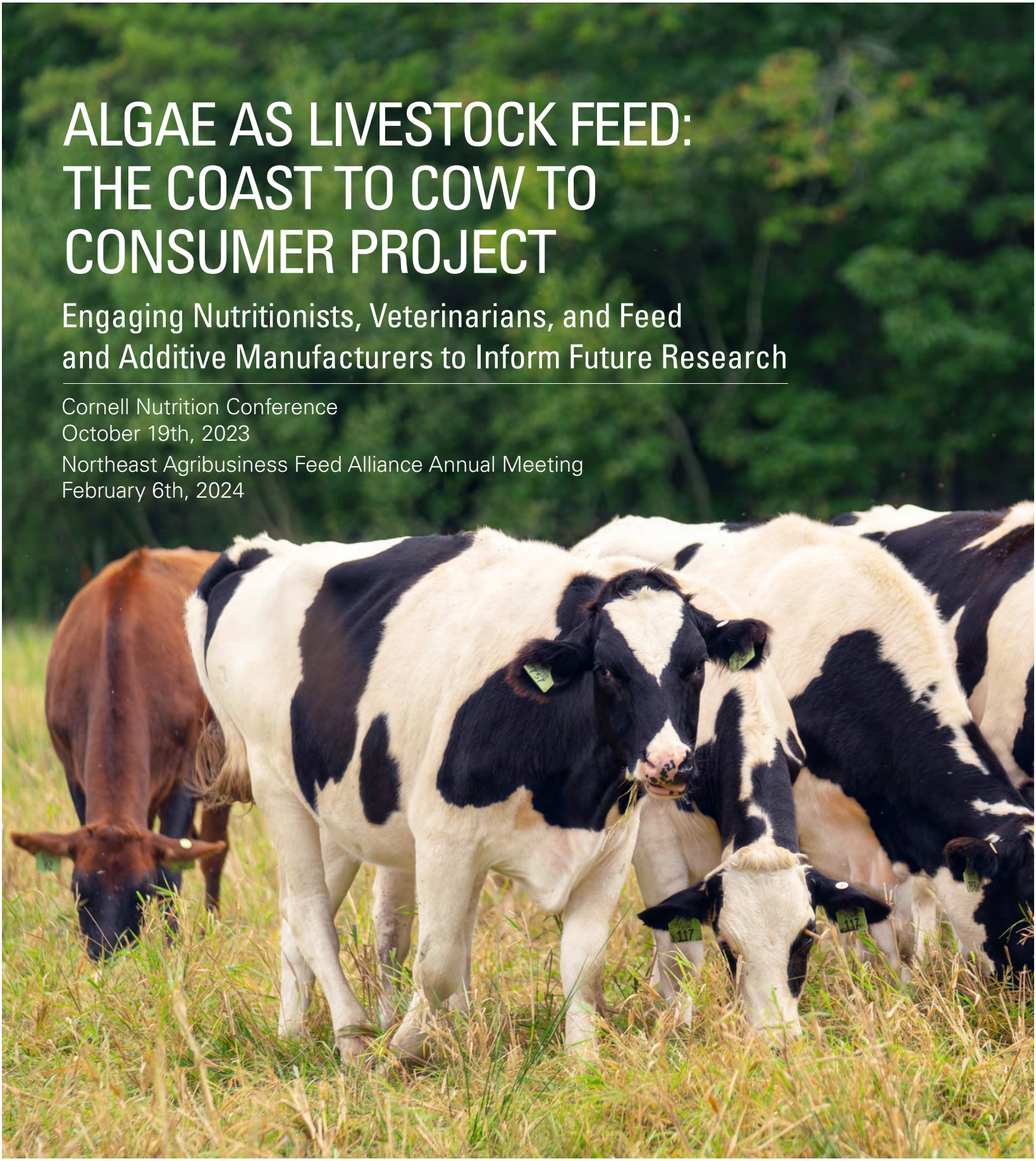
ALGAE AS LIVESTOCK FEED: THE COAST TO COW TO CONSUMER PROJECT

Engaging Nutritionists, Veterinarians, and Feed and Additive Manufacturers to Inform Future Research

Cornell Nutrition Conference
October 19th, 2023

Northeast Agribusiness Feed Alliance Annual Meeting
February 6th, 2024



Bigelow | Laboratory for Ocean Sciences

WWF

Table of Contents

EXECUTIVE SUMMARY....1

COAST TO COW TO CONSUMER PROJECT....2

ENGAGING NUTRITIONISTS, VETERINARIANS AND FEED AND ADDITIVE MANUFACTURERS TO INFORM FUTURE RESEARCH....3

CORNELL NUTRITION CONFERENCE SESSION....5

Polling Results....5

Questions From Session Participants....6

NORTHEAST AGRIBUSINESS FEED ALLIANCE SESSION....8

Polling Results....8

Safety & Efficacy....8

Additive Formulation....9

Value Proposition....11

Questions From Session Participants....12


WONDER
GRIP

Executive Summary

As leading partners in the Coast to Cow to Consumer Project (hereafter, C3)[1], the Bigelow Laboratory for Ocean Sciences (Bigelow Laboratory) and World Wildlife Fund (WWF) co-convened two interactive sessions to share research findings of this ambitious initiative and secure feedback from expert nutritionists, veterinarians, and feed manufacturers linked to industry, non-profit organizations and academia. The first session took place at the Cornell Nutrition Conference (CNC) on October 19th, 2023, with the second a few months later on February 6th, 2024 at the annual meeting of the Northeast Agribusiness Feed Alliance (NEAFA).

Bigelow Laboratory and its partners created a highly interactive forum to share C3 research, identify and discuss barriers to adopting algae as livestock feed, and explore the needs of farmers and suppliers to introduce a new feed product. With the assistance of remote facilitation support, Bigelow Laboratory used *Slido* technology to capture input from attendees, show live results to each individual poll, then facilitate follow-on discussion.

This report presents a summary of polling results and questions put forward by attendees at each interactive session. As work advances towards the goal of creating a realistic pathway for using algae in livestock feed, it is anticipated that the outputs of these sessions will further enable C3 to make informed investments and produce broadly beneficial outputs for algae, feed and dairy industries. Interested parties should direct inquiries to Dr. Nichole Price (nprice@bigelow.org) or Dr. Charlotte Quigley (cquigley@bigelow.org).

Coast to Cow to Consumer Project

Suppression of enteric methane emissions (burps) from livestock has the potential to drastically reduce the global production of this greenhouse gas, which is about 30 times more potent than carbon dioxide. C3 aims to develop a well-balanced seaweed additive for cattle feed that helps address this issue and offers major benefits to the environment, for dairy and beef production, and to the working waterfront. (See also, Sea Sketches: Algae and Cattle Methane.)

Research shows that certain tropical red seaweeds contain compounds that can influence digestion of macronutrients in livestock rumen and reduce enteric methane production. However, major limitations persist to working with these particular seaweed species, such as costs to cultivation and processing, as well as limited production capacity. At the request of algae and dairy producers in the Northeast United States, Bigelow Laboratory and its partners are screening Gulf of Maine seaweeds and microscopic algae with demonstrated, scalable production potential for nutritional effect of influencing rumen fermentation in livestock.

Funded by a flagship 5-year research program of the United States Department of Agriculture (USDA), C3 has assembled a team of scientists with a unique and exciting mix of expertise in algal physiology, microbiology, animal health, soil science, sociology and economics. With support from the Shelby Cullom Davis Charitable Fund and the USDA Agriculture and Food Research Initiative, C3 is tackling a problem of regional importance that can have impact on the global release of a major greenhouse gas.

---

[1]C3 partners include the Bigelow Laboratory for Ocean Sciences, Clarkson University, Colby College, Cornell University, Syracuse University, the University of New Hampshire, the University of Vermont, the William H. Miner Agricultural Research Institute, and the Wolfe's Neck Center for Agriculture and the Environment. This program is funded by USDA SAS Award 2021-69012-35919.

Engaging Nutritionists, Veterinarians and Feed and Additive Manufacturers to Inform Future Research

This section represents the main body of this report. It illustrates engagement and polling results with nutritionists and veterinarians (2023 CNC conference), as well as feed and additive manufacturers (2024 NEAFA meeting). It also includes a summary of questions, along with upvoting results, put forward by participants at each event.

C3 is at an inflection point in its research. In order to share the latest information about the initiative, including emerging science and the potential focus of future research efforts, Bigelow Laboratory and WWF co-convened two highly interactive sessions to engage and secure feedback from expert nutritionists, veterinarians, and feed manufacturers from industry, non-profit organizations and academia. As noted above, the first session took place at the CNC conference in October, 2023, with the second a few months later at the annual NEAFA meeting in February, 2024.

C3 is making important decisions about investments in animal experiments for the next several years. By bringing together expert nutritionists and veterinarians, Bigelow Laboratory, WWF and the C3 partners created a forum to share research, identify and discuss barriers to adopting algae as livestock feed, and explore the needs of farmers and suppliers to introduce a new feed product. Each interactive session consisted of four main elements:

- Information sharing about C3, including the latest research findings
- Informal, anonymous *Slido* polling on a range of topics to secure attendee input
- Identification of questions about the research put forward by attendees
- Brief responses by Bigelow Laboratory staff to polling results, questions and comments

Bigelow Laboratory's Dr. Nichole Price, with support at times from Dr. Charlotte Quigley, kicked off each session by describing the purpose and focus of C3, presenting recent research updates, and then exploring a range of topics with attendees. With remote facilitation support from Seatone Consulting, funded by WWF, Bigelow Laboratory used *Slido* technology to capture attendee input, show live results to each individual poll, then facilitate follow-on discussion with the full group.

At times, particularly during open group discussion, subject matter experts (SMEs) linked to C3 helped answer questions or provide additional contextual information about the initiative and the research efforts under discussion. Participating SMEs included the following:

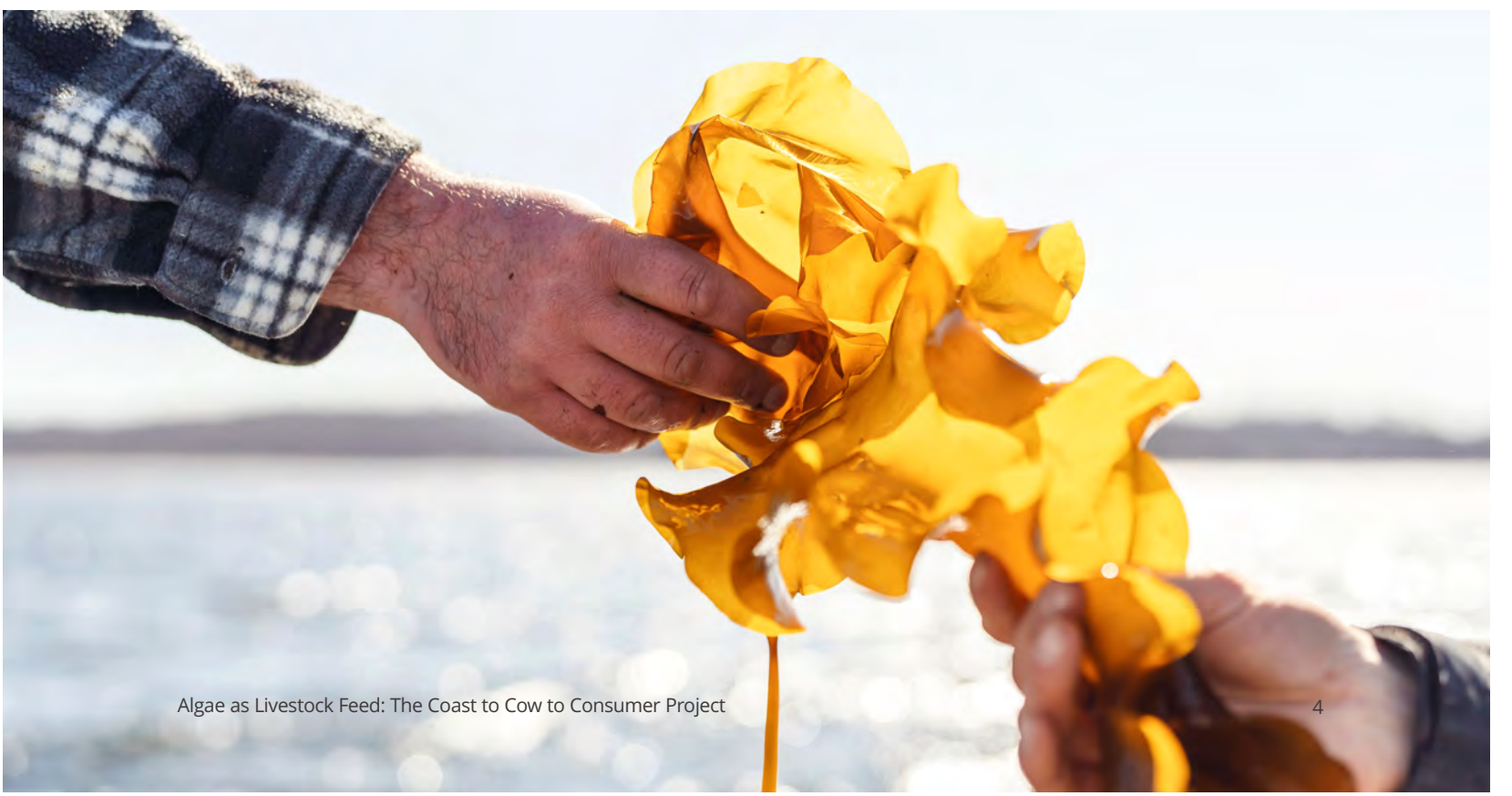
- Dr. Nichole Price – Senior Research Scientist, *Bigelow Laboratory for Ocean Sciences*
- Dr. Ellen Dierenfeld – Lead Specialist, Sustainable Feed Innovations, *World Wildlife Fund*
- Dr. Stephen Archer – Senior Research Scientist, *Bigelow Laboratory for Ocean Sciences*
- Dr. Sarah Morrison – Research Scientist, *The W.H. Miner Institute*

- Dr. Rick Welsh – Professor of Food Studies, *Syracuse University*
- Dr. Andre Brito – Associate Professor of Dairy Cattle Nutrition & Management, *University of New Hampshire*
- Dr. Susan Powers – Spence Professor in Sustainable Environmental Systems, *Clarkson University*
- Dr. Shane Rogers – Professor of Civil & Environmental Engineering, *Clarkson University*

For both sessions, polls focused principally on safety, efficacy and the value proposition for industry. Additional time was devoted at the second session to include more polls and foster discussion of boundaries and challenges associated with approving a new feed, and to ensure the focus of research is heading in the right direction. At both sessions Dr. Price summarized individual polling results and responded to a long list of questions put forward by attendees.

Response rates proved similar across the board in terms of how all engaged groups described, in a few words (wordcloud), what makes a product safe. A more expansive set of polling questions enabled deeper exploration of safety and efficacy, additive formulation, and value proposition at the NEAFA event. Conversely, inquiries around bromoform proved common among all engaged groups. Feed and additive manufacturers put forward a range of questions about methane reduction potential. At the same time, a singular question on this topic was popular with nutritionists and veterinarians. All parties showed curiosity to see both current and future results of the C3 initiative. Some attendees posed questions that may inform future research.

The following sections of this report provide a summary of all *Slido* polls conducted at each session, listed first from CNC and subsequently the annual NEAFA meeting. Given the fast pace of polling and follow-on dialogue, the report does not attempt to summarize responses offered by Dr. Price at each event. Interested readers are encouraged to contact the Bigelow Laboratory for more information.



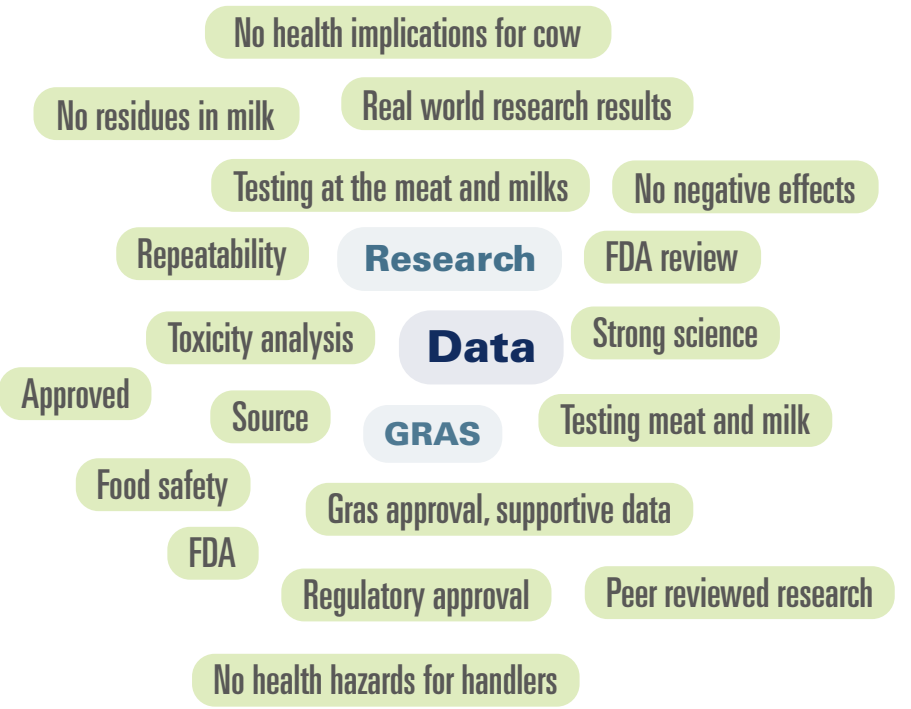
Polling Results

This section presents a summary of results from four polls about safety, efficacy and evaluation of the value proposition for farmers.

Poll 1: What type of approvals do you look for to make a decision to adopt a new feed additive?
Poll type: Multiple choice (select all that apply)
Response rate: 32 participants

- Peer reviewed, published science – **88%** support (28 votes)
- FDA or other agency approval – **84%** (27 votes)
- Third party safety analytics – **44%** (14 votes)
- Something else – **19%** (6 votes)
- Your company board or executive approval – **13%** (4 votes)
- Competitor adoption – **3%** (1 vote)

Poll 2: In just a few words, what do you need to consider a new additive safe?
Poll type: Wordcloud (more than one response is ok)
Response rate: 45 responses | 27 participants



Poll 3: What evidence do you need to determine efficacy?
Poll type: Multiple choice (select all that apply)
Response rate: 30 participants

- Peer reviewed, published science – **83%** (25 votes)
- Commercial-scale trials – **83%** (25 votes)
- FDA or other agency approval – **43%** (13 votes)
- Something else – **17%** (5 votes)

Poll 4: What information do you need to help your farmers evaluate the value proposition for using these additives?
Poll type: Multiple choice (select all that apply)
Response rate: 26 participants

- Inclusion rate and impact of balanced diet – **81%** (21 votes)
- Product source and reliable, consistent availability – **73%** (19 votes)
- Comparative technoeconomic analysis of alternative additive options – **46%** (12 votes)
- Life cycle assessment comparing with other GHG reduction options – **35%** (9 votes)
- Something else – **31%** (8 votes)

Questions from Session Participants

This section presents questions put forward by attendees following a presentation about the C3 project shared by Bigelow Laboratory's Dr. Nichole Price. Attendees were encouraged to cast a "vote" in support of any questions with which individuals agreed with or otherwise found important.

Table 1. Questions posed by attendees at the Cornell Nutrition Conference C3 session

Question	Upvotes
What do long term studies of bromoforms show-do rumens adapt and the additive becomes less effective over time?	6
Some of the studies using *Asparagopsis* show a significant reduction in DMI and milk yield. How is this being addressed by the research you are doing?	6
Are there algae species that have potential in lakes and streams or in other words not necessarily close to oceans?	6
Do differences in rations affect efficacy of products?	6
How many cows have actually been tested to date looking at the various projects and types of seaweeds?	4
Can you really scale? In the northeast United States there are over one million dairy cattle. At 100 g product, that's 100 mt dry per day. Is this realistic?	4
How do you deal with variability of bromoform concentration from raw material harvested from the sea to guarantee aimed concentrations in commercial product?	3

Question	Upvotes
Where did you get the value of $40/t CO2e?	3
How did you modulate the sugar kelp to increase the bromoform content? Would this now be considered a GMO product?	3
How can we feed algae-based feed additives to cows in a pasture based system? Many organic dairy farms in MW are pasture based.	3
What is the mechanism of bromoform inhibition? Why is there a difference in half-life between ch2br2 and chbr3?	2
You talked about the transfer of bromoform into milk. How about other elements such as heavy metals?	2
Will your bromoform analytical tests be validated? What's your timeline on that?	2
Do you plan to validate your bromoform detection method (with GLP?), and what are all the sample types you can measure bromoform in?	2
Please clarify use of term C-free milk or CH3-free milk.	2
Can you please go over the economics you presented? At $80/cow/year the math isn't adding up to how this is economically favorable.	2
We/you will need to be proactive with marketing so we don't end up in a rBST situation with the public. If “they're feeding cows arsenic” catches...	2
How long is your research program going for?	1
You showed ug of active, how many grams of product would be need to feed to get appropriate rumen concentrations?	1
Are the halogenated compounds inhibiting methanogenesis, killing methanogenic bacteria or binding/sequestering CH4?	1
What is your limit of detection of bromoform and are you working to lower it?	0
Any plans to measuring the effects of adding seaweeds in the dairy cows diet on nitrous oxide emissions?	0
How is a Goodhart's law scenario prevented (i.e., farmers being incentivized to increase their footprint so as to qualify for more carbon credits for reduction)?	0

Polling Results

This section presents a summary of results from fourteen polls about safety, efficacy and evaluation of the value proposition for farmers.

Safety & Efficacy

Poll 1: What type of regulatory approvals do you look for to make the decision to adopt a new feed additive?
Poll type: Multiple choice (select all relevant answers)
Response rate: 31 participants

- FDA (Food and Drug Administration) – **81%** (25 votes)
- AAFCO (Association of American Feed Control Officials) – **58%** (18 votes)
- GRAS (Generally Recognized as Safe) – **23%** (7 votes)
- USDA (US Department of Agriculture) Organic – **13%** (4 votes)
- EFSA (European Food Safety Authority) or other Countries – **3%** (1 vote)
- Something else **0%** – (0 votes)

Poll 2: In just a few words, what do you need to consider a new additive safe?
Poll type: Wordcloud (more than one response is ok)
Response rate: 25 participants | 43 responses

Poll 3: What evidence do you need to determine efficacy?
Poll type: Multiple choice (select all relevant answers)
Response rate: 33 participants

- Several months-long in vivo university feeding trials – **79%** (26 votes)
- Measurable methane detection reduction at farm level – **67%** (22 votes)
- No evidence of microbiome adaptation or adverse effects on animal performance – **64%** (21 votes)
- Laboratory testing – **45%** (15 votes)
- Nutritionist/veterinarian recommendation – **18%** (6 votes)
- Something else – **6%** (2 votes)

Poll 4: Would you consider using a product with bromoform, other halogenated compounds, or other biocidals?
Poll type: Multiple choice (one response)
Response rate: 33 participants

- Yes – **64%** (21 votes)
- To an extent – **33%** (11 votes)
- No – **3%** (1 vote)
- Something else – **3%** (1 vote)

Poll 5: Would you prefer that bromoform or other halogenated compounds used to reduce enteric methane be derived as a natural biologic, through 'green chemistry', or as an industrial chemical?
Poll type: Multiple choice (one response)
Response rate: 35 participants

- Yes – **63%** (22 votes)
- To an extent – **29%** (10 votes)
- No – **9%** (3 vote)
- Something else – **0%** (0 vote)

Additive Formulation

Poll 1: In just a few words, under what conditions do you store feed additive ingredients at a processor? (E.g. outside, in temperature controlled rooms, ambient temperature bays, etc.)
Poll type: Wordcloud
Response rate: 35 responses | 28 participants

Poll 2: What type of packaging is best for a dry feed additive with 1-2% of dry matter intake inclusion rate DMI at a grain processor?
Poll type: Multiple choice (one response)
Response rate: 32 participants

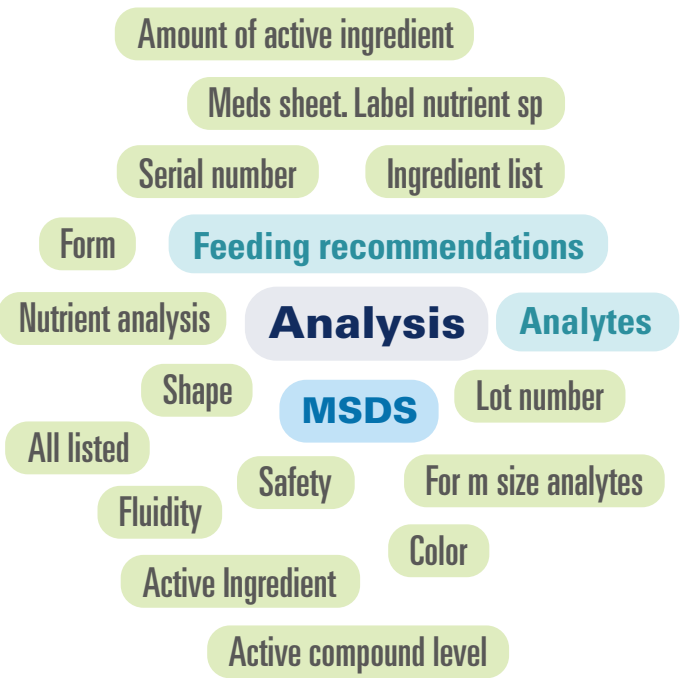
- 50-lb bags on pallets – **91%** (29 votes)
- Something else – **6%** (2 votes)
- 100-lb bags on pallets – **3%** (1 vote)

- 5 gallon buckets on pallets – **0%** (0 votes)
- 20 gallon buckets on pallets – **0%** (0 votes)

Poll 3: Do your vitamin/mineral premixes allow for mixing different levels of individual vitamins, minerals, or trace elements
Poll type: Multiple choice (one response)
Response rate: 28 votes

- Yes – **68%** (19 votes)
- To an extent – **32%** (9 votes)
- No – **0%** (0 votes)
- Something else – **0%** (0 votes)

Poll 4: In just a few words, what information do you need to see on a source spec sheet/ certificate of analysis (COA) for a batch/lot of a new product at a grain processor? (E.g., form, size, shape, color, analytes, etc.)
Poll type: Wordcloud (more than one response is ok)
Response rate: 30 responses | 22 participants

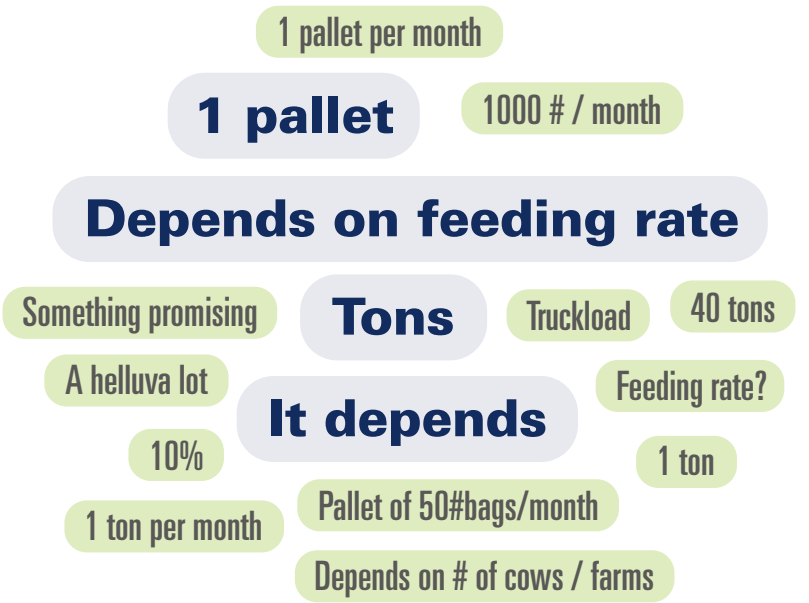


Poll 5: How long do we need a feed supplement to be shelf stable at a grain processor ahead of incorporating into a grain mix?
Poll type: Multiple choice (one response)
Response rate: 29 participants

- One year – **83%** (24 votes)
- Six months – **14%** (4 votes)
- Something else – **3%** (1 vote)
- Three months – **0%** (0 votes)

Value Proposition

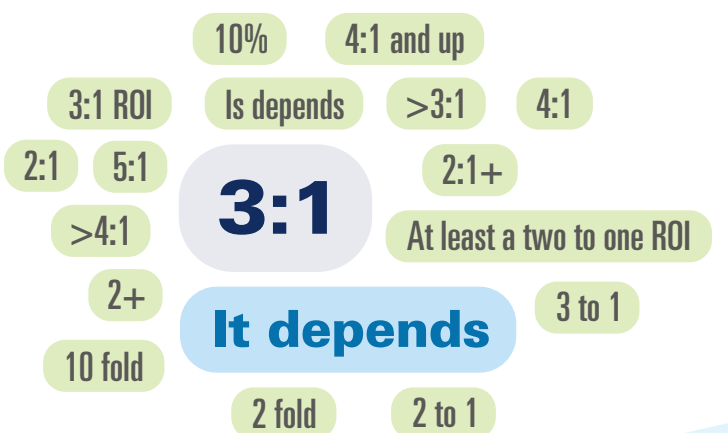
Poll 1: How much volume do you need to commit to sales to take on a new feed component?
Poll type: Wordcloud
Response rate: 24 responses | 22 participants



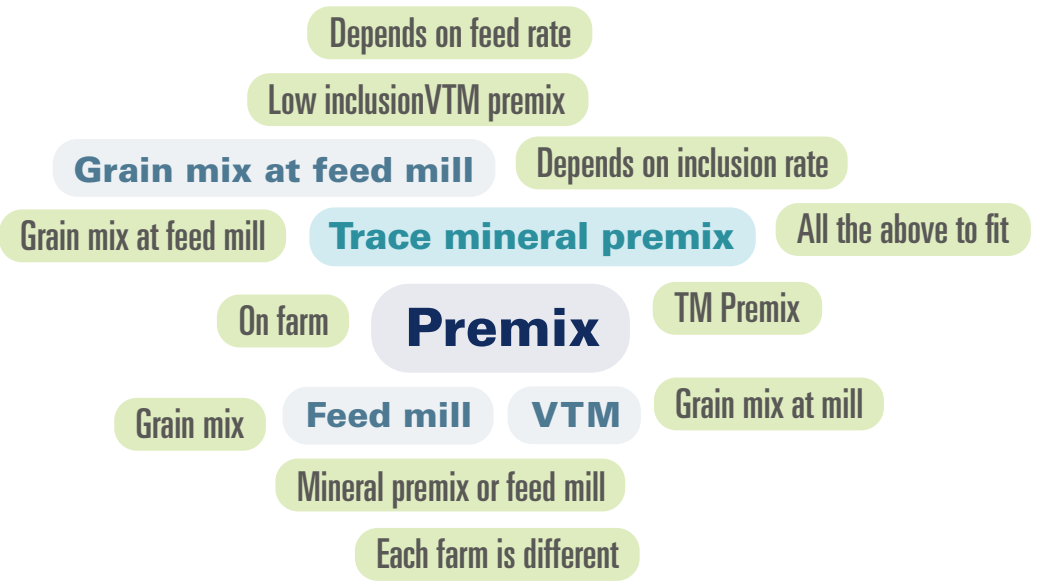
Poll 2: What information do you need to help your farmers evaluate the value proposition for using these additives?
Poll type: Multiple choice (select all relevant answers)
Response rate:

- Relative efficacy on animal performance – **93%** (26 votes)
- Ease of incorporation into existing farm and feed operations – **75%** (21 votes)
- Price comparison with other similar ingredients – **64%** (18 votes)
- Something else – **25%** (7 votes)

Poll 3: In just a few words, what return on investment is needed/expected for a farmer to implement a new feed component? (E.g., 2-fold, break-even, etc.)
Poll type: Wordcloud
Response rate: 21 responses | 21 participants



Poll 4: In just a few words, ideally, where should a new feed supplement enter the supply chain? (E.g., trace mineral pre-mix, on farm in TMR, grain mix at feed mill, etc.)
Poll type: Wordcloud (more than one response is ok)
Response rate: 26 responses | 22 participants



Questions from session participants

This section presents questions put forward by attendees following a presentation about the C3 project shared by Bigelow Laboratory's Dr. Nichole Price. Attendees were encouraged to cast a "vote" in support of any questions with which individuals agreed with or otherwise found important.

Table 2. Questions posed by attendees at the Northeast Agribusiness Feed Alliance C3 session

Question	Upvotes
What is the regulatory process to get seaweed approved as a cattle feed additive?	12
Can to speak to methane reduction potential from other seaweed and kelp species?	10
What is the longest trial run on dairy?	8
Can you elaborate on how the microchip you developed works to measure enteric methane?	8
Since seaweed is a natural sponge, is there an advantage to lab grown seaweed vs wild harvested?	7
When will you publish the bromoform decay results? These are extremely important to understand fate of bromoform and degradation products	6
Other than methane reduction potential what other benefits might be seen?	4

Question	Upvotes
Is there any sort of storage infrastructure would be required for a farm or feed mill to keep a sizable amount of on-hand?	4
How does algae feed affect manure composition? Does it increase or decrease nutrient value?	4
The claim on methane reduction, is it per cow per day or per liter of milk?	4
Without washing did milk have iodine levels that were unacceptable?	3
What is the C balance in feeding dehydrated algae?	2
Could you please repeat the minimum bromoform dose that results in measurable reductions in enteric methane?	2
How does the LCA of wild versus farmed seaweed compare to synthesized?	1
In the sugar kelp trial at miner, how much were you feeding and were there any impacts on DMI?	1
Have you considered algae as a fertilizer?	0
Carbon market math, 2.5t/c/year, 80% reduction...isn't the 2.5 tons/year in emissions total emissions, and the 80% reduction is just in enteric reductions?	0
Are the seaweeds listed in AAFCO the same species that concentrate bromoform?	0
I may have missed it, but can you describe the seaweed "boosting" processing methodology?	0
Would this be safe to use in pelleted feed?	0

Contributing audience members at the Cornell Nutrition Conference comprised roughly equal numbers of dairy nutrition/health management specialists and producers. Participation at the NEAFA session mostly consisted of feed industry and agribusiness professionals, but also included academic scientists.

The Bigelow Laboratory for Ocean Sciences and World Wildlife Fund acknowledge and thank the partners supporting the Coast to Cow to Consumer Project.

The Coast to Cow to Consumer Project is funded by:

Shelby Cullom Davis Charitable Fund
USDA AFRI Sustainable Agriculture Systems Program
USDA AFRI Organic Research and Extension Initiative

Photo credits:
Cover and pages 2 and 7: Colby College
Pages ii, 1, 4, and 13: Yoon S. Byun WWF-US