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Statistical tools to assess the breadth and depth of shrimp aquaculture certification schemes

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ABSTRACT

Nearly two decades ago, significant concern about the environmental impacts of aquaculture production gave rise to environmental certification schemes as a means to ensure production adhered to less impactful environmental standards. Currently, some governments with more robust regulations are also engaging by creating national voluntary sustainability certification schemes. While its likely that the majority of aquaculture standards originated independently of one another, they generally overlap on the main impact issues but with differing requirements for compliance, making it difficult to differentiate more unique or robust schemes. Differentiation and encouragement of the adoption of the more rigorous standards is one means to encourage the industry to lessen environmental and social impacts. One confounding factor in benchmarking studies is the lack of a consistent methodology making wider comparisons difficult. Here we created a tool for standards comparison that began with a broad reaching set of factors based on the FAO Technical Guidelines on Aquaculture Certification and the International Principles for Responsible Shrimp Farming. Our analysis first compared if the factors were addressed (the breadth of the scheme), as well the mechanism by which compliance was required (the scheme depth), a proxy for how rigorously each factor was addressed. This analysis compared 112 factors divided into five impact areas (community, environment, food safety, feed and marine resource use, and supply risk), for three national shrimp aquaculture certification schemes including Indonesia, Thailand, and Vietnam, and three global schemes including Aquaculture Stewardship Council, Global Aquaculture Alliance and GLOBALG.A.P. The global schemes were found to be of greater breadth and depth than the national schemes. As an analysis tool, the breadth–depth (B–D) graphical analysis was compared to more rigorous statistical methods including multiple analysis of variance and cluster analysis. Overall, the B–D analysis provided a relatively simple means to assess rigor (breadth and depth) of multiple certification standards when compared using a broad baseline set of factors. It was further observed that the global certification programs overlapped in breadth and depth largely because of an uneven application across the five impact areas. The use of this analysis can be implemented to better understand similarities and differences between standards, and can be foundational in developing and adjusting schemes to ensure they are unique and operating at different levels of rigor, which can be a roadmap towards increasing the sustainability of aquaculture production.

1. Introduction

In the face of burgeoning global population growth, creating a food secure future is one of the world's foremost challenges (FAO et al., 2014). Given that food production contributes almost 30% of global greenhouse gas emissions (Vermeulen et al., 2012), one of the more immediate means to ensure food security is to lessen the impacts of food production on ecosystem health (Dobermann and Nelson, 2013; Searchinger et al., 2013). Multiple approaches are necessary to improve the food system including but not limited to those addressing policy (Rosegrant and Cline, 2003), livelihoods, capabilities, and entitlements (Pritchard et al., 2013), as well as changes to access, utilization and production (Dobermann and Nelson, 2013; FAO, 2013; Searchinger et al., 2013). Many of these approaches require longer-term solutions, such as technological, behavioral, and policy innovations and modifications. However, shorter-term solutions exist with one of the more popular being environmental certification, a strategy that incentivizes more environmentally-friendly modes of food production (Ward and Phillips, 2008). Well-designed and effectively-implemented

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certification schemes can fuel improvements by providing market recognition to those working to address and minimize the common adverse impacts of food production (Bush and Oosterveer, 2015).

One upshot of the popularity of this approach is that there are now in excess of 30 certification schemes for aquaculture production (Lee, 2008). From a theoretical standpoint, both vertical (Bush and Oosterveer, 2015) and horizontal (Tlusty, 2012) differentiation of schemes is a means to create a journey toward a more sustainable state (Tlusty, 2012). Over time, markets, and major buyers can source products from schemes of increasingly greater rigor, which can create the steps toward a more sustainable food production system. In the face of these growing challenges, there is a call by industry to understand "equivalency" amongst the schemes. However, to date there has been no consistent methodology to assess the comparative rigor (Tlusty et al., 2012) of seafood certification schemes. While a number of benchmarking and comparative studies have been conducted (including but not limited to Boyd and McNevin, 2012; Sullivan et al., 2012; Thrane et al., 2009; Trade Map, 2015; Volpe et al., 2011; WWF Switzerland and Norway, 2007) they vary in their methodology and lack statistical approaches, often resulting in insufficient power to differentiate certification schemes (e.g., Sustainable Fisheries Partnership, 2011).

Here, we developed a two-dimensional analytical method for comparing the standards set by seafood certification schemes. The analysis assessed both the number of factors each standard considers (breadth) as well as the aspiration of each factor (depth). While we previously proposed (Tlusty et al., 2012) that increasing both breadth and depth would result in a more sustainable scheme, nothing implicitly suggested that breadth and depth would scale linearly. It could be argued that standards could vary according to both breadth and depth and be undifferentiated (few factors, low aspiration), single issue (a few factors, addressed aspirationally), broad but general (many factors but of low aspiration), or rigorous (many factors of high aspiration, see Graphical abstract). We then compared the results of this breadth–depth (B–D) analysis to analyses using more conventional statistical tools including multiple analysis of variance and cluster analysis. These three analytical methods were used to assess the relative positioning of six shrimp aquaculture certification schemes including 3 national (including Indonesia, Thailand, and Vietnam) and three global sustainability standards (including Aquaculture Stewardship Council, Global Aquaculture Alliance Best Aquaculture Practices, and Global G.A.P.). These results of these analyses were discussed in the light of using multiple certification schemes to create positive movement toward greater sustainability of aquaculture production.

2. Methods

The shrimp-specific aquaculture standards for certification schemes assessed here included three national schemes; Indonesia (CBIB, Decree of the Minister of Maritime Affairs and Fisheries No. KEP.02/Men/2007), Thailand (Thai Agricultural Standard (TAS) 7401-2009 Good Aquaculture Practices for Marine Shrimp Farm), and Vietnam (National Standard on Good Aquaculture Practices in Vietnam (VietGAP) No. 1503/QĐ-BNN-TCTS), as well as three global schemes; Aquaculture Stewardship Council (Draft Standards for Responsible Shrimp Aquaculture. Version 3.0 for Guidance Development and Field Testing), Global Aquaculture Alliance (Draft Aquaculture Facility Certification. Finfish and Crustacean Farms. Rev. 4/13), and GLOBALG.A.P. (Version 4.0. Edition 4.0-1_FEB2012, generic or shrimp specific and published or draft). A full description of schemes is provided in Supplemental information 1. These schemes were compared using a newly derived B–D analysis, a two dimensional analysis to assess the breadth and depth of a standard. In essence, this analysis determined if a factor was covered by the standard (breadth), and if so, the degree to which compliance was required, a proxy for how rigorously the factor was addressed (depth). The breadth dimension of this analysis was based on the FAO (2011) Technical Guidelines on Aquaculture Certification and the International Principles for Responsible Shrimp Farming (FAO et al., 2006). The 112 factors discussed in these guidelines were divided into five impact issues (community, environment, food safety, feed and marine resource use, and supply risk, nine to 31 factors per impact issue, see Supplemental information 2). Each factor was evaluated if it was covered by the standard, and the breadth value was calculated as the average percentage of factors addressed per the 5 impact issues. Each component factor addressed by the standard was then evaluated using a seven-point scale to estimate relative rigor (Table 1). The scale began at zero (factor was not addressed), where a score of one indicated legal compliance and the maximum of seven indicated the factor was aspirationally addressed by the scheme (see Table 1). Interim scores between two and six highlighted a progression from non-audited recommendations, through management plans, to performance-based metrics. The breadth and depth scores for each factor were presented graphically as averages and 95% confidence intervals of the five impact issues for each standard. Note that zero values were truncated from the calculation of the depth value, and were only used when the breadth value was zero.

Differences between standards were also analyzed as a multiple analysis of variance (MANOVA) in R (R Core Team, 2014) with orthogonal post-hoc comparisons examined for statistical similarity ($p > 0.05$) with the Pillai–Bartlett Trace multivariate test statistic (Fox et al., 2013). Contrasts included national vs. global scheme standards, along with paired comparisons of adjacent standards based on ranks of Eigen values (determined by the dist() function in R). This B–D analysis was compared to the results obtained through cluster analyses (JMP 8.0.2.2, SAS, Cary NC). Two cluster analyses were conducted, the first on the average breadth and depth scores for each impact issue, and the second on all 112 factors. Differences in these two cluster analyses assessed how the aggregation of factors into impact areas may influence interpretation of results. For each cluster analysis, a minimum (0) and maximum (100 for breadth, and seven for depth) were also forced into the model as a means to bound most and least rigorous schemes. Data were ordered by the first principle component, clusters were hierarchically determined with the Ward method, and resultant clusters were plotted with distance scales. For the cluster analysis, depth scores defaulted to 0 only if the breadth was also 0.

3. Results

For all certification schemes, there was a positive correlation between breadth and depth. As the number of factors addressed within a standard increased, the assessment became more rigorous (Fig. 1). The B–D analysis found differences between the national and global schemes, and that the CBIB standard was of lower breadth and depth than the other national schemes. There was a great deal of overlap in the B–D analysis of the global schemes standards.

The MANOVA analysis of these data supported the B–D analysis, but with a greater ability to distinguish differences between adjacent standards. There was no statistically significant difference between the impact factors (MANOVA, Pillai test statistic = 0.16, $F_{4,24} = 0.56$, $p > 0.8$), but the schemes were statistically significantly different (MANOVA, Pillai test statistic = 0.89, $F_{5,24} = 3.85$, $p > 0.001$). The national and the global schemes differed (orthogonal contrast, ASC + GAA + GG-CBIB-TAS-VG, MANOVA, Pillai test statistic = 0.53, $F_{1,24} = 13.22$, $p < 0.001$). Within this larger structure, Eigen values ranking of standards found the order to be CBIB TAS VG GAA GG

Table 1
The scoring system used in the breadth–depth analysis. Breadth is assessed as the percent of impact criteria that score ≥1 per each impact area. Depth is the average value of the scored criteria per impact area.

Score	Description of the score	Detailed description	Example: nutrients released in farm effluents
0	No specific reference of the issue is included in the standard	No standards or references found in the guidance sections to support the belief that the issue is addressed by the standard	No reference to nutrient release from the farm could be found in the standard
1	Auditor specifically verifies legal compliance.	The standard specifically requires an auditor to verify compliance with relevant legislation.	Standard: Farms must meet legal requirements for effluent water quality.
2	Promotion of improved practices or performance but without a specified standard.	Separate from audited criteria, the standard encourages better practices or performance as guidance on a standard or as information by way of introducing or raising awareness of an issue or expected future performance.	Standard: Farms must meet legal requirements for effluent water quality. Guidance: Farms should aim to limit the nutrients lost in effluents to as little as possible.
3	Risk Analysis or Best Management Practices (BMPs) or plans but without specific desired outcomes.	The use of plans or risk assessments can raise awareness of an issue and enable the farms to consider a mitigation strategy. Without specific outcomes, however, the plans may be of inconsistent quality, scope, and rigor, and mitigation methods may not be uniformly applied.	Standard: The farm must have a written effluent water quality plan.
4	Risk Analysis, BMPs, or plans which include specified outcomes and/or minimum criteria to assess. or Performance based limits (PBLs) without verification.	Greater quality, scope, and rigor can be achieved by utilizing management plans with specific outcomes in mind, while being more flexible than setting specific performance limits to address an issue. or Performance based limits can be included in standards but without verification by an auditor to ensure compliance, i.e. there is a requirement for records of sampling system, rather than verifying the accuracy of the measure	Standard: The farm must have a written effluent water quality plan that includes: - Monitoring of nutrients - Prevention of eutrophication or excessive impacts. or Standard: Farms must maintain records to show nutrient levels in the effluent are below 3 mg/l.
5	PBL that partially covers or limits the impact of the denominator.	The standard requires a specific level of performance, however the measure used only partially addresses the denominator in question.	Standard: Nutrient levels must not exceed 3 mg/l and be verified during the audit or by an independent laboratory.
6	PBL caps the level or magnitude of the impact or sets an aspirational target.	The standard requires a specific level of performance that limits the magnitude of the denominator and sets a high bar for performance.	Standard: Total nutrient lost from the farm must not exceed 300 kg per ton of shrimp produced.
7	The issue is fully addressed by the standard.	Under the audit approach, the denominator is fully addressed in a pass/fail way.	Standard: Farms must fully recycle their effluent. Zero nutrient loss is allowed.

ASC, with adjacent schemes being statistically different, except for TAS and VG which were statistically similar, as were VG and GAA (for both, MANOVA, Pillai test statistic > 0.12, $F_{1,24} > 1.6$, $p > 0.2$).

The cluster analysis returned similar results as the B–D analysis. The clustering along the breadth axis found three clusters (Fig 1). CBIB was associated with the minimum category. There was an intermediate category consisting of TAS, VG, and GAA. Finally, ASC and GG clustered with the maximum value indicating these schemes addressed relatively the greatest proportion of factors per impact area. On the depth axis, there was less differentiation in the clustering of the schemes. CBIB again clustered with the minimum score (Fig 1). The maximum score was separate and greater than the other certification schemes, that occurred in the order (min to max) of TAS, VG, GG, GAA, and ASC. Finally, a cluster analysis of depth scores of all 112 factors (thus adding a weighting to the different impact areas) observed CBIB and TAS to cluster with the minimum, VG, GAA and GG in a middle cluster, and ASC to cluster closest to the maximum (Fig. 2).

4. Discussion

Globally, the shrimp aquaculture sector is linked to a number of environmental and social issues including the destruction of ecologically important mangrove forests, misuse of chemicals and antibiotics, poor labor practices, and impacts on rural communities (Lebel et al., 2002). For the six shrimp standards compared in this study, we found that breadth tended to scale linearly to depth, and thus the schemes ran the continuum between being a few factors not rigorously addressed (undifferentiated, see Graphical abstract) to many factors addressed more aspirationally. None of the schemes analyzed in this study occupied the space of being a single issue, or being broad but general (see Graphical abstract). A simple graphical B–D method was useful in creating an overall ranking, and discerning large scale differences between programs, but differentiation of more similar certification schemes required more sophisticated statistical tools. The choice of tool did drive outcomes, as there was greater differentiation between the standards when the cluster analysis was populated with the 112 factors. This in essence weighted the impact areas given the unequal distribution of factors across the different impact areas (e.g., there were 31 factors for environmental protection, but only 9 for feed, hence analysis of the 112 factors would weight environmental protection greater than feed). When the cluster analysis was conducted with the data for the five impact areas, there was a lesser ability to discern standards, likely as a result of the averaging necessary to create the five impact areas. Overall, the B–D, cluster and multiple analysis of variance analytical methods demonstrated that the three global standards were relatively similar on average, but each had unique strengths. Across the global schemes, GG tended to be of lesser depth than GAA or ASC, in part because of GG's reliance on BMPs as the ideal mechanism for addressing each factor. Yet

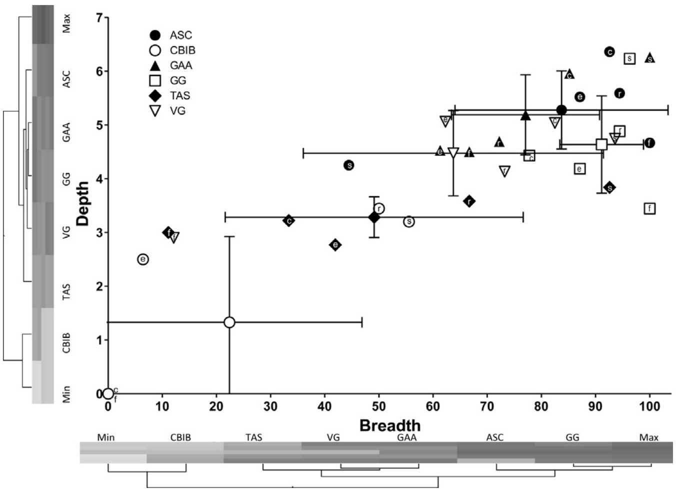

Fig. 1. A breadth–depth (B–D) analysis of 6 shrimp certification programs (Aquaculture Stewardship Council (ASC), Indonesia (CBIB), Global Aquaculture Alliance (GAA), GlobalGap (GG)), Thailand Aquaculture Standard (TAS), and VietGAP (VG). Program information is listed in Supplemental information 1. Each of the five impact areas are identified by the relevant letter code (c, community; e, environment; f, feed and marine resource use; r or s, food safety) for each certification scheme. The unlabeled symbols denoting each certification are averages and 95% confidence intervals of the five impact areas. A cluster analysis (JMP 8.0.2.2, SAS Inst., Carey NC) was conducted separately for the breadth and depth values and is provided adjacent to each axis. The cluster analyses were based on the average of the impact area values, and a minimum (0) as well as a maximum (100 for breadth and 7 for depth) value was included for reference.

GG also tended to address a greater proportion of factors within each impact area. Thus difference observed in the MANOVA analysis (where GG and ASC were similar and statistically greater than GAA) was likely driven by the differences in breadth as opposed to depth.

Understanding the variation across national and global schemes can form a foundation on which the improvement of aquaculture can occur. The entire seafood value chain can encourage operations to achieve an entrance-level certification, and then to source increasing volumes from more rigorous schemes, with rigor being determined by the methods developed here. While the model put forth here and elsewhere (Tlusty, 2012), implies horizontal differentiation across independent schemes, vertical differentiation (Bush and Oosterveer, 2015) cannot be ruled out. Individual schemes could use this type of analysis to assess weak points programmatically, and shore them up during the revision processes. However, given that aquaculture certification schemes have not yet developed tiers for specific modules (e.g., there is no platinum–gold–silver farm module), horizontal differentiation is likely the more adaptable model at this point in time. If there was interest in vertical differentiation, the B–D analysis provides a means to select key factors to augment within certification schemes to create an augmented or certification+ system (Bush and Oosterveer, 2015).

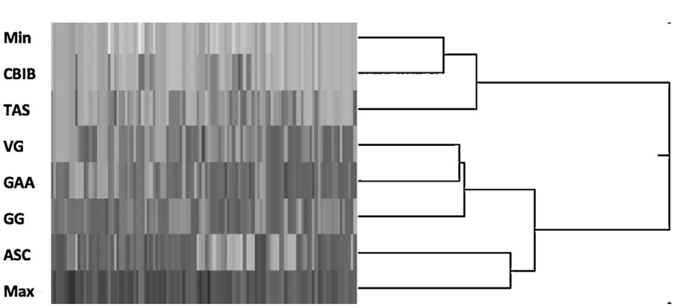

Fig. 2. A cluster analysis (JMP 8.0.2.2, SAS Inst., Carey NC) based on all 112 factors addressed within this study for six certification schemes including Aquaculture Stewardship Council (ASC), Indonesia (CBIB), Global Aquaculture Alliance (GAA), GlobalGap (GG), Thailand Aquaculture Standard (TAS), and VietGAP (VG). Each factor has equal weighting in this analysis, and because of this, the impact areas with a greater number of factors (e.g., environment) were weighted heavier.

This work demonstrated that a B–D analysis for comparison of certification standards, which can be conducted by calculating and graphing means and 95% confidence intervals, provided equivalent results to more costly (JMP 8.0.2.2, SAS Cary NC) or learning intensive (R Core Team, 2014) statistical software. This type of analysis does require a basis for determining which factors need to be assessed. Here we selected FAO (2011, 2006), given the wide range of stakeholder input on development of this guideline work, a similar tact adopted by the Global Sustainable Seafood Initiative (ourgssi.org). But rather than just assuring a baseline is met, the B–D analysis is a multivariate analysis to assess the rigor of certification standards, and could indicate where improvements need to be made for a scheme to meet the baseline, and also how certification schemes differentiate their standards beyond the baseline.

The B–D analysis also demonstrated the value of “no information”. Given the large number of factors considered within an aquaculture certification scheme (Tlusty and Tausig, 2014), it is inevitable that any one standard may be missing a number of factors. Prior standard comparison studies have dealt with a lack of information either by only considering factors common between schemes (Sustainable Fisheries Partnership, 2011), or by forcing “industry average” values when they were not addressed by the standard (Volpe et al., 2011). The B–D analysis developed here first determined the percentage of factors addressed for each impact area. This retained the true information content as set by the standard. The depth factor was then calculated as the average of the non-zero factors. Maintaining factors within a benchmark even when they were not considered by all standards will help more accurately compare and contrast schemes.

The need to differentiate between different certification standards is necessary given the rapid increase in number, and the lack of consistency between them. There is also a growing call by industry to understand “equivalency” amongst the schemes. Retailers are looking to simplify their decision making, while producers look to lessen their operational costs. However, we point to the diversity of issue areas covered by the certification schemes as being the driving force behind needing to identify programmatic differences. Given the large number of factors addressed by aquaculture certification schemes, it is difficult to ensure that they are addressed in the same manner (Tlusty and Tausig, 2014). Each certification scheme will have unique attributes that are addressed more or less rigorously than the others. This difference can form the basis by which a scheme could be selected as addressing a particular suite of impacts that aligns with a companies or consumers specific philosophy. Highlighting aspirational impact areas has been a means to vertically differentiate individuals schemes (Bush and Oosterveer, 2015).

Certification has been used in a variety of food production systems as a “carrot” to encourage and reward less impactful food production through increased or continued market access or even price-premiums (Steering Committee of the State-of-Knowledge Assessment of Standards and Certification, 2012). Certification schemes, which can provide a level of verification, accountability, and transparency into food production methods and impacts, grew out of a concern that governmental regulations and other agreements (e.g., Sanitary and Phytosanitary Measures Agreement, Henson and Caswell, 1999) alone were not sufficient to address the social and ecological impacts of food production (Bernstein and Cashore, 2007). As the development of and use of standards has matured, there has been acknowledgement that entire process, including the creating, auditing, and overseeing of the standards, is just as important as the content of the standards (Steering Committee of the State-of-Knowledge Assessment of Standards and Certification, 2012). This facet was not addressed in our analysis, but the newly developed Global Sustainable Seafood Initiative is creating a means to address rigor of the process by which standards are created (see ourgssi.org).

In some jurisdictions, regulations governing food production may be regarded by some as sufficiently rigorous to convey a "*de-facto*" claim of sustainable production (Engle and Stone, 2013). In these instances, governments have created (or are creating) a national sustainability brand in which producers may voluntarily participate (Boström and Klintman, 2006). Our findings here are that for shrimp aquaculture, the national schemes tend to be less rigorous both in breadth and depth, compared to global schemes, and in certain instances, do not even address specific impact areas (e.g., feed ingredients). We raise the concern that this creates a "race to the bottom" and caution against creating new schemes that are less rigorous than those currently in play.

5. Conclusions

In summary, this research demonstrated a means to differentiate rigor across multiple certification standards for shrimp aquaculture. Understanding these differences are important given the relatively large impacts associated with food production (Steffen et al., 2011). While we cannot avoid impacts associated with food production, we can take steps to ensure that the food we produce is done so with increasingly rigorous sustainability goals. Transitioning our hundreds of weekly food choices towards products created with relatively fewer environmental and socio-economic impacts will be important in creating a more resilient food system and food secure future. Certification schemes have a role to play as markers of our progress on the journey toward greater sustainability. A roadmap is needed for this journey, and encourage producers and consumers alike to create the market desire to support continual improvement in shrimp aquaculture.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.fishres.2015.10.008.

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	Aquaculture Stewardship Council (ASC)	Global Aquaculture Alliance Best Aquaculture Practices (GAA-BAP)	GLOBALG.A.P.	Indonesian Better Good Fish Farming Practices (CBIB)	Thai Agriculture Standard (TAS)	National Standard on Good Aquaculture Practices in Vietnam (VietGAP)
Origin	Independent non-profit organization	Non-profit trade association	Retail initiative	Government	Government	Government
Type of standard	Business to consumer	Business to consumer	Business to business, with consumer facing traceability	Unknown	Business to both	To be determined
Farmed shrimp specific	Yes	No	No, but species must be on GG product list (includes 10 crustacean species)	No	Yes	No
Scope	Environmental and social responsibility	Environmental and social responsibility, animal welfare, food safety and traceability	Food safety, environmental impact, compliance with animal welfare, worker health, safety and welfare requirements	Food Safety	Food safety, quality, animal welfare, environmental integrity and social responsibility	Food safety, minimize environmental impacts, ensure good aquatic animal health and take responsibility for social welfare and worker safety.
Scale (certification target)	Top 20% of producers	Not stated	Not stated	Unknown	Unknown	Unknown
Standards philosophy	Performance Based Limits (PBL)	PBL/Best Management Plan (BMP)	"Good aquaculture practices for individual or group certification"	BMPs	BMPs	BMPs
Rationale for standards philosophy	Standards define acceptable impacts rather than prescribe a specific production method, based on belief that farmers should be given the freedom to innovate around defined environmental or social benchmarks.	BAP certification defines the most important elements of responsible aquaculture and provides quantitative guidelines by which to evaluate adherence to those practices.	GLOBALG.A.P. standards serve as a production manual. There is a preference for documented records and management plans as these can be verified by the auditor.	Unknown	Unknown	Unknown

	Aquaculture Stewardship Council (ASC)	Global Aquaculture Alliance Best Aquaculture Practices (GAA-BAP)	GLOBALG.A.P.	Indonesian Better Good Fish Farming Practices (CBIB)	Thai Agriculture Standard (TAS)	National Standard on Good Aquaculture Practices in Vietnam (VietGAP)
Measurement of Conformity	Pass/Fail	Pass/Fail	Required (Major Must), scored (Minor Must – 95% pass required) and optional content (Recommended – 0% pass required)	Pass/Fail	Required "Major Requirement", scored (Minor Requirement - initially 70% pass increasing to 95% pass within 1 year; Recommended - initially 60% pass increasing to 75% pass within 1 year)	Pass/Fail
Chain of Custody	Separate CoC certification of all links in the value chain	Traceability requirement until the processing plant gate.	Separate CoC certification of all links in the value chain	Unknown	Unknown	Unknown
Standard Development System	ISEAL/ISO-59	ISO59	Certification Process: ISO/IEC 17065, ISO 59	Unknown	Unknown	Unknown
Accreditation, requirements	Accreditation: ASI, ISO 65	Standards Development: Accreditation: IAF Member, towards ISO-65	IAF Member with additional criteria	Unknown	Unknown	Unknown
Certification requirements	3rd Party, CB provides certification.	3rd Party, CB provides certification	3rd Party, CB provides certification.	Unknown	Aquaculture Development and Certification Center (ADCC)	"Competent authority"
Auditor Requirements	ASC-trained auditor with relevant experience and SA8000/SAI qualified social auditor.	GAA-BAP trained auditor with relevant experience	GLOBALG.A.P. trained auditor with relevant experience	Government auditor	Unknown	Unknown
Audit frequency	Annual	Annual	Annual	Unknown	Unknown	Unknown

	Aquaculture Stewardship Council (ASC)	Global Aquaculture Alliance Best Aquaculture Practices (GAA-BAP)	GLOBALG.A.P.	Indonesian Better Good Fish Farming Practices (CBIB)	Thai Agriculture Standard (TAS)	National Standard on Good Aquaculture Practices in Vietnam (VietGAP)
Standards used in this comparison	Draft Standards for Responsible Shrimp Aquaculture. Version 3.0 for Guidance Development and Field Testing. December 2011.	Draft Aquaculture Facility Certification. Finfish and Crustacean Farms. Rev. 4/13. Feed Mills. BAP Standards. Rev. 6/12	Integrated Farm Assurance – All Farm Base/Aquaculture module/Chain of Custody. Control Points and Compliance Criteria. English Version 4.0. Edition 4.0-1_FEB2012 Compound Feed Manufacturing. Control Points and Compliance Criteria. English Version 2.1. Edition 2.1-1_SEP12 GLOBALG.A.P. Risk Assessment on Social Practice (GRASP). GRASP Checklist V 1.1	Decree of the Minister of Maritime Affairs and Fisheries No. KEP.02/Men/2007 on How to Fish Culture of the Good (CBIB)	Thai Agricultural Standard TAS 7401-2009 Good Aquaculture Practices for Marine Shrimp Farm Thai Agricultural Standard TAS 7415-2008 Good Aquaculture Practices for Disease Free Marine Shrimp Hatchery	National Standard on Good Aquaculture Practices in Vietnam (VietGAP) No. 1503/QĐ-BNN-TCTS (Hanoi, 2011)
Elements excluded from this comparison	Chain of Custody Certification	Seed Production Unit (in development) Shrimp hatchery standards (to be retired)	Group Certification (Quality Management System), Chain of Custody.	None	None	None

Criteria #	Impact Issue	Denominator	Criteria	Further information
1	Community and Social	Social	Avoidance of forced/bonded labor	These issues include withholding passports from immigrant employees so they are unable to leave.
2	Community and Social	Social	Avoidance of child labor	
3	Community and Social	Social	Ensuring education for "young" workers	Definitions of “young” workers can be country dependent..
4	Community and Social	Social	Safe work practices for "young" workers	“Young” workers may not be allowed to undertake “hazardous” activities.
5	Community and Social	Social	Assurance that subcontractors and staff meet the same requirements as farm staff	
6	Community and Social	Social	Fair work practices (no harassment)	This would include sexual harassment, anti discrimination and other activities.
7	Community and Social	Social	Right of collective bargaining	
8	Community and Social	Social	Grievance process	This would include processes that allow employees to give feedback to farm management without fear of repercussion.
9	Community and Social	Social	Ensuring pay at least to national, regional, and local minimums	
10	Community and Social	Social	Responsible pay	“Responsible” denotes a aspirational goal different from national minimum wages; this would include “living wages” which include sufficient money to cover food, housing, clothing, recreation, furthering education etc. Note that definitions vary for “living wages”

11	Community and Social	Social	Benefits	These would include benefits such as health insurance or maternity leave.
12	Community and Social	Social	Fair work hours	Fair implies work hours that allow time for recreation and that do not overwork employees.
13	Community and Social	Social	Overtime protections	This would include limits to the number of hours that can be worked, whether or not they are voluntary and paid at a higher rate.
14	Community and Social	Social	Employee contracts	These enable employees to prove employment, have a stated rate of pay and clear guidance on benefits etc.
15	Community and Social	Social	Assuring suitable employee housing	"suitable" housing can be country specific but implies safe construction, hygienic habitat, can also include provisions such as those that protect privacy.
16	Community and Social	Social	Access to clean drinking water	
17	Community and Social	Social	Food provisions/culturally acceptable	This could include ensuring kitchens are hygienic and providing food that is culturally suitable for the predominant nationality of the workforce.
18	Community and Social	Social	Safe working environment	This is a worker welfare criteria aimed at reducing work accidents.
19	Community and Social	Social	Access to medical equipment	E.g., first aid kits
20	Community and Social	Social	Access to/training on medical care	
21	Community and Social	Social	Emergency response plans or actions	

22	Community and Social	Social	Access to community resources	Shrimp farming can occur in coastal environments and next to estuaries, the farm construction and precautions taken to prevent poaching could exclude rural communities from fishing grounds or other natural resources, unless these rights are protected.
23	Community and Social	Social	Conflict resolution with local communities	Shrimp farms may impact local communities in many ways, this criteria highlights approaches to addressing these, such as by hosting regular meetings with community leaders.
24	Community and Social	Transparency of Operational Information with Local Communities	Publicly visible operational permits	
25	Community and Social	Transparency of Operational Information with Local Communities	Community participation in assessing social impacts	
26	Community and Social	Transparency of Operational Information with Local Communities	Community participation in assessing environmental and biodiversity impacts	
27	Community and Social	Transparency of Operational Information with Local Communities	Contract farming, prices paid to the farmers by the processing plant	
28	Environmental Protection	Escapes	Escape prevention from pond effluent canals	Includes appropriate guards on pond gates and effluent canals, especially during harvest.

29	Environmental Protection	Escapes	Escape prevention from flooding	Ponds of insufficient height can become flooded, allowing shrimp to escape over the pond walls.
30	Environmental Protection	Escapes	Escape prevention from pond failure	Weak and poorly maintained pond walls can break, leading to mass escape of shrimp.
31	Environmental Protection	Escapes	Impact of farming non-native shrimp species	Impacts include establishment of a non-native species, introduction of diseases, and competition with native species.
32	Environmental Protection	Escapes	Escape event records and monitoring	
33	Environmental Protection	Farm Siting	Suitability of the local water quality to shrimp farming	
34	Environmental Protection	Farm Siting	Impact/standards on fauna/flora (Biodiversity) of high conservation value (HCV) by farm siting	Land conversion for shrimp farms can directly impact critical habitat and/or behavior of HCV species, and thus damage sensitive populations.
35	Environmental Protection	Farm Siting	Impact/standards on fauna/flora (Biodiversity) of high conservation value by farm operations (excludes predator control)	Day-to-day actions by the farm (e.g., noise, waste) can also impact HCV species.
36	Environmental Protection	Farm Siting	Mandatory buffer zones between farms	
37	Environmental Protection	Farm Siting	Mandatory habitat corridors on farms	
38	Environmental Protection	Farm Siting	Impact of Predator Control - HCV (threatened/endangered)	Predators such as diving birds and mammals can cause significant losses to shrimp farms and may introduce and spread disease. Lethal predator controls, such as shooting predators, however may impact HCV species populations and may have consumer concerns.

39	Environmental Protection	Farm Siting	Impact of Predator Control (Non HCV)	Lethal predator controls may lead to excessive losses to species populations and may have consumer concerns.
40	Environmental Protection	Farm Siting	Siting in National Protected Areas (NPAs) (IUCN)	Shrimp farms tend to be closer to the coast and in rural areas; sometimes farms are sited in NPAs as designated by groups including IUCN and others. Shrimp farms can have environmental impacts and left unchecked may damage protected areas and habitats.
41	Environmental Protection	Farm Siting	Ongoing conversion of habitats of HCV (mangroves/wetlands)	Before the late '90s, shrimp farms were sited on the coast, with access to seawater. Mangrove forests and other wetlands that offered critical nursery areas for many commercially important marine species and other important ecosystem services such as protection from tsunami, were converted to shrimp farms. Mangrove areas are now known to be bad shrimp farming zones, and modern farms are sited further from the coast, additionally many countries now legally protect these ecological assests, however some conversion still occurs.

42	Environmental Protection	Farm Siting	Conversion of habitats of HCV post May 1999	The Ramsar Convention in May 1999 was when the international community gathered protect and “wisely use” mangrove and other wetland areas. Modern shrimp farms do not need to be sited on the coast, so ongoing mangrove loss for shrimp farming has greatly reduced.
43	Environmental Protection	Farm Siting	Conversion of habitats of HCV (mangroves) pre-May 1999	Much of the mangrove loss for shrimp farming occurred before May 1999, mainly during the 1970-90s before the advantages of inland shrimp farming were identified. Historic mangrove loss is hard to verify, especially in built up farming areas. Restoration is also challenging.
44	Environmental Protection	Water Quality	Separation of the farm inlet and outlet	This is a measure to reduce “self-pollution”, it would be expected that the vast majority of shrimp farms would do this as standard practice.
45	Environmental Protection	Water Quality	Mandatory use of sedimentation ponds on inlet and outlet	Sedimentation ponds hold water and allow suspended organic matter to settled, thus improving water quality.
46	Environmental Protection	Water Quality	Nutrient release in farm effluents	Excessive nutrient release can cause local eutrophication. The management of nutrient loss has been approached in many different ways.
47	Environmental Protection	Water Quality	Suspended solids released in farm effluents	
48	Environmental Protection	Water Quality	Dissolved oxygen in farm effluent	
49	Environmental Protection	Water Quality	Organic matter in farm effluent	

50	Environmental Protection	Water Quality	Reduction of pond water exchange	Reducing water exchange (often represented as a daily % of pond volume) reduces the volume of water released from the farm, which may reduce waste. It also reduces the water brought into the farm, which may improve biosecurity by reducing the number of pathogens entering the farm.
51	Environmental Protection	Water Quality	Cumulative impacts of shrimp farm effluent on the surrounding environment	Individual farms may contribute small amounts of waste to an area but many little farms releasing waste can create a large impact. Measuring and managing these cumulative impacts is challenging, and uncommon in shrimp farming.
52	Environmental Protection	Water Quality	Deliberate release of saline water in freshwater resources	
53	Environmental Protection	Water Quality	Salinization from vertical seepage of pond water	Vertical seepage is where saline ponds seeps through the pond bottom and into any water resources below the farm. The main concern is freshwater aquifers below the farm that may be made undrinkable by the addition of the saline water.
54	Environmental Protection	Water Quality	Salinization from horizontal seepage of pond water	Horizontal seepage is where the saline water seeps out of the pond walls and into the surrounding land. The increasing salt content in the soils may impact agriculture and local flora.

55	Environmental Protection	Water Quality	Salinization from the disposal of pond sludge	Ponds and sedimentation ponds can collect saline sludge. Improperly disposed of, the salt in that soil may leech out and damage the local environment.
56	Environmental Protection	Water Quality	The use of freshwater for salinity control in ponds	In hot climates, evaporation of pond water may increase pond salinities until they become excessive for shrimp farming. Freshwater was sometimes pumped from groundwater wells to reduce salinities, but this could the reduced capacity in the wells allowed saltwater to penetrate them and make these resources undrinkable.
57	Environmental Protection	Water Quality	Maintenance of in-pond water quality	Ways to ensure that pond water quality was within the tolerances of the shrimp and reduce health issues.
58	Environmental Protection	Water Quality	Management of water use (water conservation)	
59	Feed	Feed	Marine resource use efficiency	Marine shrimp feeds generally include fishmeal and fish oil ingredients. Fishmeal levels generally may make up from 15-35% of the feed by weight. This inclusion rate and the feed conversion ratio can affect the efficiency that marine resources are used in shrimp farming.
60	Feed	Feed	Traceability of non-marine ingredients	Traceability here is considered to include species and farming source. Non-marine ingredients can include terrestrial proteins. Some 3rd party certifications exist for these.

61	Feed	Feed	Traceability of marine ingredients	Traceability here is considered to include species, area of harvest, and catch method. 3rd party certification exists for these.
62	Feed	Feed	Avoidance of marine ingredients from Illegal, Unreported and Unregulated (I.U.U.) fisheries	
63	Feed	Feed	Avoidance of marine ingredients from stocks of endangered species	
64	Feed	Feed	"Responsible" direct sourcing of marine ingredients (wild fisheries)	"Responsible" denotes products of higher environmental and/or social performance. 3rd party certification exists for these.
65	Feed	Feed	"Responsible" sourcing of marine ingredients (byproducts of wild fisheries processing)	"Responsible" denotes products of higher environmental and/or social performance. 3rd party certification exists for these
66	Feed	Feed	"Responsible" sourcing of marine ingredients (byproducts of farm-raised fish processing)	"Responsible" denotes products of higher environmental and/or social performance. 3rd party certification exists for these
67	Feed	Feed	"Responsible" sourcing of non-marine ingredients	"Responsible" denotes products of higher environmental and/or social performance. 3rd party certification exists for these
68	Food Safety	Food Safety	Chemicals/toxins in the local watershed	E.g., PCBs, heavy metals
69	Food Safety	Food Safety	Domestic/farm sewage treatment	
70	Food Safety	Food Safety	Biological contaminants in the local water shed	E.g., animal manure/human waste

71	Food Safety	Food Safety	Active pest control	This could include placing and monitoring of traps.
72	Food Safety	Food Safety	Feed Food Safety Screening, (including pesticides, biological, chemical and physical contaminants, and/or other adulterated substances)	
73	Food Safety	Food Safety	Feed Food Safety - legal compliance	
74	Food Safety	Food Safety	Compliance with veterinary drug treatment withdrawal periods	
75	Food Safety	Food Safety	Clean ice use during harvest	
76	Food Safety	Food Safety	Food safe transportation of harvested products	"Food safe" denotes standards on transport hygiene.
77	Food Safety	Food Safety	Training for employees on food safety practices	
78	Food Safety	Traceability and Record Keeping	Veterinary drugs (inc. type, concentration, dosage, method of administration, and withdrawal times and the rationale for their use)	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
79	Food Safety	Traceability and Record Keeping	Chemicals (inc. type, concentration, dosage, method of administration and withdrawal times and the rationale for their use)	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
80	Food Safety	Traceability and Record Keeping	Additives (inc. type, concentration, dosage, method of administration and withdrawal times and the rationale for their use)	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
81	Food Safety	Traceability and Record Keeping	Culture unit identification number	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.

82	Food Safety	Traceability and Record Keeping	Record of stocking date	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
82	Food Safety	Waste Disposal and Storage	Maintaining a trash free/waste-free farm environment	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
83	Food Safety	Traceability and Record Keeping	Quantity of postlarvae stocked	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
84	Food Safety	Traceability and Record Keeping	Source of postlarvae (hatchery)	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
85	Food Safety	Traceability and Record Keeping	Harvest date	This requires the specific requirement to maintain these records, some programs include these data in their traceability or chain of custody standards.
86	Food Safety	Traceability and Record Keeping	Processing plant products are sold to	
87	Food Safety	Traceability and Record Keeping	Record of sulfite use in shrimp	
88	Food Safety	Traceability and Record Keeping	Manufacturer and lot number for each feed used	
89	Food Safety	Waste Disposal and Storage	Fuel leakage and safe storage	
90	Food Safety	Waste Disposal and Storage	Prevention of contamination by stored chemicals	This could include separate storage in a suitable area.
91	Food Safety	Waste Disposal and Storage	Prevention of contamination of stored feed	This would include isolation from chemicals and reducing pest access to stored feed.

93	Food Safety	Waste Disposal and Storage	Disposal of farm waste (non-hazardous)	
94	Food Safety	Waste Disposal and Storage	Avoidance of creating borrow pits/piles of soil	
95	Supply Risk	Seed	Environmental impacts of wild broodstock sourcing	This could include sourcing from overfished stocks, bycatch of other species and the impact on those populations and the spread of disease.
96	Supply Risk	Seed	Environmental impacts of wild post larval sourcing	Wild post larval collection has had social and environmental impacts, including significant bycatch and impacts on other species. Wild PLs are also likely to have unknown health status, and could result the spread of disease.
97	Supply Risk	Seed	Sourcing disease-free post larvae	This could include the sourcing of Specific Pathogen Free (SPF) Post Larvae, and verification of disease-free status for World Animal Health Organization (OIE) listed diseases.
98	Supply Risk	Seed	Maintaining/sourcing from biosecure hatcheries	
99	Supply Risk	Seed	Use of transgenic shrimp	
100	Supply Risk	Shrimp Health Management	Maintaining farm biosecurity	
101	Supply Risk	Shrimp Health Management	Pest control on farm inlet (e.g., the use of screens)	
102	Supply Risk	Shrimp Health Management	Prevention of the spread of disease from the farm.	
103	Supply Risk	Shrimp Health Management	Ability to quarantine diseased shrimp ponds	
104	Supply Risk	Shrimp Health Management	Survival rate	
105	Supply Risk	Shrimp Health Management	Shrimp disease diagnosis	
106	Supply Risk	Shrimp Health Management	Staff training on biosecurity/shrimp health management plans	

107	Supply Risk	Shrimp Health Management	Prevention of antibiotic resistance	This would include measures to specifically address the spread of antibiotic resistant bacteria which could have been increased by the farms use of these drugs. Actions to prevent this might include a rotation of treatments.
108	Supply Risk	Shrimp Health Management	Prevention of the use of illegal or banned chemicals and antibiotics	
109	Supply Risk	Shrimp Health Management	Prevention of the prophylactic use of antibiotics (misuse/abuse of antibiotics)	
110	Supply Risk	Shrimp Health Management	Appropriate selection of veterinary drugs and chemicals (effective use)	Appropriate selection denotes the use in response to a diagnosed disease for which that treatment is effective. Some national and international veterinary institutions have codes of practice for this.
111	Supply Risk	Shrimp Health Management	"Responsible" veterinary drug selection strategy	“Responsible” denotes recognition of additional consideration to the selection of antibiotics, such as those listed by the World Health Organization as critically important to human health
112	Supply Risk	Shrimp Health Management	Environmental impact of chemical/antibiotic wastes	