How ATP^3 is Addressing the Challenges of Scale-up in Algae Technology R&D

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One little cell,
a world of
possibilities.

ATP3
Algae Testbed
Public-Private Partnership

Steady and encouraging progress

Challenge Space:

1. High cost of production
2. Demonstrating scalability
3. Availability of nutrient resources

Opportunity Space:

Technical	Policy	Business
▪ Increase productivity ▪ Increase lipid (or other bioproduct) content ▪ Increase robustness and resiliency to resist predators ▪ Improve early detection of contaminants ▪ Develop new strains (polyculture/extremophile) ▪ Improve energy efficiency of downstream processing ▪ Scale keeps you honest but scale costs $$$	▪ Support from USDA for algae as precision agriculture ▪ EPA and USDA collaboration critical on CO_2 and GMO policies, crop designation, agricultural practices and policies and tax incentives/rebates. ▪ Carbon reuse and EPA rule-making: recycle waste rather than bury waste	▪ Take advantage of higher value markets to facilitate learning ▪ Continue to focus on multiple technology pathways and strategies ▪ Foster business innovation

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Example business opportunity: Near term markets facilitate long term learning

Small markets, High value products

Pharmaceutical & specialty chemical products:

$25k to $800k per MT

A higher-value, multi-product focus is **essential for cash flow** for start-ups, and part of a diversified, targeted marketing strategy to generate revenues.

Mid-sized markets, mid to high value products

Pharmaceutical, chemical & nutraceutical products: $2,000 to $25,000 per MT

Baby food formula | Cosmetics
Plastics | Food additives| Healthy oils |

Many of the stakeholders seeking access to the test beds and ATP^3 services are in the higher-value market or are developing and commercializing innovations that are market agnostic.

Large market, Low-value products

Bigger Markets, lower values: $500 to $2,500 per MT

Vegetable oils for consumption and biofuels
Carbon capture, bioremediation
Algal crude and bio-crude

Source: "Algae 2020 Study" Emerging Markets Online report (2009)

Relevance: ATP^3's near term impact

- Taking algal biofuels and co-products development from research to successful commercialization demands:
  - Solid and objective testing to provide **data**
  - **Integrated process equipment** needed to inform and guide research, systems and process development
  - Subsequent **analysis to support** strategic technical and investment decisions
- Providing stakeholder access to quality testbeds in real-world outdoor settings, and expertise and related resources, is necessary to generate new tools, datasets and best practices

Project Overview: ATP³ national open test bed

The formation of the Algae Testbed Public-Private Partnership **leveraged** the existing resources at AzCATI and our partner sites. The network represents a **collaboration** of industry, laboratory, and educational facilities across nation. ATP³ aims to **convene** all algae stakeholders to facilitate opportunities and progress more rapidly to commercialization.

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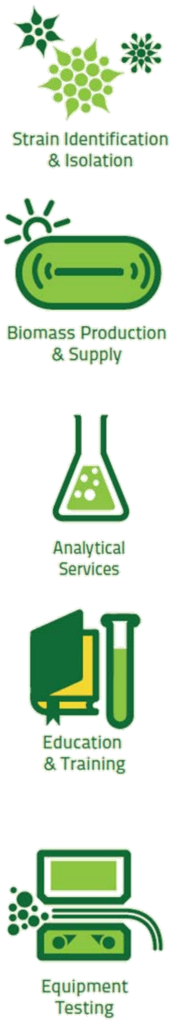
ATP^3 Primary Objectives



ATP^3 offers access to a wide array of services, capabilities and facilities:

Regional testbed facilities for the partnership are physically located in **Arizona, Hawaii, California, Georgia, and Florida.**

Create Collaborative Open Testbeds

- Form a national network
- Provide access to stakeholders
- Accelerate R&D outcomes

Collect and Distribute High Impact Data

- Unified research programs
- Pipeline for collection of **high-quality cultivation data** to support algae computational **modeling** including biomass productivity, techno-economic, and life cycle assessment.
- Make data available publically

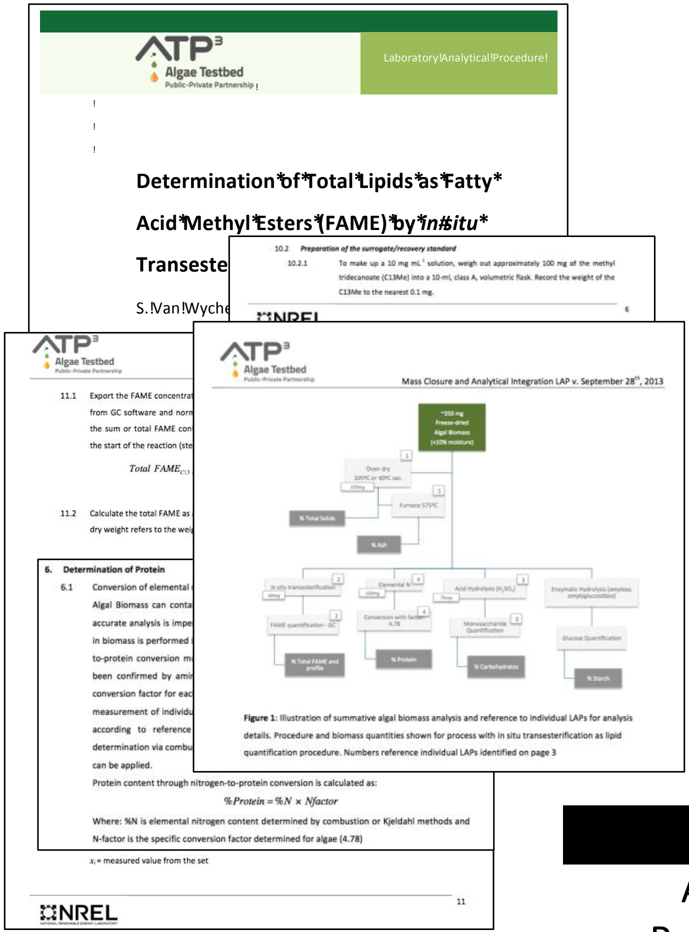
High Impact Data:
Long Term Algal Cultivation Trials

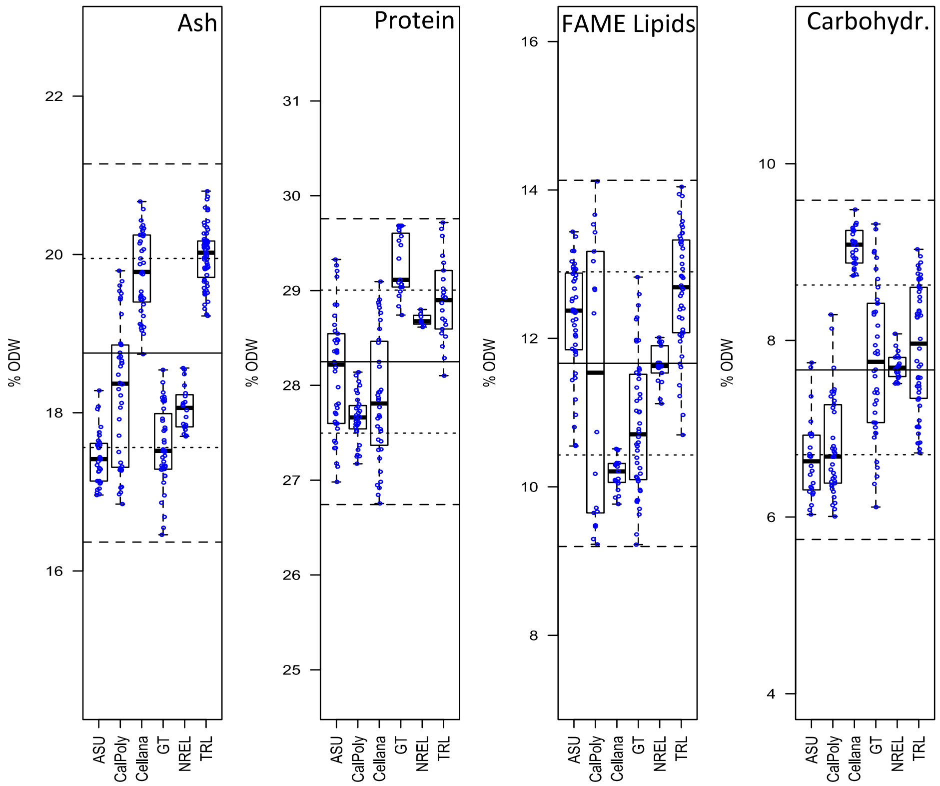
ATP[3] sets standards and conducts harmonized, rigorous, and objective **long term cultivation trials** to provide a realistic assessment of the **state of technology** for algal based biofuels and bioproducts.

- Our Unified Field Studies (UFS) at the testbed sites along with our Advanced Field Studies (AFS) enable **comparison of promising production strains at meaningful scale** across variable conditions
- Our **Scientific Data Management** System and validated, harmonized SOP's for analytical and production processes ensures **data integrity** across all sites
- Our protocols and data from the UFS and AFS are publicly available and provide a critical resource to TEA and LCA analysis yielding **high impact, validated data**

Standardization of processes and systems is key to executing meaningful multi-site cultivation trials

Setting Standards: Analytical and Production Methods



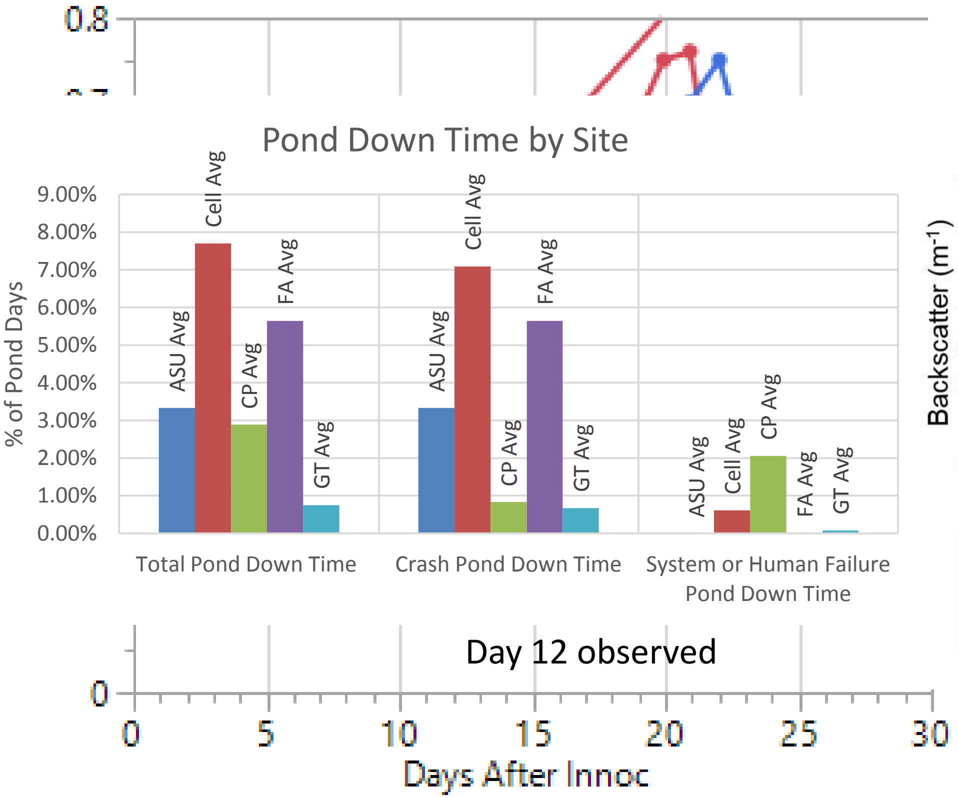


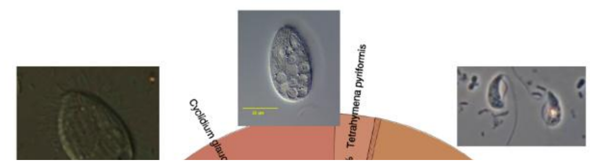
	mean	sd	RSD	*N*
Ash	**18.8**	**1.2**	**6.4**	*237*
Protein	**28.2**	**0.8**	**2.7**	*153*
FAME Lipids	**11.6**	**1.2**	**10.6**	*191*
Carbohydrates	**7.7**	**1**	**12.5**	*198*

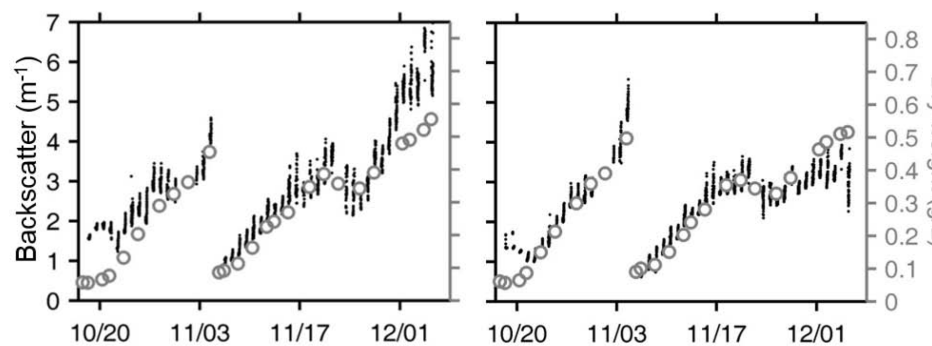
The ATP³ Framework: systems, tools, data, models and projections

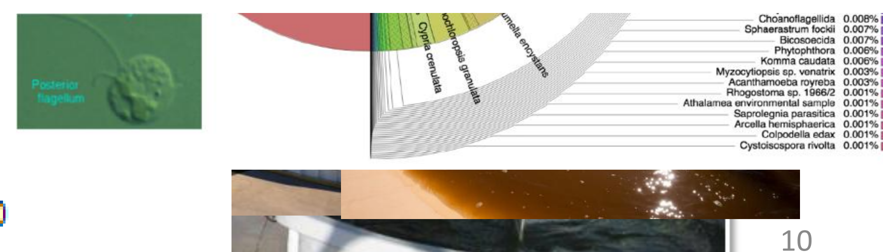
ATP³ is using a harmonized, experimental framework to implement Unified Field Studies that enable comparison of promising strains at a standard system scale.

ATP³ has developed and implemented a pipeline for the collection and distribution of high-quality cultivation data to support algae computational modeling including biomass productivity, techno-economic, and life cycle assessment and making this data publically available.









Summary

- ATP^3 has established validated framework for implementing rigorous, long-term multi-site cultivation trials including standard methods for biomass and bioproduct productivity assessments
- Allows determination of the effects of regional, seasonal, environmental variation that is to be expected for a national (international) deployment of algae cultivation
- Experimental program has expanded (AFS) to include larger scale, more cultivars, nutrient sourcing, media recycle and other additional capabilities of the partner sites
- Critical validation data source for biomass productivity modeling, TEA, LCA and RA community - will allow for refinement of the current state of technology (SOT) assessments utilized by DOE and the broader industry/investment community
- Challenges remain, but access to expertise and leveraging existing investment in facilities can help to accelerate algae R&D, de-risk technology, accelerate commercialization

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THANK YOU!

QUESTIONS?

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