weighting * time in state * probability of being in that state
E.g. Excruciating pain: 3000 * 10 seconds * 100% = 8.3 Hours of Disabling Pain

**Formula = (Probability of being in state Y * weighting of state Y + Probability of being in state Z * weighting of state Z) * time
E.g. Time period 2: (40% * 1 + 60% * 0.03125) * 2 hours = 0.8 Hours of Disabling Pain

Result: the average shrimp that has her eyestalks ablated experiences an estimated 12.2 hours in disabling pain.
The result from the Guesstimate probabilistic analysis was a 90% confidence range of 9 to 16 HDP, with a mean at 12 HDP.

The Guesstimate model for eyestalk ablation can be found here.

Obviously with more literature research a nuanced and accurate picture could be formed.

As is shown in the table, the result of my estimate is that an average shrimp experiences 12.2 HDP, where HDP is the unit “Hours in Disabling Pain equivalent”. 70% of that number comes purely from the 10 seconds spent in Excruciating pain, which shows just how sensitive the framework is to extreme forms of suffering, due to the logarithmic weighting of pain intensities.[2] If the assumption about the weightings of pain is correct, then this high sensitivity implies that **in order to maximise accuracy the estimate for the amount of time spent in the more intense states of pain should be more carefully researched than the amounts of time spent in the less intense states.**

[2] If I had chosen the amount of time in Excruciating pain to be 5 seconds, then the result would have been 8 HDP instead of 12.

Different methods of stunning before slaughter

Asphyxiation (i.e. no method of stunning)

According to this study, shrimp can survive out of water for about 30 mins. I assumed that while they are out of water the shrimps are experiencing Excruciating pain 5% of the time, Disabling pain 85% of the time, and Hurtful pain 10% of the time.

Slaughter via asphyxiation						
Comment:					**Weighting (constant)**	**Total (HDP) by pain intensity***
Excruciating	5%				3000	75.00
Disabling	85%				1	0.43
Hurtful	10%				0.03125	0.00
Annoying					0.00201	0.00
Time in state	30 minutes				**Total HDP:**	**75.4**
Total (HDP) per time period**	75.4	0.0	0.0	0.0		

*Formula = Weighting * time in state * probability of being in that state
E.g. Excruciating pain: 3000 * 0.5 hours * 5% = 75 Hours of Disabling Pain

**Formula = (Probability of being in state Y * weighting of state Y + Probability of being in state Z * weighting of state Z) * time
E.g. Time period 1: (5% * 3000 + 85% * 1 + 10% * 0.03125) * 0.5 hours = 75.4 Hours of Disabling Pain

Result: the average shrimp who dies due to asphyxiation experiences an estimated 75 hours in disabling pain.
The result from the Guesstimate probabilistic analysis was a 90% confidence range of 28 to 140 HDP, with a mean at 76 HDP.

The Guesstimate model for asphyxiation can be found here.

Ice stunning

After 30 seconds of exposure to ice slurry no further sensory responses were recorded (Weineck et al., 2018), and so for the first 30 seconds let's assume that the shrimps suffer in the same way as though they were asphyxiating (same numbers as in the asphyxiation section).

According to Lucas' report, "In practice, tight packing or insufficient ice layering may cause some shrimps to die from asphyxiation because they have little contact with ice." So let's assume that 10% of shrimps are not sufficiently covered in ice, and so they will suffer the same way that shrimps who are asphyxiated to death do, and the other 90% will experience ice stunning before death.

Even though the shrimp are paralysed for the time after the first 30 seconds, this does not necessarily mean that they are also anaesthetised, so let's assume there is a 20% probability that the shrimps continue to suffer after being paralysed, and let's assume that it takes 30 minutes in ice slurry in total before they stop suffering and die.

Stunning via ice	90% affected by ice stunning		10% unaffected by ice		
Comment:	Full pain for first 30s for 90%	Assume 20% prob of continuation of suffering	Assume 10% of shrimp asphyxiate to death, unaffected by ice	**Weighting (constant)**	**Total (HDP) by pain intensity***
Excruciating	4.5%	0.9%	0.5%	3000	21.90
Disabling	76.5%	15.3%	8.5%	1	0.12
Hurtful	9.0%	1.8%	1.0%	0.03125	0.00
Annoying				0.00201	0.00
Time in state	30 seconds	29.5 minutes	30 minutes	**Total HDP:**	**22.0**
Total (HDP) per time period**	1.1	13.4	7.5		

*Formula = Weighting * time in state * probability of being in that state
E.g. Excruciating pain: 3000 * (30 seconds * 4.5% + 0.49 hours * 0.9% + 0.5 hours * 0.5%) = 21.9 Hours of Disabling Pain

**Formula = Probability of being in state Y * weighting of state Y + Probability of being in state Z * weighting of state Z) * time
E.g. Time period 1: (4.5% * 3000 + 76.5% * 1 + 9% * 0.03125) * 30 seconds = 1.1 Hours of Disabling Pain

Result: the average shrimp that dies after being stunned by ice experiences an estimated 22 hours in disabling pain.
The result from the Guesstimate probabilistic analysis was a 90% confidence range of 9 to 40 HDP, with a mean at 22 HDP

The Guesstimate model for ice stunning can be found here.

Electrical stunning

Sources: I've used a subset of the sources from Lucas' Shrimp Welfare Report.

[1] Results of an electrical stunning study can be found here: https://www.compassioninfoodbusiness.com/media/7444897/tesco-and-hilton-seafood-case-study-improving-the-welfare-of-whiteleg-shrimp-at-harvest.pdf
[2] And the report (Birch et al., 2021, p.71) has a discussion of the electrical stunning of crabs

According to [1], the normal procedure for electrical stunning involves the shrimps falling into ice slurry after they are shocked by electricity

It is said [2] that electrical stunning is "effective within one second" for crabs, so let's assume that the shrimp feel excruciating pain for that 1 second, and there is a 90% probability that they experience nothing after that, and a 10% chance that they continue to suffer.

According to [1], 97% are stunned almost instantly, and 3% are not stunned and fall in the ice slurry conscious. It is not said whether those 3% do not receive the electric shock, or if they do receive it but are not stunned by it. Let's assume the worst and imagine that those 3% do receive the shock but are not stunned, and say that there is 1 second of excruciating pain from the electricity, **and then** they experience the same suffering of being stunned via ice.

So 3% are not rendered paralysed by the electricity, and for the other 97% that are paralysed, there is a 10% probability that they continue to suffer. In total, this is equivalent to 3%+97%*10% = 12.7% of the shrimps continuing to suffer as though they are being stunned by ice slurry after experiencing the 1 second electrical shock.

Stunning via electricity		**Assume 12.7% of shrimps experience the same as ice stunning after the electric shock**				
		Of these, 90% are affected by ice stunning		The other 10% are unaffected by ice		
Comment:	1 second of excruciating pain	Full pain for 30 seconds	20% probability of continuation of suffering	10% of shrimp unaffected by ice	**Weighting (constant)**	**Total (HDP) by pain intensity***
Excruciating	100%	0.6%	0.1%	0.1%	3000	3.61
Disabling		9.7%	1.9%	1.1%	1	0.02
Hurtful		1.1%	0.2%	0.1%	0.03125	0.00
Annoying					0.00201	0.00
Time in state	1 second	30 seconds	29.5 minutes	30 minutes	**Total HDP:**	**3.6**
Total (HDP) per time period**	0.8	0.1	1.7	1.0		

*Formula = Weighting * time in state * probability of being in that state
E.g. Excruciating pain: 3000 * (1 second * 100% + 30 seconds * 0.6% + 0.49 hours * 0.1% + 0.5 hours * 0.1%) = 3.6 Hours of Disabling Pain

**Formula = (Probability of being in state Y * weighting of state Y + Probability of being in state Z * weighting of state Z) * time
E.g. Time period 1: (100% * 3000) * 1 second = 0.8 Hours of Disabling Pain

Result: the average shrimp that dies after being stunned via electricity experiences an estimated 3.6 hours in disabling pain.
The result from the Guesstimate probabilistic analysis was a 90% confidence range of 1.7 to 6.1 HDP, with a mean at 3.7 HDP.

The Guesstimate model for electrical stunning can be found here

Due to all of the caveats I've already mentioned it would be unwise to draw any strong conclusions from this. However, after filling in all of these estimates I would find it very difficult to form an argument to show that abolishing eyestalk ablation should be a more pressing concern than improving the slaughter methods.

And what if I don't trust the weightings between pain intensities?

Even if the Cumulative Pain Framework is used as intended and thus we do not aggregate the times spent in different pain intensities into one number, we can still make some claims about which practices are worse than others. This can be seen by looking at the total time spent in each pain intensity for the four different practices examined.

Time spent in each pain intensity by practice (seconds)				
	Eyestalk Ablation	**Asphyxiation slaughter**	**Ice stunning**	**Electrical stunning**
Excruciating	10	90	26.3	4.3
Disabling	2880	1530	446.8	56.7
Hurtful	177120	180	52.6	6.7
Annoying	2419200	0	0.0	0.0

As can be seen in the table below, for the 3 slaughter methods there is a clear hierarchy, with electrical stunning having less time in pain for each intensity than either ice stunning or slaughter by asphyxiation.

From worst to best:

- Asphyxiation
- Ice stunning
- Electrical stunning

Eyestalk ablation is worse than electrical stunning, but otherwise it does not fall neatly into the hierarchy, due to the shorter length of time spent in Excruciating pain, and longer time periods spent in the other pain intensities. Thus we can not say with certainty if eyestalk ablation is better or worse than slaughter by ice stunning or asphyxiation without agreeing on a weighting between the pain intensities.

It is even possible to make some more precise claims without having weights, such as "[the mean estimate for] Ice stunning is at least 6 times worse than [the mean estimate for] electrical stunning" (as the time in pain for each of the intensities associated with ice stunning is at least 6 times longer than electrical stunning). As well as, "[the mean estimate for] slaughter by asphyxiation is at least 3 times worse than [the mean estimate for] ice stunning".

Note of course, that to make more meaningful statements of this kind the uncertainties from the Guesstimate models would need to be considered.

Some complications

Sleep
Is it right to assume there is no suffering during sleep? If so then how many hours a day do shrimp sleep? This should be factored into the spreadsheet, e.g. if shrimp sleep 6 hours of every 24 hours, then the Annoying pain experienced for over a week should be scaled down to (24-6)*7 hours instead of 24*7. However, it may also be true that shrimp sleep less when in pain, and so this factor would depend on the intensity of the pain.

Capabilities
Another aspect which is missing from the framework is the disvalue created by the loss of capabilities. For example, in the eyestalk ablation section, after the shrimp have stopped experiencing pain due to their eyestalks being ablated, the framework views them as being in an equivalent position as they were before the procedure, which feels intuitively wrong. This could be rectified by either saying that the loss of their sense of sight is equivalent to them being in a perpetual state of Annoying pain, or by including this effect in an external way (through a DALY like system for example).

The shorter the better?
As this framework focuses purely on pain and ignores positive states of consciousness, as well as not assigning negative value to death, it is suffering-focused in nature. If this metric is used blindly, readers may interpret the results as saying it is always better for the animals to die earlier rather than later. For example, even if the individuals we examine are enjoying a 99% blissful time on an ideal farm, where the only negative parts of their lives are very mild inconveniences amounting to short periods of Annoying pain, then the Cumulative Pain Framework would only consider the painful experiences. Taken in isolation, the framework only reaches its optimal outcome (i.e. zero pain) if the animals are not alive. Therefore, if SWP were to blindly accept the framework as the only metric to consider, then interventions that shorten the lifespan of the shrimp (all other things being held constant) would always be seen as a good thing. Of course this is mistaken, as **the framework does not assign moral judgements, it merely measures pain**, so I would recommend the Cumulative Pain Framework to be thought of as only one lens through which to view shrimp welfare.

A large part of my time examining the Cumulative Pain Framework was spent investigating plausible weights for the different pain intensities so it could be used to make direct comparisons between different interventions. I ended up taking the weights of the badness of different pain intensities that were in the author's abandoned report, but I still wanted a justification for the large differences between the weights, so I spent a lot of time reading about the potential nature of logarithmic experiences. My summary and discussion of a website post on this topic can be found here: Logarithmic Pain Weightings for SWP

Conclusion

The Welfare Footprint's Cumulative Pain Framework is a useful tool to focus our thinking and estimate how much pain is experienced by individuals. By selecting certain representative

lives of shrimp, we can build a picture of how much suffering is caused by different farming practices, and thus make more informed decisions on how to prioritise certain interventions over others.

In the (flawed) preliminary examples shown in this report, it seems as though shrimps slaughtered through asphyxiation suffer far more than shrimp which have their eyestalks ablated, or shrimp who are stunned by electric shocks before slaughter. The range of uncertainty is very large for some of the examples, however the huge differences between the examples and lack of overlap between error bars shows that decisions can be made despite the uncertainties.