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Reviewing GAA-BAP shrimp farm data to determine whether certification lessens environmental impacts

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Abstract

The sustainable seafood movement is over a decade old. It has done much to raise awareness regarding improper production and harvest of seafood and to derive a course to lessen the deleterious environmental impacts of this industry. Certification has been a key tool, yet few programmes have demonstrated comprehensive improvements. Here, the degree of aquaculture improvement through the implementation of certification was assessed using data from the Global Aquaculture Alliance (GAA) Best Aquaculture Practice (BAP) shrimp standard. An examination of 323 audits from 192 farms spanning 2005–2012 showed that overall, 35% of the farms were conditionally certified, indicating they had to improve prior to being certified. This version of the BAP shrimp farm audit had both compliance and scored components. Out of the 28 critical points, only six were in full compliance by all farms during all audits and hence provided no value to determine farm performance. Farms that passed the audit without compliance issues had a greater aggregate scored value than those that farms with noncompliances. However, performance-based metrics exhibited few differences between the compliant and noncompliant farms. Overall, issues pertaining to water quality were a leading cause of farms being scored as noncompliant, although they were distributed among the seven different water quality parameters. Certification systems have not been designed specifically to demonstrate adherence to continual improvement. Because of this, and the multitude of factors with which a fully compliant farm needs to acquiesce, the specific means by which certification improves aquaculture and the overall value of improvement will remain challenging to demonstrate.

Key words: aquaculture, certification, improvement, seafood, shrimp, sustainability.

Introduction

Demand for finfish and shellfish will continue to increase as the global population grows and is estimated to exceed 160 million metric tons by 2030 (Delgado *et al.* 2003), double the estimated total sustainable catch of wild fish. Aquaculture already contributes an estimated 63.6 million metric tons to the food supply (FAO 2012) and will need to double again in the next 15 years to ensure the global seafood supply (OECD 2010). Historically, there have been issues of increased production leading to environmental degradation (Hall *et al.* 2011; Boyd & McNevin 2012). Because of this, there is a current acknowledgement that any increase in aquaculture, as with all food production, needs to occur with attention to sustainability objectives (Ward 2008b; Tlusty 2012; Tlusty *et al.* 2012).

Multistakeholder developed standards involving third-party assessments of performance resulting in a farm-level certification has been one of the main tools used behind the drive towards responsible aquaculture production and market-based approaches and to assure seafood adheres to corporate sustainability goals (see examples in Ward & Phillips 2008b; Boyd & McNevin 2012; Steering Committee of the State-of-Knowledge Assessment of Standards & Certification 2012). Over the past decade, the general guidelines behind how the certification programmes should be constructed and operated have grown and matured. Collectively, this development across the entire certification space has been a balance between the rush to create products for the marketplace, while at the same time, honing the ideals and the process by which the standards are created. Much of this progress to date has been encapsulated in the recent FAO guidance document 'Technical guidelines on aquaculture certification' (2011). Currently, there are in excess of 30 aquaculture certification programmes (Lee 2008; Boyd & McNevin 2012), but these programmes cover only ~2.5% of total aquaculture production (Boyd & McNevin 2012).

Seafood certification is viewed as a means to improve the environmental, social and economic performance of production (Steering Committee of the State-of-Knowledge Assessment of Standards & Certification 2012). As part of this, continual improvement is a basic tenet of the overall process of certification creation and refinement (Pelletier & Tyedmers 2008; Boyd & McNevin 2012; Tlusty 2012). In some instances, improvement occurs because there are initial requirements to enter into a certification programme, and then, participants need to meet additional criteria over time. For example, the Global Aquaculture Alliance (GAA) Best Aquaculture Practice (BAP) standards for effluent water quality have an initial value farms need to meet, but a more rigorous value after 5 years. The other way for continuous improvement to occur in the certification process is for the metrics and control values to be honed and increased in rigour during the revision process (ISEAL Alliance 2010). The revision process is important as it evaluates the impacts and practices with feedback from stakeholders and increases the quality and effectiveness of the programme over time (Steering Committee of the State-of-Knowledge Assessment of Standards & Certification 2012). Ideally, there is analysis of the data collected during the audit process (ISEAL Alliance 2010). This analysis is important as it forms the basis for assuring metrics are being met and also to the extent that they can be adjusted to increase rigour. While guidelines for assessment methodology of certification have been developed (ISEAL Alliance 2010), this occurred after many of the certification systems were already functioning, and as a result, they have not yet been implemented for any aquaculture programme (Jonell *et al.* 2013).

If one considers all farms producing a single species, each farm independently determines whether it will enter the certification process (Fig. 1, left). A certain percentage will opt not to enter the certification process (Ø), but for those that do (Y_1 in Fig. 1), there can be three end states. Farms that enter the certification process can either fail and not be certified (ν), or can be certified either with (ι) or without (Ψ) further improvements. The farms that have to fix non-compliances (ι), or do not pass and then come back to be certified at a later date (ν) represent the potential for improvement as a direct result of the certification process. This scheme can be best analysed with a path analysis (Fig. 1, left).

One difficulty in evaluating progress in seafood sustainability is that the history of seafood certification is brief, spanning approximately a decade, and only limited analysis of extant data has been conducted (Ward 2008b). Likewise, few theoretical frameworks exist for understanding how to assess improvements (Tlusty 2012). Because of these deficiencies, there is a poor foundation from which to predict future trends. To overcome these difficulties, it is necessary to find and analyse existing data. Such an analysis will allow

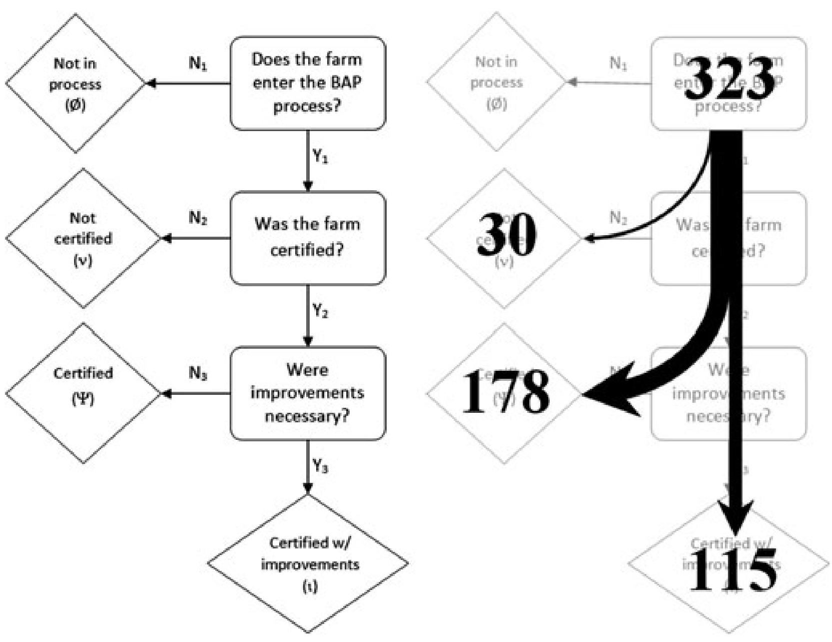

Figure 1 The flow of farms through the certification process. Farms can be differentiated by the environmental impacts based on outcome (diamonds). The right portion of the figure indicates the total number of farms for which data were available and their outcomes. Line thickness indicates the relative proportions of the farms.

for an assessment of the total improvement in aquaculture production. It will also inform the certification body of the standards performance by discerning if any factors is overly restrictive (all farms fail) or not discriminating enough (all farms pass). Here, we analyse data collected during the audit of shrimp farms as part of the Global Aquaculture Alliance (GAA) Best Aquaculture Practice (BAP). This review is not an attempt to force the ISEAL impacts code of good practice (ISEAL Alliance 2010) onto the GAA certification process, but rather to integrate the lessons from this code. Namely, this review provides for the assessment of the results to determine the environmental impact of farms that are certified, those that are not compliant and those that are not certified. It also assesses trends to determine where improvements can be made in the standard to increase its rigour.

Methods

Background on the Global Aquaculture Alliance Best Aquaculture Practices shrimp standard: The GAA-BAP standards currently certify in total an estimated 1.1 billion pounds of shrimp, tilapia and catfish. The shrimp standard was the first GAA farm-based certification developed and that put product in the marketplace, and in excess of 600 audits have been conducted (William Moore, GAA, 2011, pers. comm.). The GAA-BAP programme was initially developed under the philosophy to improve the most impactful farmers, as this was the category that was creating the majority of the environmental impacts (G. Chamberlain, GAA, 2007, pers. comm.). The analysis in this report assessed data from GAA-BAP shrimp farm audits to determine differences between the three outcome states ν, ι and Ψ. The GAA-BAP shrimp farm audit assessed a total of 13 impact categories related to 'community/ governance', 'environment' and 'food safety'. This standard was created with a combination of critical (compliance (pass/fail) data), scored and informational questions. The scored components range from 0 to 3, with a value of 0 indicating unsatisfactory compliance, 1 = needs major improvement, 2 = needs minor improvement and 3 is the criteria was met satisfactorily. Metrics are mensurative and include those for effluent parameters, feed conversion ratios and animal protein conversion ratios. These tend to be informational pieces, but ultimately track back to a critical control point. According to the GAA certification guidelines (Global Aquaculture Alliance 2007),

> 'To be certified, applicants must comply with all (100%) of the critical inspection requirements, score at least 70% (52 of 75 points) on the scored inspection requirements and maintain specified production records for traceability for at least three months. If a facility fails any critical elements, it will not be certified, regardless of its score otherwise. After five years, certified facilities shall comply with all critical requirements and score 80% or better on the scored requirements.'

With regard to the 28 critical points, a farm may not comply with one or more points (designated as a nonconformity), yet still be awarded a certificate provided the deficiency is corrected within 28 days (International Trade Centre 2013).

The GAA-BAP shrimp standard has remained relatively the same since it was unveiled in 2004. However, recently, the GAA-BAP shrimp standard was harmonized with the finfish standard (save for salmon) into a finfish/crustacean combined standard. Given the occurrence of this revision, this was an ideal time for the analysis of the audit data to assess how metrics were performing compared with their set point. This path analysis at this juncture provides an opportunity to assess if all of the critical, compliance (pass/fail) criteria were of utility to distinguish the performance of farms, as well as to assess if effluent metrics were greater or less than their set standard values.

Data analysis

Here, we review the data from shrimp farm audits conducted under the GAA-BAP certification process. 323 completed shrimp farm audits for farms certified under the guidelines for best aquaculture practices of shrimp farms (Global Aquaculture Alliance 2007) were converted to an Excel format and anonymized by GAA staff before being transferred to a database at the New England Aquarium (NEAq). Anonymization was achieved by reducing all farm information (name and location) to a three digit code prior to the transfer of data to NEAq. There was no information with regard to the certifier or the certification body. Each audit record indicated if the farms did or did not pass the audit. In this case, a 'pass' value indicated both those farms that were fully compliant for all critical points, all as well as those that initially had a noncompliance of their critical points, but the deficiency was corrected within sufficient time. 'Did not pass' farms were those that ultimately were not certified, although it was not declared whether the farms self-selected to forgo the certification process, or attempted to be certified, but did not meet all conditions. If a farm was denoted as a 'pass', but had zero values for critical points, it was further marked as being noncompliant. Thus, farms were categorized as being in one of the three states (did not pass ν, not compliant ι and fully compliant Ψ).

The critical points were assessed for those that were most likely to be noncompliant for farms in either state that pass noncompliant (ι) or did not pass state (ν). The values for the scored components, as well as the continuous environmental impacts related to effluents, were compared to these different result states, and differences were determined using a one-way ANOVA. If data were not normal, a Kruskal–Wallis nonparametric method was used (SigmaPlot 12, Systat Software, Inc, San Jose, CA, USA). Data were presented for countries only if data were available for six or more separate farms. In all cases, results were presented on untransformed data to allow for a greater interpretation of the results.

Results

A total of 323 audits from 11 countries were provided for the assessment. These audits represented 192 separate farms, as 82 farms were certified in multiple years, with two of these farms being audited five times. The average production per farm was 622.9 MT. However, this average was skewed by a few large farms. The median size was 161.5 MT, and roughly one-quarter (43/151) of the farms were 100 MT or less. Of the 323 audits, 30 (9.3%) farms 'did not pass' and were not ultimately certified (ν, Fig. 1). 178 audits (55.1%) were fully compliant (Ψ), while the remaining (115, 35.6%) had noncompliances (ι) that needed to be addressed (Fig. 1). The scored components also differed between Ψ, ι and ν ($F_{2,320}$ = 18.8, $P < 0.001$), with those that were fully compliant (Ψ, 65.2 ± 0.49, μ ± σ) being greater than those that were noncompliant (ι, 60.6 ± 0.55), while those that did not pass (ν, 62.4 ± 1.15) were intermediate to and not statistically different from Ψ or ι.

To eliminate overrepresentation of the few farms that were audited in multiple years, only the first audit for any farm was assessed (*n* = 192). There was a similar distribution of Ψ, ιand ν as observed with all audits (51.0, 39.1 and 9.9% respectively, compare with Fig. 1). The 19 farms not certified (ν) on their first audit had noncompliances observed on 10 of the 28 critical points (Fig. 2). These farms had 16 unique combinations of critical point noncompliances, indicating a variety of paths through which a farm may not be certified. Of the 75 farms that had noncompliances which needed corrective action in order for the farm to be certified (ι), the noncompliances occurred over 12 of the 28 critical points (Fig. 3). There were 28 unique combinations of the noncompliances. Similarly, 20 of the 75 farms had a unique combination of noncompliant critical points, again indicating the multitude of ways in which farms can have difficulty being certified.

The critical point *Does effluent water quality comply with BAP standards* (5.2) resulted in the most noncompliance scores for both farms that were (65.2%) and were not (52.6%) certified. For the farms that were ultimately certified (ι), only the critical point relevant to documentation the shrimp analysed for residue were contaminant free (standard point 10.5.1) exceeded 10% occurrence. For the farms that ultimately did not pass (ν), 12 critical points exceeded 10% occurrence, with the critical points indicating effluent records were maintained and available (5.1) and the critical point for monitoring chloride content of surficial waters (7.2.1) being the two that exceeded 20% occurrence (Fig. 2).

Even though the water quality criteria were the critical point most likely to lead to a noncompliance (Fig. 2), the average and 95% confidence interval for all effluent values were well within the limit defined by the GAA standard. There were few differences observed between any of the water quality parameters for the Ψ, ι or ν farms

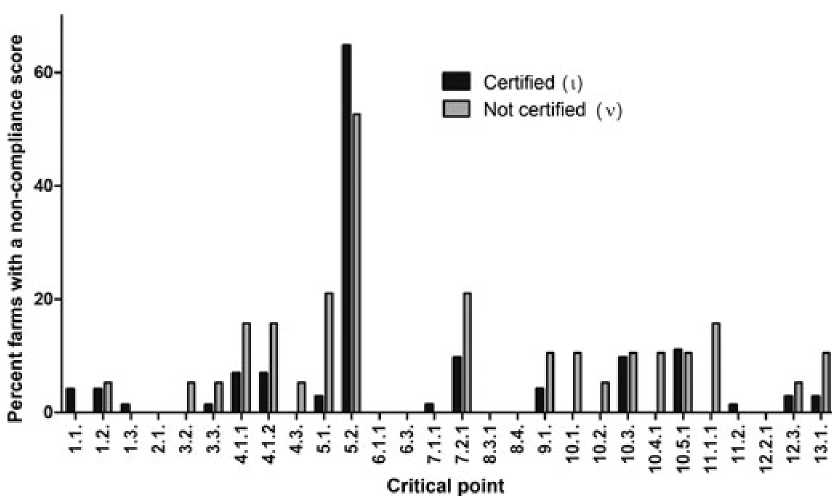

Figure 2 The percentage farms that had a noncompliance score for each control point depending if they were (ι) or were not certified (ν). Data are based on first audits of 192 farms.

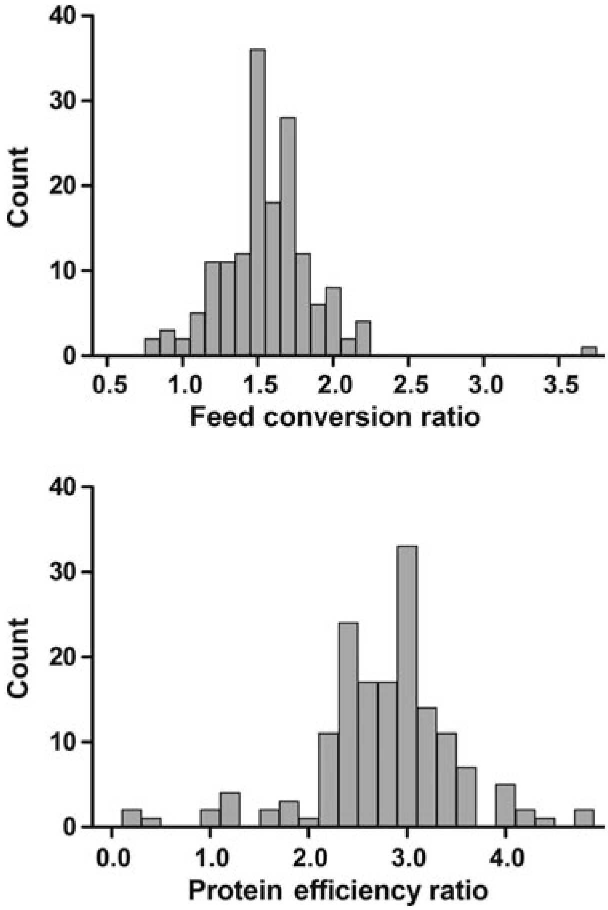

Figure 3 Histograms of feed conversion ratio (top) and protein efficiency ratio (bottom) as recoded during the first audits of 192 shrimp farms during a Global Aquaculture Alliance Best Aquaculture Practices audit.

(Kruskal–Wallis one-way ANOVA, Table 1). Protecting the *P*-value for the multitude of comparisons made (p/n), none were significant enough to warrant discussion, particularly given the values were within standard limits. For example, the standard for total ammonia nitrogen was ≤5.0 mg L^{-1}, and the average for all first assessments of farms was 1.17. Adjusting the standard to remove 10% of the most impactful farms would lower the standard value to ≤3.3 mg L^{-1}, while removing 20% of the impactful farms would reduce the standard to ≤2.2 mg L^{-1} (Table 2). A similar process can be conducted for 5-d BOD, dissolved oxygen, total suspended solids and soluble phosphorus (Table 2). Dissolved oxygen was the only parameter where the current standard falls within range of impacts observed during this analysis of audit data. The average feed conversion ratio for first time audits of all farms was 1.56 ± 0.32 (n = 161), while the protein efficiency ratio was 2.77 ± 0.73 (n = 159). The distributional data of FCR and PER (Fig. 3) provide an

Table 1 Environmental performance data collected during Global Aquaculture Alliance Best Aquaculture Practice shrimp farm audits. Values are from the first audit of farms. Influent, effluent and differential values (effluent – influent, average ±95% confidence interval) are provided for the seven effluent parameters, while averages (±95% confidence interval) are provided for annual water use, feed conversion ratio and protein conversion ratio

	Total ammonia nitrogen (≤5.0 mg L^{-1}) 5.4.4	5-day biochemical oxygen demand (≤50 mg L^{-1}) 5.4.5	Dissolved oxygen (≥4.0 mg L^{-1}) 5.4.6	Salinity (ppt) 5.4.7	pH (6.0–9.0) 5.5.1	Total suspended solids (≤100 mg L^{-1}) 5.5.2	Soluble phosphorus (≤0.5 mg L^{-1}) 5.5.3	Estimated annual water use (cubic metres) 5.4	Annual feed conversion ratio 5.4.7a	Annual protein conversion ratio 5.4.7b
Pass – Compliant										
Influent	0.84 ± 0.28	10.35 ± 2.91	6.16 ± 0.53	15.32 ± 2.55	7.50 ± 1.12	63.60 ± 35.46	0.19 ± 0.11	4 360 299 ± 3 833 352	1.55 ± 0.08	2.71 ± 0.15
Effluent	1.18 + 0.26	12.48 ± 2.00	6.24 ± 0.35	15.24 ± 2.72	7.96 ± 0.52	53.77 + 25.48	0.21 ± 0.08			
Δ (e-i)	0.14 ± 0.24	1.80 + 2.42	−0.19 ± 0.44	−0.40 ± 1.51	0.30 ± 0.51	−1.32 ± 8.02	0.02 ± 0.05			
Pass – Noncompliant										
Influent	0.58 ± 0.30	7.42 ± 3.46	6.83 ± 1.58	14.98 ± 3.87	7.16 ± 0.76	152.71 ± 147.07	0.24 ± 0.13	274 970 ± 38 333	1.59 ± 0.06	2.89 ± 0.14
Effluent	1.28 ± 0.56	11.09 ± 3.72	7.16 ± 2.01	13.50 ± 4.18	7.51 ± 0.53	48.19 ± 14.54	1.53 ± 1.99			
Δ (e-i)	0.20 ± 0.17	1.91 + 3.19	0.12 ± 0.89	−1.93 + 2.83	−0.05 + 0.86	−42.47 + 70.0	0.30 ± 0.45			
Did not pass										
Influent	1.06 ± 1.08	8.43 + 4.60	9.65 ± 5.36	13.13 ± 7.60	6.80 ± 1.39	30.01 ± 20.66	0.06 ± 0.05	2 187 242 ± 1 778 114	1.48 ± 0.12	2.44 ± 0.60
Effluent	1.23 ± 0.61	18.21 ± 6.49	7.35 + 4.43	13.59 + 6.74	6.84 + 1.24	49.92 + 23.15	0.18 + 0.07			
Δ (e-i)	−0.13 + 0.48	7.95 + 8.14	−1.81 ± 1.71	−1.97 + 4.75	0.04 ± 0.45	19.90 + 7.71	−0.01 + 0.11			

Table 2 The effluent parameters as defined by the standard, the average value as currently assessed during audits (see Table 1) and a proposed new standard value to result in a 10% or 20% increase in rigour

Parameter	Standard (mg L^{-1})	Avg	Increased rigour	
			10%	20%
Total ammonia nitrogen	≤5.0	1.17	≤3.3	≤2.2
5-day biochemical oxygen demand	≤50.0	12.45	≤28.6	≤20.4
Dissolved oxygen	≥4.0	7.50	≥4.3	≥4.4
Total suspended solids	≤100.0	51.09	≤91.4	≤70
Soluble phosphorus	≤0.5	0.49	≤0.47	≤0.35

Table 3 'Double noncompliant' control points. These were found to be in noncompliance within the same farm on the first and second audits

Critical point	Indicator
1.2:	Proof of operating licences.
4.1.1:	Mangroves removed for allowable purposes?
4.1.2:	Proof of mangrove removal mitigation.
5.2:	Effluent water parameters meet BAP criteria.
11.1.1:	Proper disposal of human waste/sewage.
13.1:	Traceability records maintained properly.

opportunity to develop metrics. In the case of FCR, a value of 1.9 and 1.75 would encapsulate 90% and 80% of the farms, respectively. For PER, values of 3.5 and 3.26 would envelope 90% and 80% of the farms, respectively. There was a positive significant association between feed conversion and protein efficiency ratios (linear regression analysis forced through 0, $t = 72.87$, $P < 0.001$; $r^2 = 0.49$).

Of the 82 farms that were audited at least twice, 45% ($n = 37$) were found to be in full compliance at both audits. 12% ($n = 10$) of the farms 'improved', meaning they had noncompliances on the first audit, and none on the second, while 20% ($n = 16$) 'backslid', meaning they were fully compliant on their first audit, but had noncompliances on their second. The final 23% ($n = 19$) of the farms had noncompliances in both audits. However, only 10 of these farms were noncompliant for the same critical point across the two audits (indicating a lack of change between the two audits). Yet, these 'double noncompliant' critical points included six that were different (Table 3). These farms exhibiting both improvement (a noncompliance in audit 1 was corrected in the second audit), and 'backslide' (a compliance in the first audit became a noncompliance in the second audit) occurred for 15 and 26 (respectively) of the 28 critical points.

There were few critical or scored components that all farms passed (were compliant or were scored a value of 3). For the 192 first assessed farms, there were only six critical points that all farms passed regardless of the final audit outcome. These points included access of native peoples to coastal waters (critical point 2.1), sediment properly contained (6.1.1), dredged material properly contained (6.3), government compliance with non-native species import rules (8.3.1), hatchery reared postlarvae (8.4) and sulphites used in safe manner (12.2.1, Fig. 2). None of the scored components were maximal (a score of 3) for all 192 farms. However, three scored components (7.3, does not use well fresh water to dilute saline ponds; 7.4, soil salinization does not occur; and 12.2.3, sulphite solutions deactivated before disposal) had less than maximum score for fewer than only 2% of the audited farms.

There were differences between countries in the quantity of audits, as well as the first audit performance of farms. 50% or more of farms in Ecuador, Indonesia, Thailand and Vietnam passed the first audit with full compliance (Ψ, Fig. 3). Over 75% of the farms ultimately passed (Ψ, ι) for six of the eight countries for which there were more than six farms audited. Thailand had the maximum farms passed with 98% of farms ultimately being certified (Fig. 4).

Discussion

There is currently a great deal of interest placed on the development of environmentally responsible seafood (Ward & Phillips 2008a; Steering Committee of the State-of-Knowledge Assessment of Standards & Certification 2012; Tlusty 2012). A variety of approaches have been created to assure this need is met including species campaigns, consumer wallet cards, market-based approaches, certification and eco-labelling (see examples in Ward & Phillips 2008b). The fundamental construct of all these

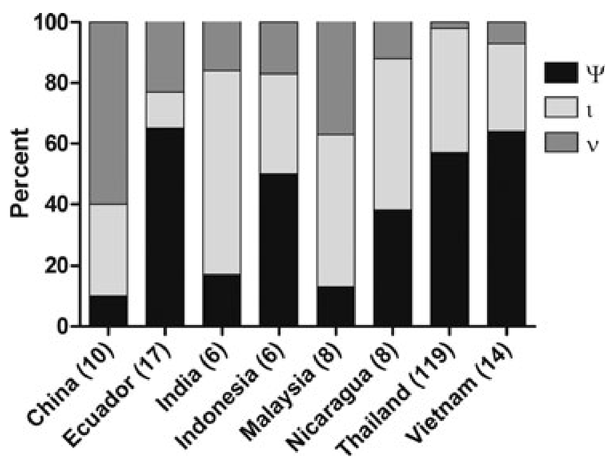

Figure 4 The outcome states (pass, pass with nonconformities or do not pass) for each country with six or more farms audited (the number indicates the farms audited).

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programmes is to use market-based mechanisms (consumer choice and industry buying practices) to change current purchasing practices to influence production, in effect, moving the industry towards sustainability (Ward 2008b). For all of the benefit that these programmes potentially can provide, it is uncertain if they, and in particular certification, are measuring up to their expectations (Gardiner & Viswanathan 2004; Kaiser & Edwards-Jones 2006; Ward 2008a).

While the GAA-BAP shrimp programme has existed for over a decade (Global Aquaculture Alliance 2007), it has been only recently that guidelines have been developed to assess the impacts of certification programmes (ISEAL Alliance 2010). The ISEAL code (2010) states that in addition to defining intended change, monitoring through data collection and evaluation of those data with subsequent learning and improving of system effectiveness are necessary. The work encompassed within this report was the first independent evaluation of the data collected through the GAA-BAP audit process. This report represented the first step in linking audit data back into programmatic learning so that there can be an improvement in the standards setting process.

To demonstrate the effect any programme has on improving the seafood production system, a few key pieces of information need to be collected. First, the impact conditions on the farms before the programme is initiated (baseline data) need to be known. Next, the amount of improvements prior to attempting certification needs to be recorded. Then, if the farm passes the audit/inspection conditionally, the improvements necessary to correct the deficiency need to be tracked. Finally, improvement can come through the re-audit process if the programme increases its rigour. Only with these bits of information can the difference as a result of any improvement process be assessed.

For shrimp farming, baseline data were collected through a survey conducted in 2001 (Boyd *et al.* 2001). The effluent data recorded within the 2001 assessment did not provide specific performance values (Jackson & Boyd 2001). 75 of the 90 farms provided data relevant to the permitting and siting of the farms. Few of the effluent parameters were required to be recorded (Jackson & Boyd 2001). From this standpoint alone, certification has had a positive effect in the requirement to record environmental parameters from which an assessment of impacts could be made.

During the period when a farm establishes contact with GAA concerning the process to become certified (step Y_1 in Fig. 1), there can be a degree of improvement that occurs as the farm self audits and corrects identified deficiencies to comply with the standards requirements (J. Peterson, GAA, 2012, pers. comm.). Unfortunately, these improvements were not recorded. The information collected through the audit process as discussed in this analysis captures farm improvements as a direct result of the audit process. To truly understand how certification improves current production practices, it would be necessary to compare those farms that engaged in certification compared with those farms that did not. Alternatively, a questionnaire could be used to determine the improvements the farm made prior to its first certification attempt. However, these data are lacking.

For all of the volume of aquaculture and fisheries products that are certified (Ward & Phillips 2008b), it has not been demonstrated to date how effective certification programmes have been in driving change within the seafood industry. The concern is that if certification programmes lack rigour, then farms will be merely assuring that the 'status quo' is being met. This is an important question because the certification process incurs a monetary cost, and incremental costs are easier to justify when faced with demonstrable results. In this analysis, the GAA-BAP shrimp farm certification programme demonstrated that farms did operate at a manner above the 'status quo'. 35% of the farms for which audit data were available had noncompliances and had to improve their practices to become fully certified. It was also observed that 55% attained certification without having to alter practices, while 10% of the farms that entered the certification process were not ultimately certified. This distribution, particularly the low percentage of farms that were not certified, was similar to that observed within the MSC certification process (Cambridge *et al.* 2011).

One facet of audit data that will impinge upon discussion of results is that audit-based data are not a completely random subset of the farms. There is a degree of self selection occurring where farms that are likely to be compliant, or those that have a production philosophy that includes certification will enter the process (the difference between steps Y_1 and N_1 in Fig. 1). What is missing is a truly random sample of farms that would include the full suite of characteristics defining aquaculture production of shrimp. Thus, the first decision state of the certification process, those farms that do not engage (state Ø in Fig. 1), cannot be ascertained. In the absence of these baseline data from farms that do not engage in the process, it will be a struggle to prove statistically the specific positive changes in the environment brought about by certification. Because farm management actively decides to engage in the certification process, the farms that cannot reach full compliance and ultimately become certified will be a minority (see also Cambridge *et al.* 2011 for a similar scenario with MSC).

The 35% of farms that had noncompliances requiring remediation prior to being certified represent one means of improvement that will come through certification. However, the noncompliances occur over 2/3 of the entire suite of critical points. Because of this, each individual critical point was used to differentiate a farm that needed improvement on a limited basis, typically less than 5% of the audits. That being stated, the most discerning critical point was 5.2, which focused on water quality monitoring. This indicated the importance of the environmental monitoring capacity of this standard. Critical point 5.2 had such a profound impact because it aggregated all of the specific water quality requirements, along with the capacity for adequately monitoring them into a single parameter.

The rapid degree to which farm sample size shrinks as the data were filtered with specific critical control points and levels, again demonstrated the broad basis for how farms can fail to comply with a specific standard. But the upshot of this phenomenon of numbers was it then becomes difficult to make overarching statements about the degree of change that occurred in specific metrics via the certification process. While water quality issues were one of the main determinants of why a farm would not be in compliance with the GAA-BAP certification scheme (where 'main' indicates only represented ¼ of the time), the data did not demonstrate any significant differences in the specific parameters allowing for differentiation between farms that did or did not pass certification. The idea that there is a multitude of ways to be in noncompliance is further reinforced by the 19 farms that had noncompliances in both their first and second audits, and yet only half of these farms had noncompliances for the same critical point. The large number of ways in which noncompliance can occur leads to a reduction in the ability to discern discrete improvements because of the certification.

Performance-based limits are important in determining improvement of certification programmes (ISEAL Alliance 2010; Steering Committee of the State-of-Knowledge Assessment of Standards & Certification 2012), and it is critical that certification programme not lose site of the value of data collection and analysis (ISEAL Alliance 2010). This review demonstrated the necessity for audit records to not only state the compliance with a predefined metric, but also the value of the metric as well. These data are required to evaluate the functioning of the standard. Yet standards programmes must deliberately and *a priori* develop the necessary software and data entry framework to collect these variables. Without the collection of the values of the metrics, it will be impossible to effectively improve the standard through increasing the rigour of the metrics.

Summary

Aquaculture certification is not a panacea to mitigate all deleterious impacts, it is only one of a myriad of tools (OECD 2010; Steering Committee of the State-of-Knowledge Assessment of Standards & Certification 2012; Tlusty 2012; Jonell *et al.* 2013). In the broader context of food production, aquaculture certification has a variety of challenges including a small percentage of production being certified, high value species are primarily covered, whereas the most commonly produced products (e.g. carp) are not, emerging Asian markets and domestic production are typically not considered, the focus is on the better performing farms, and the small-scale sector very poorly represented (Jonell *et al.* 2013). These are larger programmatic concerns, and not issues that can be addressed by a review of audit data. This analysis does feed into the knowledge and ability to improve such certification programmes, which can then work to address the issues raised by Jonell *et al.* (2013).

The overall improvement in aquaculture as a result of farm-level certification will never be truly known because farms will make improvements prior to communicating intent to be certified. It is only when a farm declares intent that it can be assessed against the audit criteria. Furthermore, little information is captured on the impacts of farms that opt not to enter a certification programme. Because of this, estimates of the impact of certification will be conservative.

Once a shrimp farms commits to being certified to the GAA-BAP standard, it was observed that over half of the farms did not have to change practices, while 10% of those that attempted the process were not certified. The remainder were certified only after making improvements. It can be argued that not all improvements were for environmental sustainability, as many did occur in the community and food safety areas. With regard to the environmental impacts, few direct improvements were observed as a result of certification. This occurred for two reasons, the first being that while half the farms with noncompliances had difficulty with the effluent parameters, the difficulties were spread over the seven components parameters. As such, only a subset of farms improved on any single metric. Secondly, many of the changes were of a procedural nature and dealt with the recording of appropriate information. With 28 critical points that must be in full compliance for a farm to pass the audit, there are a multitude of reasons that farms will not be in compliance.

One unexpected facet of certification that this analysis uncovered was 'backsliding', where a farm will be noncompliant for a critical point during the second audit after it had passed during the first yearly audit. This could be because there was significant year-to-year variation in methods of assessment, variation between auditors or a true decline in on-farm practices. Regardless, this does point out the important function of yearly checks and the need to assure that improvements are being implemented, and backsliding does not occur.

In moving forward, it will be critical to be able to track improvement to better indicate how certification can make a difference. While audits are designed to be independent among years, it may be best to create a series of 're-audit' questions to be addressed during the process. These questions, which could include such aspects as 'is there improvement in previous noncompliant control points', could be effective in adequately tracking such information. Without specific attention to the noncompliant points, the changes that occur in the 5 or 10% of farms that are noncompliant for a specific metric will be swamped by the metric's natural variation. Directed questioning regarding previously noncompliant control points will also elevate the issues pertinent to the control point and should increase the probability that the farm's performance will increase for this metric.

The majority of the effort in creating a new standard is in the development of the criteria and indicators. Less attention is provided to how that standard functions, and the subsequent analysis of data collected through the audit process (ISEAL Alliance 2010). Within seafood certification, MSC and GAA are two of the more established organizations. A small number of analyses of MSC data have been carried out (Agnew *et al.* 2006; Cambridge *et al.* 2011), but this is the first assessment of the GAA-BAP programme. This shrimp standard was found to be effective in identifying farms that need to increase their practices and performance. However, moving forward, an integrated data capture system from the audit process can be constructed to better assess the programme's effectiveness. In addition, routine review of the metric-based data such as performed within this assessment are necessary to tighten the requirements around the environmental metrics to assure that aquaculture production via this certification programme continues to improve.

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