

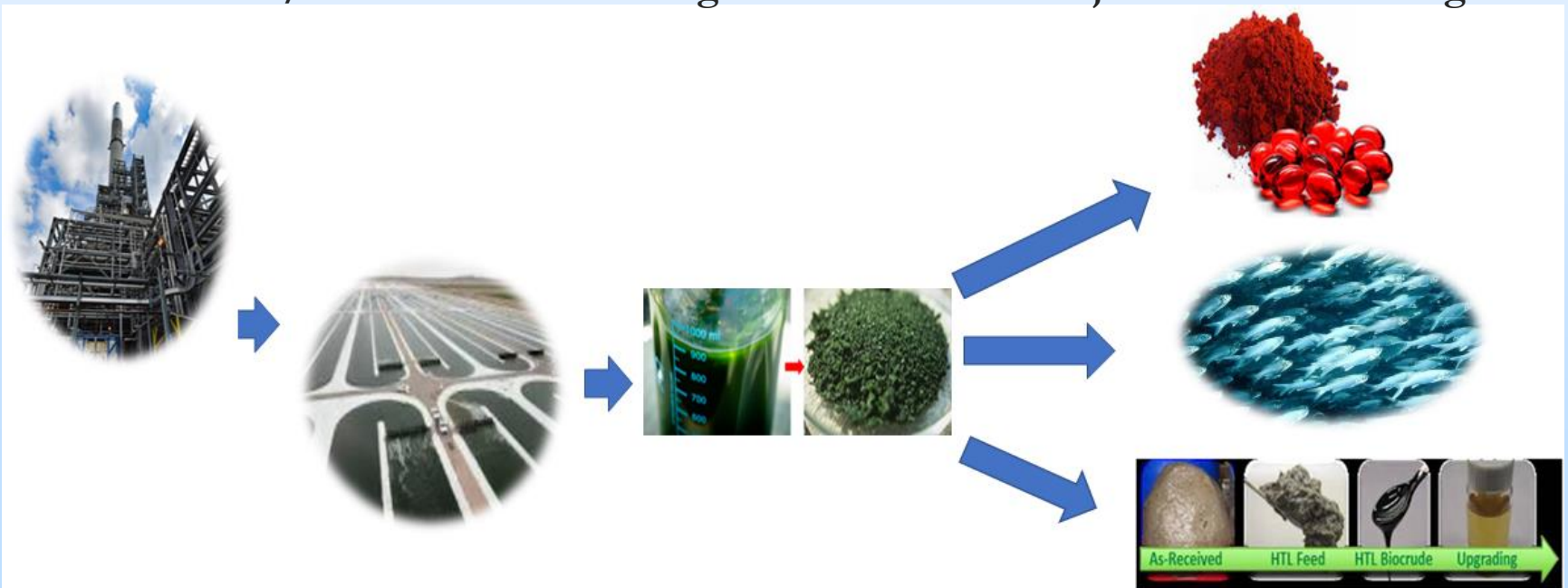
**Engineering-Scale Validation of Novel Algae  
CO<sub>2</sub> Capture and Bioproducts Technology**

**Award No: DE-FE-0032103**

**PI: Dr. Fred Harrington**

**NETL/DOE Federal Project Manager: Naomi O'Neil**

**2024 FECM/NETL Carbon Management Research Project Review Meeting**



# General Project Information

- **Title: Engineering-Scale Validation of Novel Algae CO<sub>2</sub> Capture and Bioproducts Technology**
  - Recipient: Helios-NRG, LLC
  - PI: Fred Harrington, PhD, Chief Scientist
  - Business Mgr: Jim Maloney, VP
  - DOE Federal Project Manager: Naomi O'Neil
- **Project Funding:**
  - **Total: \$2,499,030**
  - **Government Share: \$1,999,228**      **Cost Share: \$499,802**
- **Project Period: 10/1/21 – 10/31/25**

# Project Partners

- University of Buffalo-Lin
- University of Buffalo-Bradley
- Bozeman Fish Technology Center
- The Conservation Fund - Freshwater Institute
- National Carbon Capture Center
- Craft Nutrition

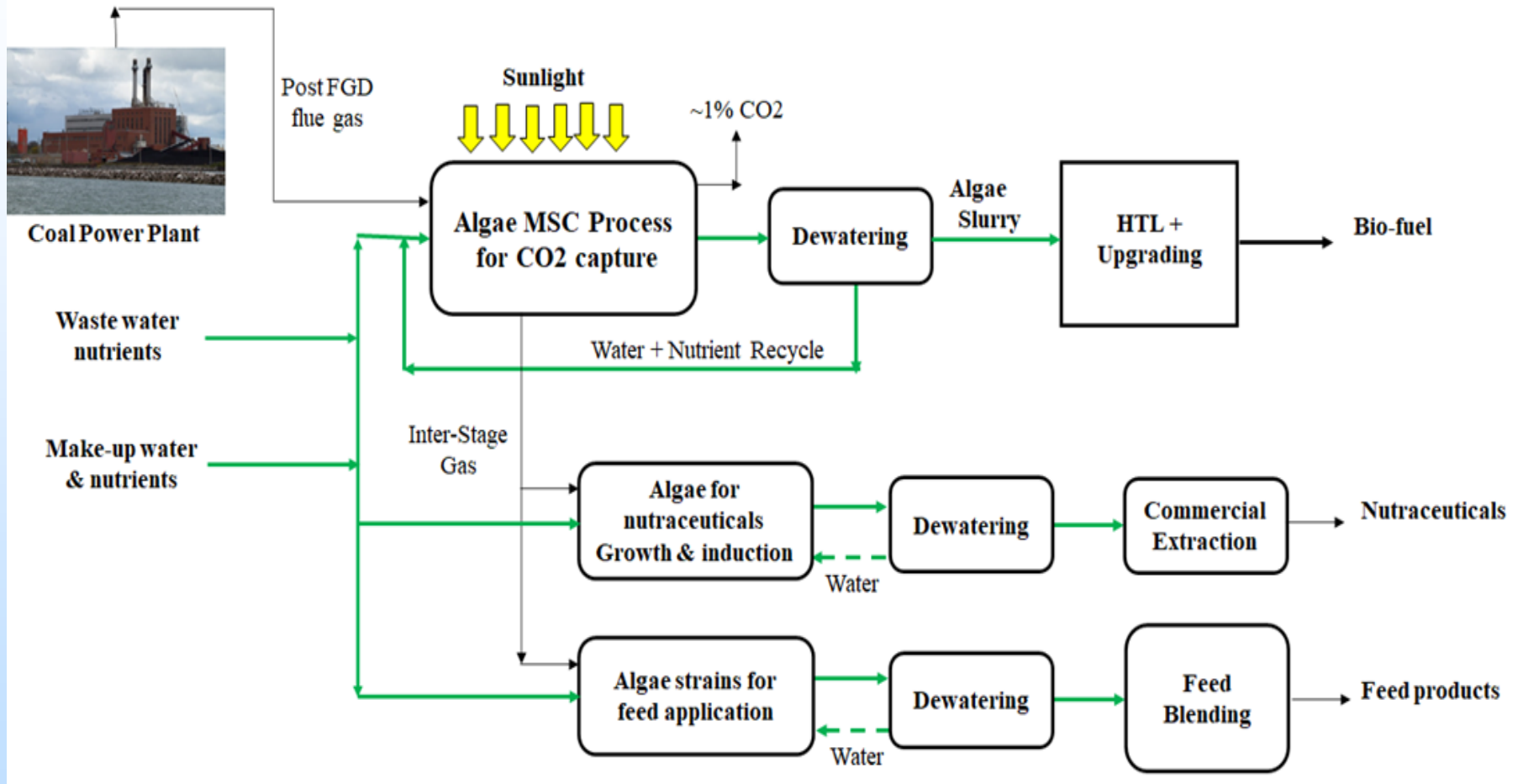


Bozeman Fish Technology Center

# Overall Strategy

- *For CO<sub>2</sub> capture to be economically viable, a revenue stream is required to offset cost of capture*
- **Develop algae technology for high CO<sub>2</sub> capture efficiency and high productivity from fossil fuel power plants**
- **Reduce capture cost via operational efficiency, wastewater credits & product revenue**

# Process Schematic at Commercialization

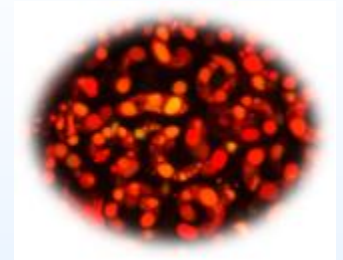


# Key Advantages of the Technology

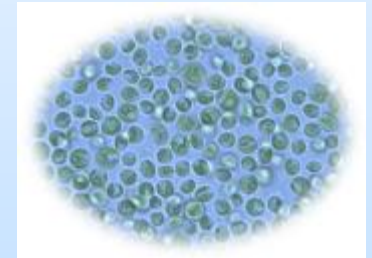
- **CO<sub>2</sub> captured as a biomass - avoids gas sequestration**
- **Sustainable primary energy source (sunlight)**
- **Capture cost offset by revenue from products**
- **High productivity + capture efficiency**
- **Closed system minimizes contamination & water loss**
- **Continuous scalable process**
  - Easier integration with upstream/downstream processes
  - Lower operational cost

# Algae Species Selection

- **Primary criteria for CO<sub>2</sub> Capture**
  - High growth rates in presence of flue gas contaminants
  - Can utilize wastewater (Municipal and HTL-aqueous)
  - Adapted naturally occurring species – no GMO's
  - Prior Helios experience & well characterized
- **Capture species selected for project (H-1903)**
  - Backup species available (H-0322)
- **Species are application & product specific**



**H-1903**



**H-0322**

# MSC process for Carbon Capture

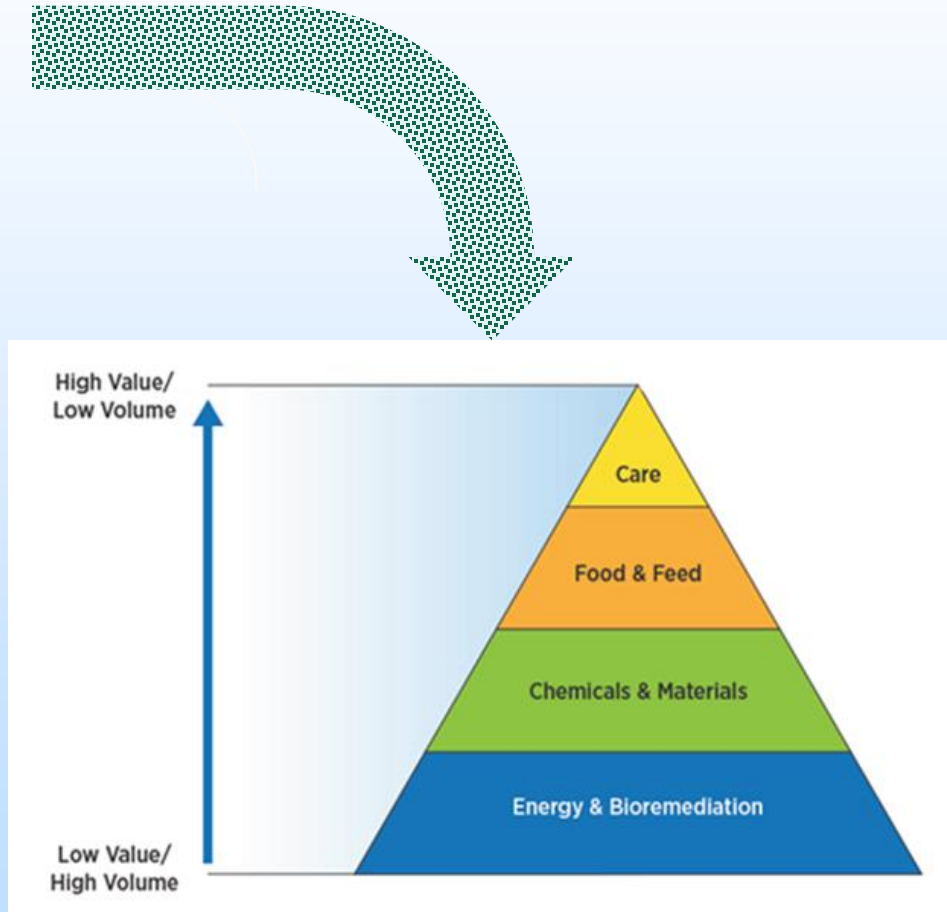
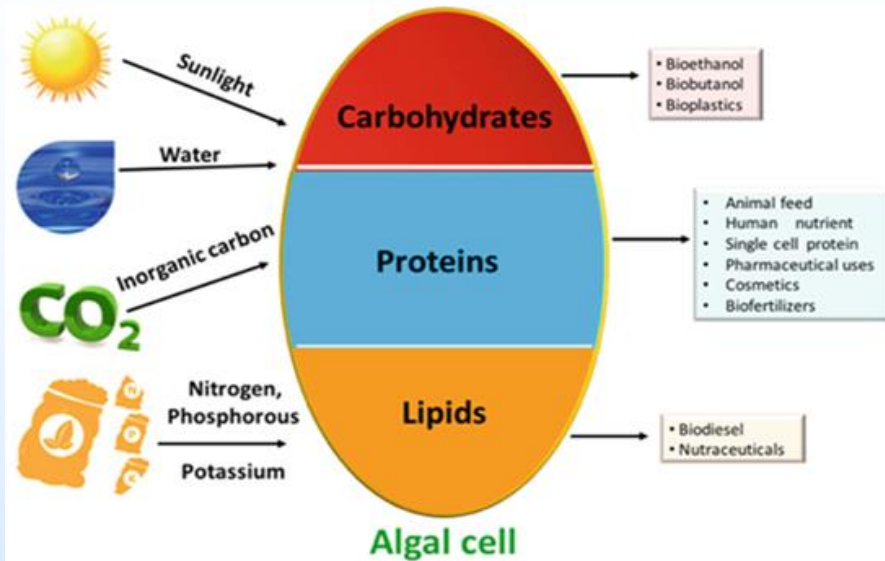
- **Concept developed using proprietary model**
  - Predictable operation - automated control
  - Top lit closed system
  - High productivity & capture efficiency
  - Various MSC tank designs developed & tested
- **Stability demonstrated in ~100 day outdoor test**
- **MSC operation validated at NCCC test in 2022**
  - Performance exceeded project targets



Location	Sim. Flue Gas Contaminant	Nutr-WW Replacement	Normalized Algae Prod	Avg CO2 Capture
GH-1 Indoor	SOX/NOX + 5HM	50%	92%	59%
Outdoor	N/A	N/A	139%	81%
Outdoor	SOX/NOX + 5HM	80%	141%	76%
Outdoor	N/A	N/A	142%	77%
NCCC'22	NCCC SSTU Flue Gas	N/A	123%	87%



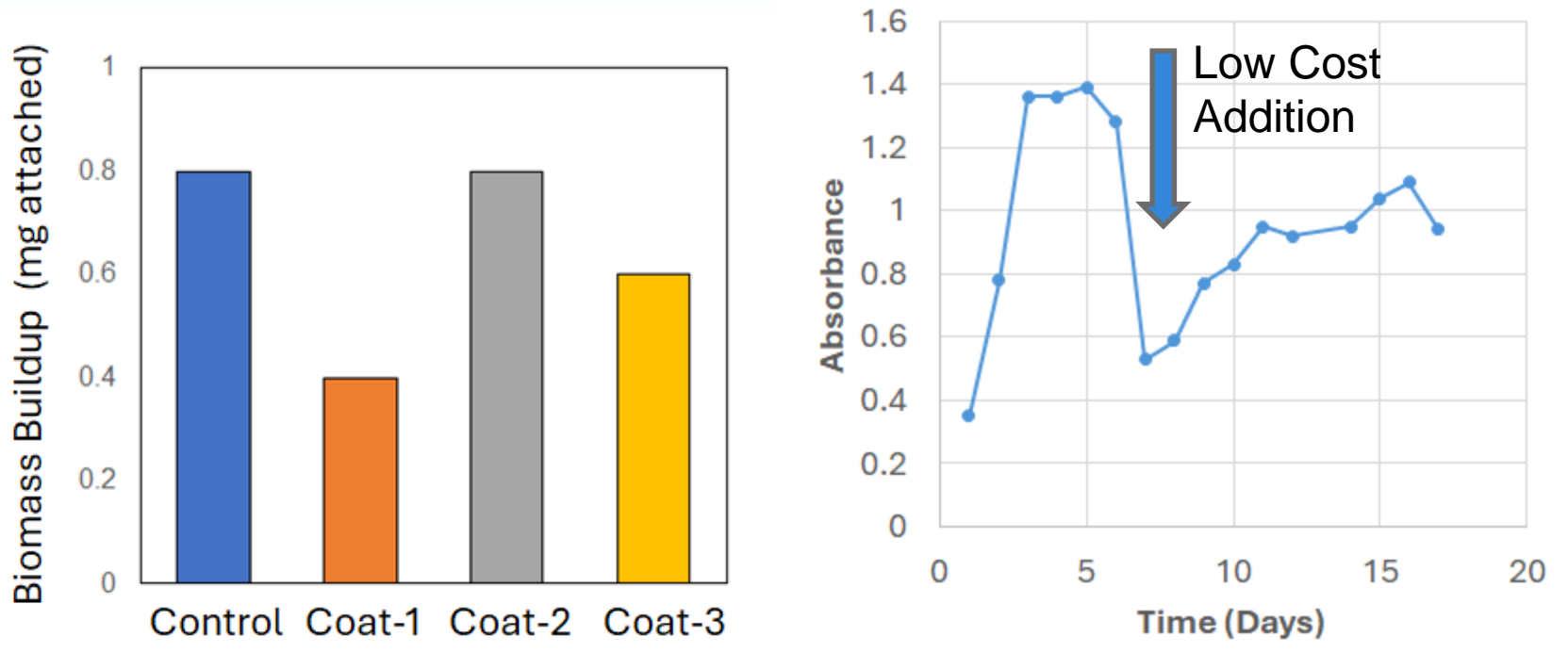
# Products from Algae with Existing Markets



# Primary Goals of Current Project

- **Develop 3<sup>rd</sup> Gen MSC to maximize productivity, capture eff & scalability**
  - Improved control system
  - Innovations for scaling
  - Biocontamination control
- **Advance products from algae to increase revenue potential**
  - Fish feed that utilizes valuable components
  - Additional nutraceutical compounds
- **Demonstrate performance in outdoors operation, NCCC**

# Bio-contamination control strategy



- Sequencing results indicate primarily predators (e.g., amoeba, ciliates) and bacterial/fungal infection connected to biofilm build up and culture crashes
- Mitigation includes monitoring, process controls, anti-biofilm coatings and low cost chemical additions targeting specific contaminants

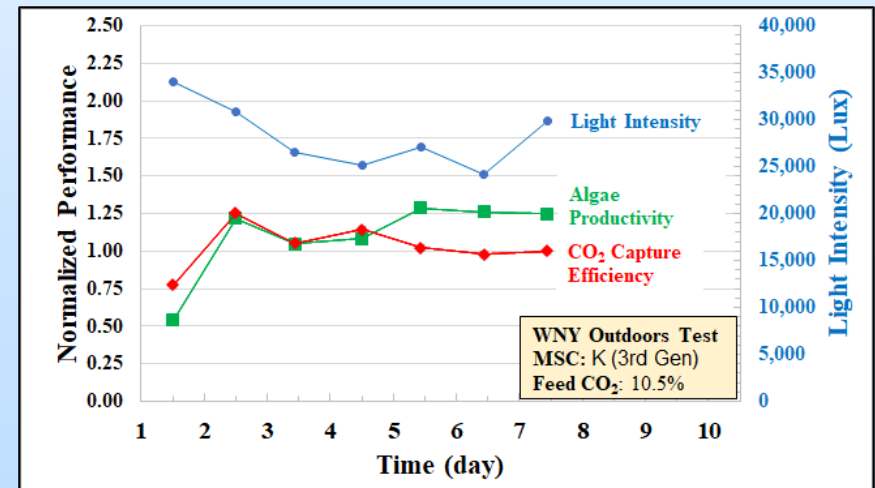
# MSC operation for optimal performance

- **Improved MSC system designed & fabricated**
  - Advanced control-system built & being tested
  - Efficient culture circulation
  - Efficient gas-liquid contacting
  - Scalable, low cost seals
- **Integrated multi-stage operation demonstrated**
- **Ongoing tests to demonstrate system functionality**
  - Outdoors test performance exceeds project target

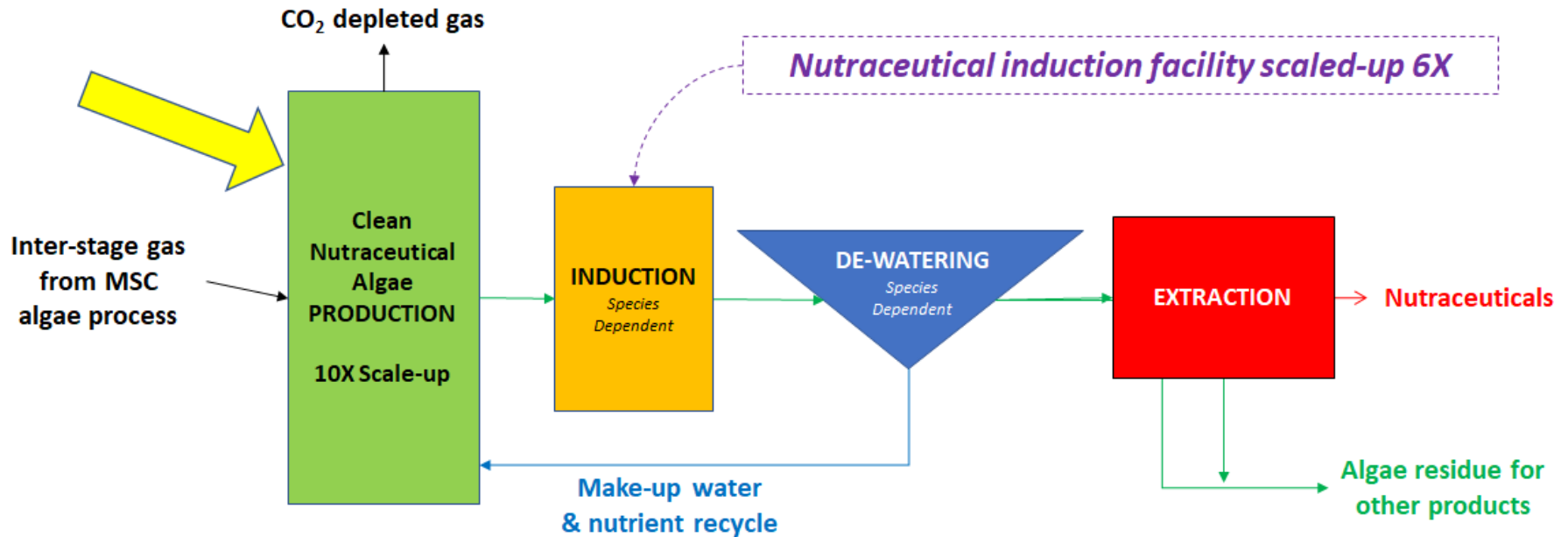
## Scalable, sealed raceway design



## MSC's Outdoors Performance

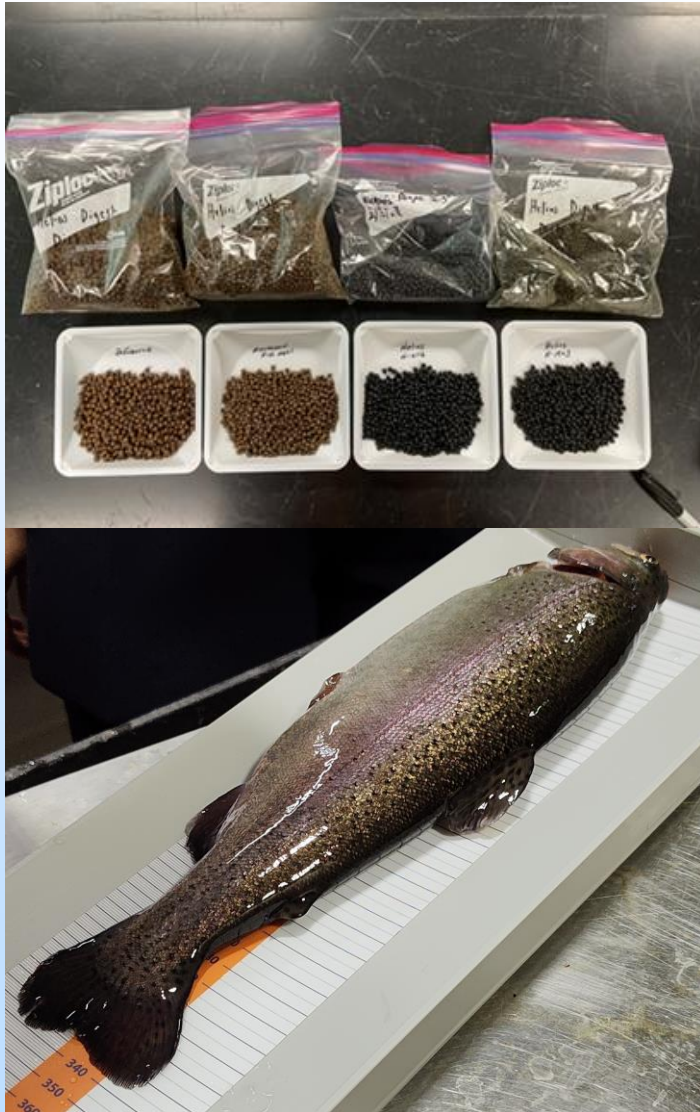


# Nutraceutical Production Process



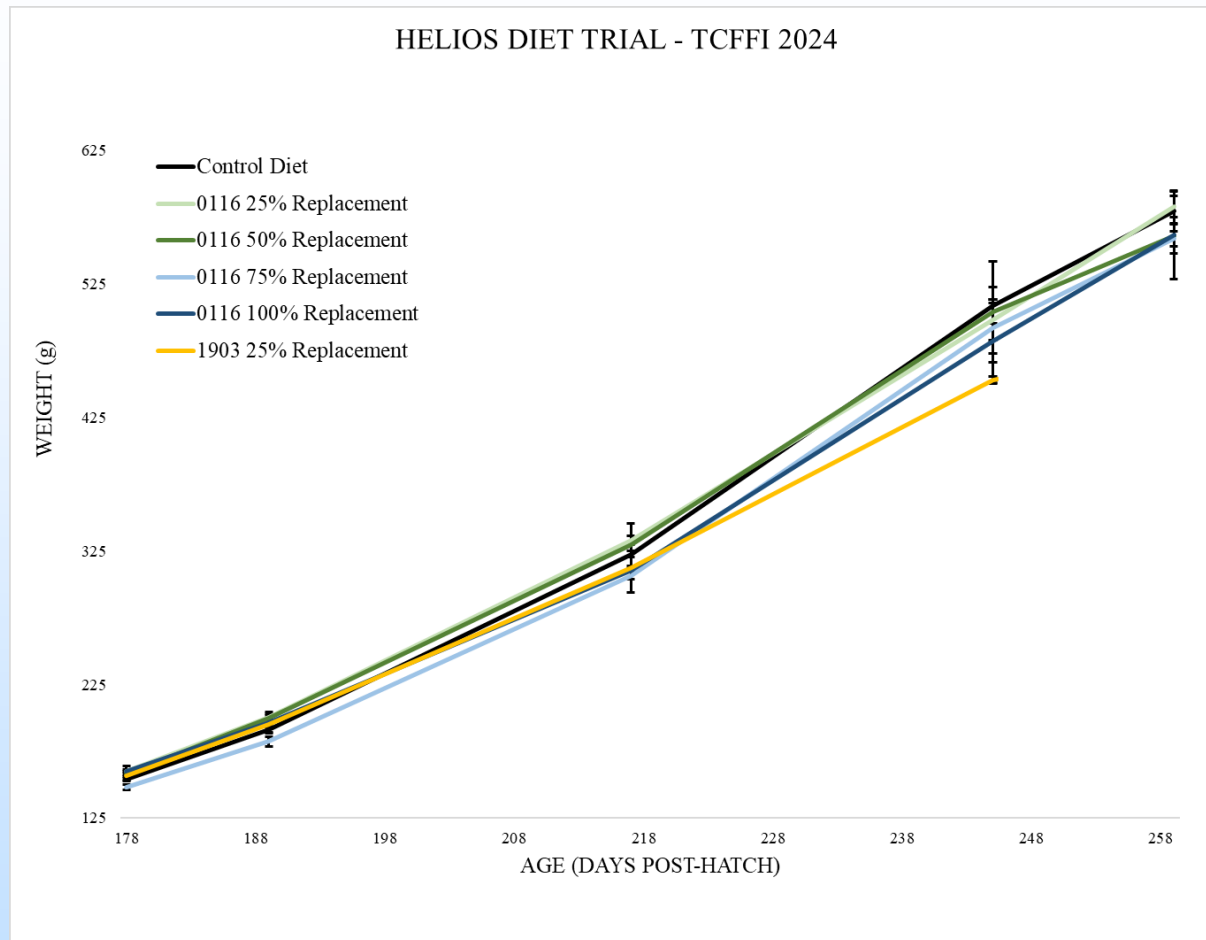
- Two nutraceutical product classes evaluated from two species of algae each
- Pathways advanced towards commercialization looking at current markets and possible future markets

# Algae qualification for aquaculture feed blends



- Feed produced with variable rates of fish meal replacement with algae (0-100%) based on digestibility
- Two algae species tested H-1903 and H-0116
- Feed trial conducted in Recirculating Aquaculture System (RAS) with rainbow trout
- Fish growth and health, and the water quality of the RAS monitored over feeding experiment

# Algae qualification for aquaculture feed blends



- Fish fed feed with 25 – 100% algae replacement of fish meal grew at similar rates to control

# Work In Progress

- **Protocols for biocontamination control & mitigation**
- **Validate improved MSC operation outdoors; NCCC**
- **Advance nutraceutical production towards commercialization**
- **Complete analysis of RAS fish feed study**
- **Perform LCA and TEA**



# Plans for future testing/development/ commercialization

- **Implement dynamic process control**
- **Develop in-ground-MSR systems**
- **Implement biocontamination control**
- **Integrate MSR with de-watering and operate with high water/nutrient recycle**
- **Utilize municipal wastewater to replace purchased nutrients - cost reduction + remediation credits**

# Summary

## Demonstration of:

- **Outdoors testing of MSC dynamic control**
- **Improved bio-contaminant control**
- **Value of nutraceutical products at commercialization**
- **Algae can replace non-sustainable components of fish feed**

# Thanks to DOE, NETL and our Partners

## **Acknowledgement**

This material is based upon work supported by the Department of Energy under Award Number DE-FE-0032103.

## **Disclaimer**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.