Potential Economic Value of Growth of U.S. Aquaculture to U.S. Soybean Farmers

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Purpose of Study

This project aims to explore the likely effects of increased growth of U.S. aquaculture in terms of increased demand for soybeans through a comprehensive and detailed examination of soybean inclusion rates in feeds for the various types of aquatic animals raised in aquaculture, for both the near future (next 5 years) as well as longer-term potential development. Specific objectives were:

1. To estimate current soybean usage in U.S. aquaculture;
2. To estimate increased quantity demanded of soybeans for varying percentages of growth of U.S. aquaculture;
3. To develop case studies of U.S. aquaculture with greatest potential for growth;
4. To estimate potential benefits to U.S. soybean producers from increased domestic demand for soybeans from U.S. aquaculture.

Objective 1: To estimate current soybean usage in U.S. aquaculture

Study Design

A spreadsheet was developed that lists each species, the percent of diet formulations typically composed of soy products, as well as common ranges of inclusion of various soy

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products, and representative averages and ranges of feed conversion ratios. Once the percent of the diets that were composed of the various soy products was known, then that percentage was multiplied by the feed conversion ratio (FCR) to obtain the weight in pounds of that soy product ingredient in a single pound of aquatic animal. The number is then multiplied by the total weight of aquatic animal produced in the U.S. in 2018 to obtain the total volume of soybean meal used for each aquaculture segment. Those values were then converted to bushels of soybeans and summed across aquaculture segments to estimate the current total usage of soybeans in U.S. aquaculture.

- **1 bushel of soybeans = 47.5 lb of soybean meal**
- **1 bushel of soybeans = 10.7 lb of soy oil**

Results

Soybean meal was by far the principal soy product used in U.S. aquaculture, constituting 99.7% of the usage of all soy products, with very minor amounts of soy oil and soy lecithin used.

Total soybeans demanded in U.S. aquaculture in 2018 were estimated to be (average inclusion rates) 8.6 million bushels, with a range of from 5.5 to 12.6 million bushels.

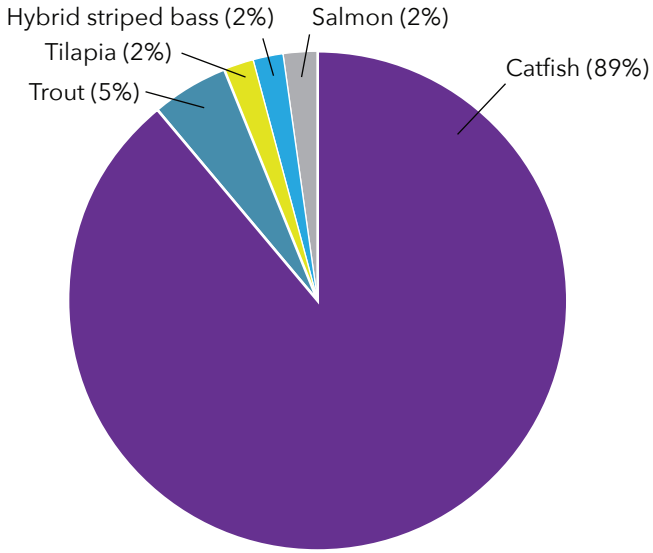
The U.S. catfish industry utilization of soybeans was 89% of the total demand for U.S. soybeans from U.S. aquaculture. This is due to two primary reasons: 1) catfish continues to be the largest segment of U.S. aquaculture; and 2) catfish tolerate soybean meal well and, hence, inclusion levels in diets are greater than in diets of many other aquaculture species.

Table 2. Inclusion Rates of Soybean Meal in Commercial Diet Formulations by Various Types of U.S. Aquaculture Products

	Percent of diet from soybeans		
Type of aquatic animal	Mean	Minimum	Maximum
Alligators	5%	1%	7%
Baitfish	35%	22%	51%
Carp	0%	0%	0%
Catfish	35%	22%	51%
Crappie	25%	20%	48%
Hybrid striped bass	31%	20%	40%
Largemouth bass	25%	20%	48%
Muskellunge	15%	10%	23%
Ornamental fish	3%	2%	5%
Prawns	13%	10%	28%
Red drum	8%	0%	8%
Salmon	8%	4%	15%
Shrimp, marine	13%	10%	28%
Smallmouth bass	25%	20%	48%
Sturgeon	3%	2%	5%
Sunfish	40%	25%	48%
Tilapia	35%	22%	51%
Trout	15%	10%	20%
Walleye	15%	10%	23%
Yellow perch	15%	10%	20%
Other foodfish	15%	10%	20%
Other sportfish	15%	10%	23%

NOTE: Commercial feed mills typically use least-cost feed formulations periodically; thus, inclusion rates vary as prices of various feed ingredients vary. Values in this table represent typical ranges used by commercial feed mills at the time this study was done. These may differ from potential inclusion rates identified in recent research.

Figure 10. Percent of soybean demand by U.S. aquaculture segment



Objective 2: To estimate current soybean usage in U.S. aquaculture

Study Design

This was accomplished by increasing the total pounds of U.S. aquaculture production in increments of 10% up to 100%, to estimate the total increased quantity demanded of U.S. soybeans.

Results

Figure 12 shows the increase in demand for U.S. soybeans with incremental growth in U.S. soybean production up to a doubling of the total volume of U.S. aquaculture production.

Research advances have demonstrated the nutritional feasibility of increasing soybean usage in diets for several species. Such findings are based on trials that address species-specific constraints to soybean meal usage that include:

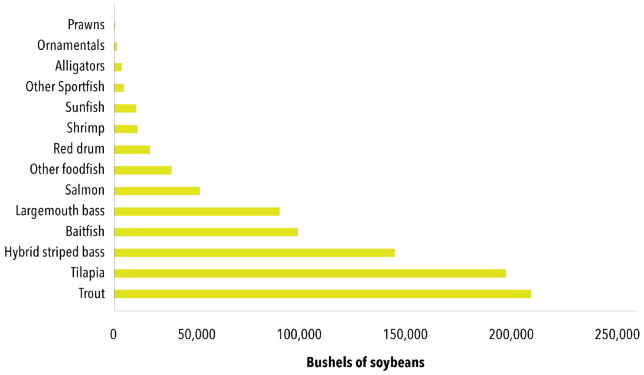
- **Improving the palatability of soybean meal with the addition of feed attractants**
- **Amino acid supplementation**
- **Low-antigen forms of soy products, among others**

Table 3. Species for Which Research has Shown Potentially Greater Maximum Inclusion Levels Than What are Currently Recommended

Species	Current maximum	Maximum identified through research
Alligators	7%	34%
Ornamental/tropical fish	5%	34%
Prawns	28%	58%
Red drum	8%	74%
Salmon	8%	30%
Marine shrimp	28%	58%
Sturgeon	5%	34%
Trout	20%	30%

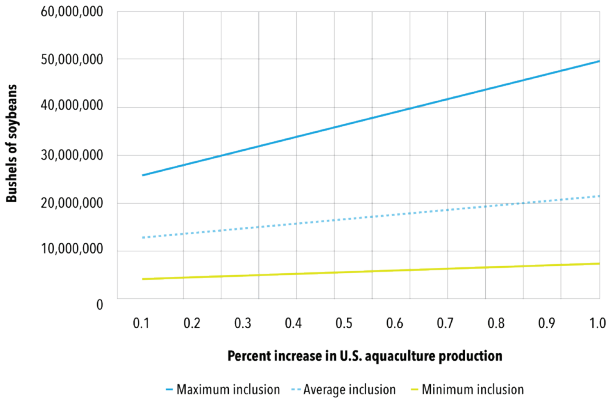
Species for which research has shown potential to increase soybean usage include: alligators, ornamental/tropical fish, shrimp and prawns, red drum, salmon, sturgeon and trout.

Figure 11. Soybean demand by U.S. aquaculture segment other than catfish



After catfish, trout used the next greatest volume of soybeans, followed by tilapia, hybrid striped bass, baitfish, largemouth bass, salmon, other foodfish, red drum, shrimp, sunfish and other minor species.

Figure 12. Increase in U.S. soybean demand with growth of U.S. aquaculture



The total demand for soybeans from U.S. aquaculture would increase by 5% over the recommended maximum inclusion levels to 13.1 million bushels, at current production levels of U.S. aquaculture.

Objective 3: To develop case studies of U.S. aquaculture with greatest potential for growth

Study Design

In Objective 3, six case studies were developed of segments of U.S. aquaculture with the greatest potential for growth. Case studies developed included: U.S. catfish, trout, salmon, marine shrimp, tilapia and expanded offshore production of marine finfish.

Results

Research studies over several decades have contributed to increased use of soybean meal in diets for a variety of fish species, including studies funded by soybean checkoff programs.

Catfish

Study Design

The current (2018) demand for soybeans from the U.S. catfish industry was compared with that of the U.S. catfish industry at its peak in 2003 to show what the demand for soybeans would be if the U.S. catfish industry would recapture the sales lost after 2003.

Results

Replacing more than 50% of the soybean meal in catfish diets has been found to result in lower processed yield that creates economic losses for catfish processing plants.

Soybean meal has been a major component of catfish diets from the first complete diet formulated to meet the nutritional needs of catfish, Auburn No. 1, which encompassed 35% soybean meal. There is difficulty in replacing soybean meal with other types of plant-based meals. Thus, soybean meal has and will continue to play a critical role in catfish feeds even when soybean prices are high.

Table 5. Increase in Demand for U.S. Soybeans if the U.S. Catfish Industry Recovered Back to 2003 Levels.

Soybean use in U.S. catfish industry	2018	2019
Pounds		
Mean	462,439,629	804,249,600
Minimum	294,640,107	512,421,888
Maximum	673,840,603	1,171,906,560
Bushels		
Mean	7,707,327	13,404,160
Minimum	4,910,668	8,540,365
Maximum	11,230,677	19,531,776

2003 production of catfish was 94% greater than that of 2018.

The market for U.S. farm-raised catfish, at its peak in 2003, was 661,504,000 lb sold. A simulation model was ran with the same poundage of that sold in 2003. Resulting in that soybean demand from U.S. catfish production would be 74% greater, at 13.40 million bushels with average inclusion rates.

Trout

Study Design

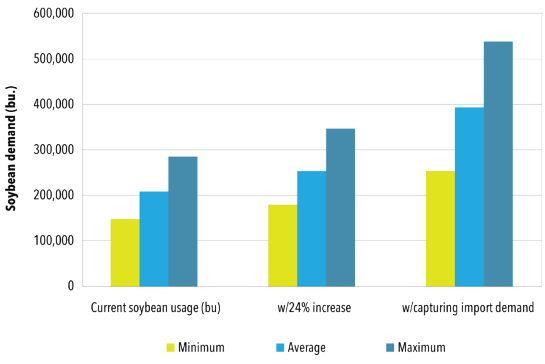
Without regulatory restrictions on expansion of trout farming businesses or on market development, recent estimates show that the trout industry could be 24% larger than it currently is if the regulatory burden were to be streamlined. These values were used to demonstrate what the demand for U.S. soybeans could be if the trout industry were able to grow to meet the growing demand for their products.

Results

Current demand for soybeans from U.S. trout production was estimated to be 212,419 bushels with average inclusion rates of soybean meal, with a range of from 141,612 bushels to 283,225 bushels.

In this case study, increased demand for soy products was modeled based on the 24% greater volume of trout production documented by Engle et al. as well as the total demand represented by the volume of imported trout products. A more competitive cost position of U.S. trout production if the regulatory cost burden would be reduced, has the potential to increase soybean demand from trout producers by as much as 92%. With increased inclusion rates of soybean meal that have been reported to be nutritionally feasible for trout production, soybean demand from U.S. trout production would increase by 50%, or 141,612 bushels above current maximum recommended inclusion levels.

Figure 15. Increased soybean demand from expansion of U.S. trout production



Salmon

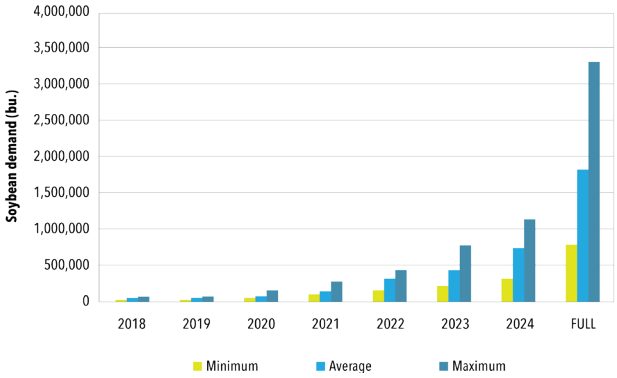
Study Design

Atlantic salmon pose an interesting case study in that, in spite of a current low average inclusion rate of 8% of soybean meal in the diet, some researchers have indicated that there is evidence that Atlantic salmon have a similar capacity to utilize higher-protein plant products as rainbow trout. Thus, both current levels and greater levels of inclusion reported in the research literature have been used in this case study.

Results

Current demand for soybeans from U.S. salmon production was estimated to be 50,754 bushels at average soybean inclusion rates, with a range of 25,377 bushels to 95,163 bushels.

Figure 19. Growth in demand for soybeans from the projected growth of salmon in RAS



The projected increase in production of Atlantic salmon in the U.S. would result in increased demand of 1.75 million bushels of soybeans.

Glencross et al. (2004) reported that Atlantic salmon was able to use similar levels of soybean meal to that of rainbow trout. If a maximum level of 30% of Atlantic salmon diets can consist of soybean meal, then the future demand from salmon, assuming that the projected increases in production in RAS are met, would be an increased demand of 6.5 million bushels.

Marine Shrimp

Study Design

This case study will compare the current demand for soybeans from U.S. shrimp production with that of estimates of potential growth of marine shrimp in the U.S. through expansion of indoor shrimp production.

Results

Current demand for soybeans from U.S. shrimp production was estimated to be 16,575 bushels, with a range from 12,277 bushels to 34,377 bushels. This level of demand represents less than 1% of the total demand for soybeans from U.S. aquaculture.

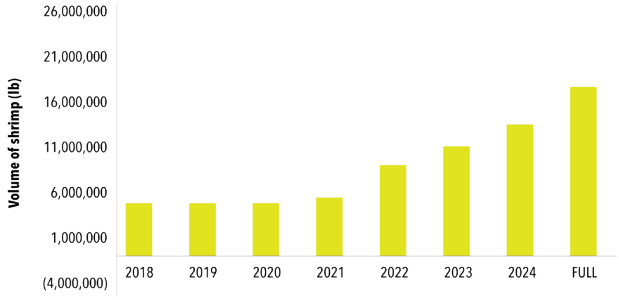
Table 7. Projected Volumes (lb) of Indoor, Tank-based Production of Marine Shrimp in the U.S.

Year	trū Shrimp	2nd not announced publicly
2018		
2019	500	
2020	1,000	20,000
2021	100,000	100,000
2022	2,075,000	1,500,000
2023	4,150,000	3,000,000
2024	6,225,000	4,410,000
Full	8,300,000	4,410,000

trū Shrimp, based in Minnesota, has announced that they now plan to construct a production facility in South Dakota. A second potential investment is under consideration that has not been announced publicly that would be an indoor shrimp farm with a targeted production level of 4 million pounds annually.

trū Shrimp hopes to produce 8.3 million pounds of shrimp per year with their new expansion.

Figure 21. Projected growth of U.S. shrimp production, with addition of new investments in U.S. shrimp production



Thus, with maximum inclusion rates and the projected expansion of U.S. shrimp production, total demand for soybeans from shrimp production could reach 131,776 bushels.

Tilapia

Study Design

There are a few new investments and proposed new investments in tilapia farms in the U.S., whose production was modeled to estimate the increased demand for soybeans from such expansion.

Results

Current demand for soybeans from U.S. tilapia production was estimated to be 194,968 bushels, with a range from 124,223 bushels to 284,097 bushels.

Tilapia is able to utilize soy products well and has one of the greatest soybean inclusion rates.

While growth of tilapia production in the U.S. has been modest on an annual basis and has shown a decline in more recent years, there are two large projected ventures currently under discussion or implementation that are expected to increase the total volume of tilapia produced in the U.S. by approximately 18 million pounds. Such an expansion would more than double demand for soybeans from tilapia production to 433,705 bushels, with a range of 347,077 bushels to 542,842 bushels.

Expanded Offshore Production of Marine Fish

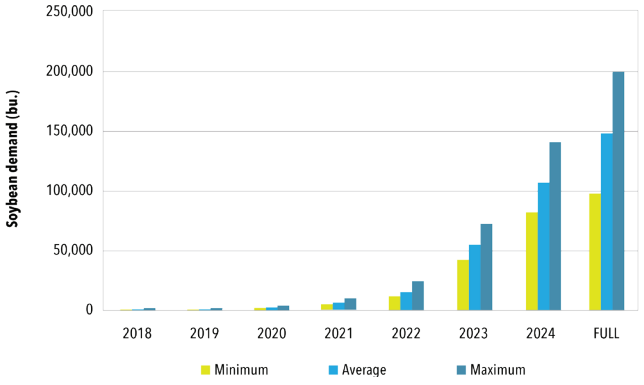
Study Design

The growth of marine finfish production in the U.S. average soybean meal inclusion rates were used with growth of marine finfish production from new investments currently underway.

Results

Given that the "Other foodfish" category was not sub-divided into species, it is not possible to calculate a specific percentage that this category composed of total aquaculture production.

Figure 25. Growth in demand for soybeans with the growth of marine finfish, all other sectors held constant



By 2024, an additional 152,995 bushels of soybeans are expected to be demanded, based on an assumed average inclusion rate of soy products of 15%, with a range of from 101,996 bushels at minimum to 203,993 bushels at maximum inclusion rates. However, given that sablefish have been found to be able to use greater inclusion rates of soy protein concentrate, it is likely that the inclusion rate of 15% is highly conservative.

The estimated increase in inclusion rates of soy products in marine finfish diets shows an annual average increase in demand for U.S. soy products of 135%.

Combined Effects of the Scenarios Analyzed

Figure 27. Greatest percentage growth in future (beyond 5 years) soybean demand (%)

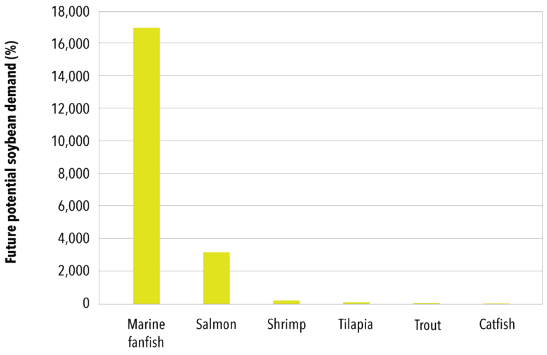


Table 8. Increased Soybean Demand with Projected Increases from the Case Studies (percentage inclusion rates of soybeans are listed in Table 2)

U.S. aquaculture sector	Current soybean demand (bu)	Potential increase in soybean demand (bu)	Maximum
Catfish			
Minimum[a]	4,910,668	3,629,697	8,540,365
Average[b]	7,707,327	5,263,492	13,404,160
Maximum[c]	11,230,677	8,301,099	19,531,776
Trout			
Minimum	141,612	130,868	272,481
Average	212,419	196,302	408,721
Maximum	283,225	261,736	544,961
Salmon			
Minimum	25,377	874,134	899,511
Average	50,754	1,748,797	1,799,022
Maximum	95,163	3,278,004	3,373,167
Shrimp			
Minimum	12,277	34,785	47,063
Average	16,575	46,960	63,535
Maximum	34,377	97,399	131,776
Tilapia			
Minimum	124,223	152,109	347,077
Average	194,968	238,737	433,705
Maximum	284,097	347,874	542,842
Marine finfish			
Minimum	600	101,396	101,996
Average	900	152,095	152,995
Maximum	1,200	202,793	203,993
Total			
Minimum	5,493,602	4,922,989	10,208,553
Average	8,620,834	8,079,724	16,700,558
Maximum	12,568,208	12,488,905	25,057,133

[a]Minimum inclusion rate of soybean meal.
[b]Average inclusion rate of soybean meal.
[c]Maximum inclusion rate of soybean meal.

The combined potential demand from the growth projections in this analysis for U.S. aquaculture were 16.7 million bushels at average inclusion rates, with a range of 10.2 million bushels to 25.1 million bushels over the next 5 years.

The greatest potential for growth are in the U.S. catfish industry, followed by salmon, tilapia, trout, marine finfish and shrimp.

On a percentage basis, however, marine finfish demonstrated the greatest percentage growth followed by salmon. These percentage increases show the potential growth over the longer-term if other, currently small segments of U.S. aquaculture experience rapid growth, with the announced substantial investments in new, relatively large-scale farms.

Objective 4: To estimate benefits to U.S. soybean producers from increased demand for soybeans for U.S. aquaculture

Study Design

Objective 4 addresses the potential benefits to U.S. soybean producers from increased domestic demand for soybeans. This section was developed from a review of a number of research studies.

Results

There are a number of clear benefits to U.S. soybean producers from expansion and growth of U.S. aquaculture. These include the following:

1. Feed ingredients in U.S. aquafeeds are sourced from the U.S.
2. Many U.S. aquafeeds use greater percentages of soybean meal than those used in terrestrial animal agriculture.
3. Rural farming communities would be supported and strengthened.
4. Soybean crushing mills would be supported.
5. Markets would be diversified and demand for U.S. soybeans would be more stabilized.
5. Effects on prices of U.S. soybeans from expansion of U.S. aquaculture
6. U.S. food security would be increased.