Advancing the sustainability of farmed seafood

ASC remote monitoring pilot: final report

This project was made possible thanks to a grant from the ISEAL Innovations Fund, which is supported by:

seawarden.io | May 2022
About us:

Sea Warden’s mission is to advance the sustainability of farmed seafood by addressing critical data gaps within the aquaculture industry.

Sea Warden was founded in 2020 by Zack Dinh, Shelby Oliver, and David Wang and is based in California.

Why satellites?

- independent and verifiable data
- simple: specify location and receive insights
- low cost: ~$1/day per farm
Project development:

Our collaboration with ASC has focused on shrimp farming.

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**Challenge Phase**

Gravity Challenge competition: ASC selects SW and ThinkAqua.

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**Pilot Phase I - start**

ASC selects SW to support ISEAL-funded pilot to explore Earth Observation (EO). SW begins providing ASC with EO insights.

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**Pilot Phase I - end**

Sw designs, implements, and delivers EO insights for ASC’s Aquaculture Improvement Program Pilot in Indonesia. Farmers share data using digital tools w/ YSAI support.

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**Pilot Phase II - start**

Build on Phase I learnings. Continue work with AIP participants, integrate EO into ASC certified and improver program operations.
What we're trying to solve:

**Most aquaculture certification programs are reliant on in-person audits**

Audits occur just once a year due to cost and have been difficult to conduct because of COVID-19. Tracking improvements is time-consuming and costly with only in-person methods. Emerging technologies can address data gaps in smallholder shrimp farms and help grow farmer participation in ASC.

*Smallholder farms* contribute strongly to global production. However, their small size (less than 5 hectares) make them **difficult to audit and track improvements** using current methods.
What we're trying to solve:

**We're focused on making remote auditing an option for shrimp farmers**

Certification and improvement programs lead to **better environmental outcomes** for habitat and resource use while encouraging **socially responsible farming** practices.

ASC Shrimp Standard for *L. vannamei* and *P. monodon*
Summary: Remote monitoring strengthens the integrity of aquaculture certification programs while increasing access to more producers.

**Approach:** satellite observation and a mobile phone app to remotely audit key shrimp production indicators.

**Users:** data is provided to standard setters, auditors, implementer, and as useful insights to the farmers.

**Rationale:** pilot opportunity for satellite monitoring and digital tools to scale improver programs and allow ASC to explore emerging technologies.
Scope of work

Piloted remote monitoring framework consisting of 3 components to understand potential.

**Region Monitoring**
*East Java, ID & Guayas, EC*

Area-based assessments & understanding regional farm characteristics. Initial scoping tool to identify farms suitable for improvement program.

**Site Monitoring**
*East Java, ID*


**Connector**
*East Java, ID*

Deploy Sea Warden Connector (Chatbot assistant, survey tool) on AIP->ASC farms. Test digital monthly data collection. Verify data from pilot & test farmer’s willingness to share KDEs digitally.
METHOD: REGION MONITORING

Define parameters of interest to conduct initial suitability scoping of farms under consideration for the ASC improver program.

Steps

1) Gather recent satellite imagery from region.
2) Apply Sea Warden’s object-detection model to identify and map pond boundaries across region.
3) Collect geo-spatial attributes on proximity of ponds to: historic mangroves (Global Mangrove Watch, 1996 data), protected areas, coastline
   a) Coastline - generate ‘average’ coastline based on composite of images across year
   b) Pond estimates: size, dimension, # aerators, use (production, non-production pond)
4) Produce pond-level and region summary information for evaluation by ASC & AIP implementers
5) Overlay AIP candidate farms with region results as initial scoping against location based parameters of ASC standard (e.g. historic mangrove)
DELIVERABLE: REGION MONITORING

Provided up-to-date baseline production-unit level (i.e. pond) map to estimate annual production & location based-parameters in Guayas, EC and Situbondo and Probolinggo in East Java.
REGION SUMMARY: ECUADOR

Overview
- Location - Guayas, Ecuador (-3.086, -79.912)
- Total area (ha) - 2,544

Aquaculture area
- Total number of ponds - 5,594
- Total pond area (ha) - 58,387.3
- Median pond size (ha) - 7.1
- Pond area coverage of region (%) - 23%

Production estimates
- Crop yield for region, low (mt/crop) - 94,898.1
- Crop yield for region, high (mt/crop) - 113,983.8
**POND-LEVEL INFORMATION: ECUADOR**

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</table>

- **Unique id for 5,594 ponds**
- **Per pond crop yield & classification**
- **Pond proximity to mangroves, protected areas, and coastline**

Users can query to assess level of risk at the pond level, and potential production volume estimates for assurance purposes.
TAKE-AWAY: REGION MONITORING

Successes
- Delivered production-unit maps for 3 regions
- Mapped two very different shrimp farming systems (i.e. semi-intensive large ponds in Ecuador, intensive farms in Indonesia)
- Provided regional estimates on production capacity and identified ponds/farms of risk

Area-level assessments provide value:
- For AIP implementers to scope farm sites and identify additional suitable candidates.
- For situational awareness of surrounding farms/aquaculture area
- To support future area-based assessments and standard requirements
METHOD: SITE MONITORING
Evaluate ability of farm-level satellite monitoring of historic production to assess risk and collect key data elements.

Steps
1) In-depth satellite observation analysis of farms in ASC AIP to certification track. 4 farms in Indonesia.
2) Analyze historic satellite imagery at weekly intervals from Jan 2021 to 2022-present to assess production activity (i.e. when ponds full/empty with water).
3) Satellite imagery used includes open source and commercial data. Resolution range (0.5m-10m resolution). Sea Warden prioritizes open-source data to keep costs low and Planet satellite imagery to fill in gaps.
4) Evaluate shrimp production performance and predictability. Identify any incidences of risk (e.g. early harvests, <60 days of cultivation) for implementers to assess.
5) Estimate annual production capacity and operational aspects for assurance purposes.
SITE MONITORING: 4 farms

PT Agel, Situbondo

ANK, Probolinggo

ABK Kraksaan Probolinggo

CV. Trimitra Makmur, Bali
DELIVERABLE: SITE MONITORING

Provided farm site reports for 4 farms. Reports summarized location parameters and historic weekly production activity at the farm. All data obtained via satellite observation.
Key Data Elements derived from satellite imagery
Independently collect production data to inform ASC AIP & certification assessments.

Detection & Mapping → Activity Monitoring → Key Data Elements

- 21 intensive ponds: 6 ha
- 3 crops in 2021: 204 mt
- Stocking and harvest dates
- No early pond emptying
- 0.35 km from coastline
- 19 km from mangrove habitat
- 15 km from protected habitat

Artificial intelligence enables automation of repetitive tasks (pond detection and activity monitoring), enabling us to leverage cloud computing to scale monitoring for anywhere in the world.

2021 production activity, all ponds
blue = active | red = inactive

All ponds mapped and measured

PT Agel, Situbondo
TAKE-AWAY: SITE MONITORING

Successes

- Conducted in-depth production activity analysis for 4 ASC farm sites in 2021.
- Analysis showed all were intensive farms, had consistent production and produced 3 crops per year.
- All farms passed initial scoping for location siting to critical features

Site-level assessments provide value:

- As background information for AIP implementers to understand and evaluate risks prior to visiting farm
- Increased assurance through independent data and greater visibility throughout the year.
LESSONS AND CHALLENGES

Technical and cost issues exist with satellite monitoring, but institutional barriers and incentive structures present the greatest challenges.

- **Analysis time** - time is not a considerable constraint. Site monitoring can be conducted in a 24-hour period, regional assessments can take up to 2 weeks depending on region size and production type (i.e. are existing models refined for system). In the pilot, Sea Warden developed different analysis techniques for pond detection of intensive systems (i.e. Indonesia) and large semi-extensive systems (i.e. Ecuador). Sea Warden has developed methods to make open source imagery viable for regional pond detection through utilization of different satellite sources and multiple image analysis, significantly reducing the cost.

- **Financial costs** - Depending on the granularity of production timing accuracy needed, commercial imagery may need to be purchased. This increases cost ($50 to $150 pure imagery cost depending on number of images needed), but still falls well below the cost of sending a person to visit the farm (by 2-5X less expensive, as reported by an Indonesia aquaculture company). And most importantly, imagery in the past can be accessed to address key questions for assurance purposes. More frequent farmer submission of photos from farm can reduce costs/fill in gaps.

- **Validity and accuracy of satellite monitoring** - No validation was conducted specific to this pilot given the limited scope (2 farms) and ongoing nature of monitoring. However, past projects with other Sea Warden clients in Indonesia, Thailand and India found these levels of accuracy against various parameters:
  - Pond area - 93% accuracy
  - Aerator counts - 91%
  - Crop cycles - number of cycles predicted (90%) & duration/timing of cycles (80%)
  - Production volume - 86%
LESSONS AND CHALLENGES

Create an incentive structure and streamline the standard/evidence collection to leverage benefits of emerging technologies.

- **Establishing farm coordinates and location** - Some communication with the farm is necessary to establish farm coordinates. Sea Warden Connector (see next section) and the pond-ownership survey was successful in confirming farm location and boundaries. It can be difficult to distinguish a farm boundary if only a single GPS point is provided in regions with dense aquaculture production (e.g. Ecuador).

- **Effective scoping mechanism** - Site monitoring was used by implementers to ensure prospective AIP farms met minimum standard requirements for the program (e.g. mangrove siting). Analysis rapidly conducted.

- **Difficulty with incentives** - Farmer participation was particularly challenging. While the sample size was incredibly small, only 2 of 4 farms participated in the Connector trials. An incentive for participation (e.g. reduced audit burdens, competition, eg) would improve likelihood of success for remote monitoring programs.

- **Challenges with evidence/audit efficiency** - Satellite monitoring (and farmer photo-submitted data, such as through Connector) should ideally reduce the burden on the farmer of collecting evidence for the audit. It was unclear in the pilot to what degree outputs from Sea Warden were used and whether ASC considers data collected via these methods as sufficient to meet audit criteria.

- **Modify standard to capture benefits of emerging technology** - to better leverage emerging technology for greater audit efficiencies and improved assurance, certain indicators of the standard could be streamlined. Or, risk assessment of onsite audits for some farms/certain issues (rather than requiring all annual audits, regardless of risk or data availability) could increase ASC uptake and reduce burden on farms. Remote monitoring becomes particularly important for maintaining assurance in the program while balancing financial/time burdens for farmers, implementers, and auditors.
SEA WARDEN CONNECTOR

Hello:
- Learn about our program: reply "learn"
- Join our program: reply "join"
- Share data with us: reply "send"
- Check farm status: reply "status"
- Check your points: reply "points"
- For assistance: reply "help"
- Share feedback: reply "share"
Farmers have WhatsApp & Open Camera app for geo-tagged photos. Sea Warden sends farmers WhatsApp message with survey links. Farmers answer questions, upload photos (taken through Open Camera), and submit survey. Sea Warden receives survey results. Confirm photos from farm.

Once a month, for 2 months.
METHODS: CONNECTOR

Developed chatbot system, created survey questions, and program material for training/data collection.

Steps

1) Analyzed ASC standard and created four surveys to inform compliance against select indicators and inform satellite insights. Input provided by ASC and YSAI (implementers).

2) Sea Warden created Connector chatbot system over WhatsApp.

3) Developed training material to ensure AIP farmers and implementers for installation and operation of Connector and collection of survey information (i.e. text, photos).

4) Implementers visited farms in person. Enrolled 4 ASC -> AIP farms in the program and completed initial surveys and covered sampling requirements.

5) Sea Warden analyzed initial data from farmers to ensure data integrity and photos geotagged.

6) Ongoing - farmers continue to receive sampling reminders. Monthly operation and harvest surveys will be sent over next 6-months. YSAI continue to support farmers in completing surveys, Sea Warden will analyze data and provide feedback. Data will inform site monitoring satellite component.
SURVEY DETAILS
Created four surveys to collect background info and farm location, performance for select ASC indicators, and harvest data.

Basic info
- Basic farm information
  - Text based

Pond ownership
- Confirm farm location
  - Photo based

Monthly operations
- ASC indicators - escapes, DO, energy
  - Photo & text based

Monthly harvest data
- Harvest information
  - Text based

Farmers receive automatic weekly sampling reminders on WhatsApp for checking traps & DO sampling.
CONNECTOR: ROLE OF IMPLEMENTERS

Implementers helped farmers install apps and complete surveys (in-person and remote).

- **Tech install**
  - **In-person:** Help farmers install tech on phone. Ensure farmers have smartphone, internet/data connection & pond ‘location services’ on.

- **Help enroll farms**
  - **In-person:** Fill out enrollment surveys with farmers at the farm.

- **Train farmers: data collection**
  - **In-person/remote:** Train farmers with photo and data collection. First surveys in person, monthly surveys if needed.

- **Contact farmers**
  - **Remote:** Sea Warden will notify implementers if issues with surveys, implementers contact farm.

Survey here: https://jotform.com/tw/a
CONNECTOR: INITIAL RESULTS

Enrollment survey results from one farm, demonstrating efficacy of the system.

PT Agel, Situbondo

Enrolled
Implementers installed tech and enrolled farmers.

Enrollment survey
Farmers submitted baseline info.

Pond ownership
Photos geo-tagged to establish farm boundary
TAKE-AWAY: CONNECTOR

Successes
- Developed user-friendly digital tool for farmers to collect and share data.
- Initial results show promise in approach to support satellite monitoring framework, and provide value as sampling reminder tool.
- Deployed onto 2 of four farms. Delayed start of pilot due to COVID-19 and registration challenges.

Next steps:
- Pilot will continue through to Dec 2022 across four farms. Data combined with satellite imagery to create remote monitoring framework.
- Continue to assess farmers willingness to submit data digitally.
- Evaluate value of digital data collection to ASC, implementers and auditors.
## OPPORTUNITIES AND CHALLENGES

Satellite & digital tools can support improvement programs and increase assurance. But logistic, cultural, and operational barriers exist.

### Opportunities

**Satellite imagery**
- Remote collect Key Data Elements, little input from farmer required
- Scoping tool for identifying suitable farms for a program and informing ASC’s growth strategy
- Independent data source to improve assurance against standard

**Digital tools**
- Reinforce good sampling practices and standardize data collection.
- Reduces workload for auditors/implementers to collect data onsite.
- Potential to lower cost/need for in-person audits by reducing auditor/implementer time onsite, and through more frequent data transfer from farmer to ASC (i.e. not only once a year)

### Challenges

**Satellite imagery**
- Unclear how to incorporate/leverage value of satellite data within ASC’s certified & AIP farms
- Perceptions: concerns over farmer privacy as it relates to satellite imagery & challenges with ASC’s country relationships. (Note: there are no legal restrictions on use of satellite data for monitoring aquaculture.)

**Digital tools**
- Small sample size (4 farms)
- High barrier to learning data collection requirements, training on survey processes etc.
- Farm internet connectivity: cumbersome data collection requirements. Photos had to be collected prior to starting survey.
- Language/translation requirements (noting ASC Standard in English). Not all countries use WhatsApp commonly.
**NEXT STEPS**

The second phase could focus on a framework to institutionalize satellite data into ASC operations and expand remote monitoring to more farms/regions.

**Institutionalizing satellite data**

ASC is interested in further incorporating satellite and broader digital technology into their certification and improvement programs. However, the best pathway to do this is unclear and ASC has many other competing priorities which limit their ability to explore this topic. Thus, the key next step is to identify how ASC can institutionalize and integrate satellite data into their work-flow to achieve actionable results. The three key areas where Sea Warden intends to explore these opportunities are:

- **Assurance** - compare satellite-derived parameters on production timing and capacity against farm/audit reported figures. Flag risk areas for additional investigation from the Standards and Chain of Custody team.
- **Farm mapping** - ASC has an ArcGIS platform where location of farms are displayed. Farmers are required to upload boundary data. There’s an opportunity to streamline the process and remove burden on farmer using object detection models & Connector.
- **Key Data Elements** - support program using satellite-derived KDE for independent assurance & reduced manual data entry burden on farmers/producers.

**Expand pilot**

The pilot can be expanded to include more farms in Indonesia, or other locations where ASC operates. Sea Warden will continue site monitoring (Connector + satellite imagery) for the 4 Indonesia farm sites until December 2022. We will evaluate the effectiveness of this system to: create good sampling practices, assess performance against ASC indicators, and bring value to farmers/implementers/certifiers.

Interviews will be conducted with farmers in the pilot to get their perspective on Connector. This will inform future development/incorporation of digital tools & data into ASC’s certification and improver program.
**SUMMARY**

- Satellite observations and digital tools can assist Improver programs in the scoping, deployment, and assessment phase.
- Sea Warden delivered regional insights across Situbondo & Probolinggo, Indonesia and Guayas, Ecuador. Site monitoring was conducted for 4 AIP to ASC sites for the 2021 period and training and Connector has been deployed on several farms.
- Connector and site monitoring will continue on the 4 farms until December 2022.
- There is opportunity to create a remote monitoring framework for certification/improvement programs but more work is needed to integrate data into ASC’s existing workflow and to understand farmer’s willingness to engage with digital tools in different countries/cultural contexts.

**ACKNOWLEDGEMENTS**

Sea Warden wishes to thank the ISEAL Innovations Fund and Swiss State Secretariat for Economic Affairs SECO for supporting this project and ASC for the opportunity.

We also want to thank Yayasan Sustainaqua Indonesia (YSAI) for their insights and assistance with deploying Connector with farmers in the AIP program. We are grateful to ThinkAqua (Anton Immink) for his guidance and feedback throughout this pilot.
DEVELOPERS
Pilot deliverables can be accessed in the Google Drive folder and using links below.

GOOGLE DRIVE FOLDER CONTAINS:

- Region monitoring results
  - Ecuador
  - Probolinggo
  - Situbondo
- Site monitoring
  - Farmsite reports - 2021 production history and associated analyses
- Connector
  - Remote pilot 1pg summary & Farmer program manual (also online at: https://www.asc-aqua.org/programme-improvements/improver-programme/)
  - Implementer training material/instructions
  - Survey results from farmers

WEBSITES

- Connector surveys (in English)
  - Enrollment: https://form.jotform.com/212645557564160
  - Pond ownership: https://form.jotform.com/212646225128149
  - Monthly operations: https://form.jotform.com/212645645401148
  - Monthly production: https://form.jotform.com/212704352258149