Economic Analysis of Alternative Oyster Culture (AOC) in Louisiana

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EXECUTIVE SUMMARY

1. Louisiana is interested in promoting Alternative Oyster Culture (AOC). AOC is the term used in Louisiana to describe the production of hatchery-set oysters in containers, floating or suspended in the water column or on the sea floor. In other places, this method is called "oyster farming", "oyster aquaculture", "container culture", "off-bottom oyster farming", or some variation of these terms. This method differs from the traditional method of harvesting oysters from the sea floor that recruit naturally on existing reefs or on cultch (shell, limestone, broken concrete, or some other substrate) placed on the sea floor where oysters can attach.

2. I was tasked by Louisiana Sea Grant, as part of the duties of the 2023 Laborde Chair, to work on a project titled "Identifying Economic Opportunities and Challenges for Commercial Oyster Production in Louisiana" to help develop targeted economic analysis and outreach for alternative oyster culture (AOC) operations. This report is the economic analysis. I analyze costs, break-even prices, and profits for multiple scales of operation ranging from as few as 27,000 oysters planted on half an acre to as many as 1.28 million oysters planted on four acres. A two-acre lease is the largest scale of operation currently offered for growers utilizing one of the state's AOC parks.

3. The state has provided grant funding for farms, nurseries, a hatchery, and AOC parks to jump-start this nascent industry. The effects of the farm grants are examined as part of the broader economic assessment of AOC feasibility in Louisiana. Information from published studies and reports from other states are referenced as appropriate to supplement economic assumptions.

4. An Excel spreadsheet-based tool was developed as part of this work to allow for the estimation of cost and profit under other assumptions and scenarios.

5. These results are meant to represent an "average" AOC operation under a range of reasonable assumptions on production, environmental conditions, and markets likely to hold during the first five years of operation. Some growers will be profitable even at low production levels, by keeping costs down and capitalizing on favorable market conditions. Growers are doing this now in Louisiana and elsewhere and will continue to do so. Others will fare much worse, facing higher costs, worse environmental conditions, and more challenging market conditions. It is also expected that some growers will engage in AOC as a form of "hobby farming". Such farms are often small-scale, operated more for pleasure rather than business, perceived as an opportunity to supplement household income, and come with some expectation or at least willingness to accept financial losses. Although this analysis may be informative for such farms, it is not targeted at them because it focuses on economic feasibility and profitability.

6. Results are provided in two forms: "Full Accounting" results that include all relevant costs (explicit costs and opportunity costs), consistent with economic theory and practice and which I recommend for decision-making; and "Partial Accounting" results that exclude owner labor costs and depreciation on boat, motor, truck, and trailer. This second set of results are provided because they were requested and deemed by some to be the results that some growers would want to see. Because these latter results ignore certain major cost components, their results appear much more favorable. I do not recommend them for commercial decision making.

7. Data from other states indicate that the average AOC farm ranges from two to ten acres. Among the newest entrants into AOC, Mississippi has an oyster park with two-acre slots, whereas new farms in Georgia and Texas range between eight and ten acres. In Alabama, average farm size has grown 4.5 acres. States with longer track records – Florida, Maryland, and North Carolina - have average farm sizes of 3-6 acres.

8. Data from other states indicate that prices received by growers vary widely. Although prices at or above $1 per oyster have been observed, the average price is in the $0.40-0.59 per oyster range. Data from Maryland indicate that 40-47% of their AOC oysters end up in the lower-value sack-oyster market, where prices are below $0.25 per oyster.

9. AOC is expensive. It requires gear, seed, and labor at levels not associated with traditional oyster production. A single line of 200 floating bags, holding 30,000-40,000 oysters, is estimated to cost over $6,000. Other equipment, including refrigeration for direct delivery, is estimated at nearly $5,000. Including the cost of a boat, motor, truck, and trailer ($45,000) and other start-up costs, total initial investment is estimated to range from less than $60,000 for a single line of floating bags to over $200,000 for twenty-four lines (Figure ES-1). The AOC start-up grants (up to $45,000) cover some, but not all, investment costs.

10. Total annual cost, including depreciation and interest on invested capital, labor, fuel, seed, and other expenses, is estimated to range from approximately $50,000 to operate a single line of floating bags to approximately $250,000 to operate twenty-four lines (Figure ES-2). The AOC grants cover only a small fraction of annual costs.

11. Under reasonable assumptions of a farm start-up period and moderate crop losses due to periodic adverse environmental conditions, the five-year average break-even price under Full Accounting is estimated to range from $2.57 per oyster for 40,000 oysters planted on half an acre, to $0.71 per oyster for 480,000 oysters planted on two acres, to $0.52 per oyster for 960,000 oysters planted on four acres (Figure ES-3). The AOC grant reduces the break-even price by $0.38 at the lowest production level, by $0.06 for 480,000 oysters planted, and by $0.03 at the highest production level.

12. Average annual profit under Full Accounting is estimated to be negative for production levels at or below 480,000 oysters planted on two acres. Profit is estimated to be positive at production levels at or above 720,000 oysters planted on three acres (Figure ES-4). Sensitivity analysis indicates that none of the production levels considered are fully robust to the variety of conditions that an AOC farm is likely to face. Only the largest production level, on four acres, is estimated to be robust to most of the various scenarios considered. The AOC grant increases the estimated average annual profit by $7,000-$14,000 per year depending on production scale, and pushes it from negative to slightly positive for 480,000 oysters planted on two acres.

13. AOC is dependent upon a small set of buyers willing to pay high prices. I estimate that there are 10-15 establishments in the region that feature AOC half-shell oysters. The expected price to grower for AOC oysters is $0.75-$1.00 if delivered directly to restaurants, and $0.50 if sold dockside to a wholesaler. The larger sack-oyster market can act as a backstop, but that market's price is unlikely to be at a level that can sustain AOC.

14. AOC in Louisiana is located distant from markets. Some AOC growers in Louisiana do not have access to an established wholesaler/distributor, requiring them to market and deliver oysters directly. Delivery can yield higher prices, but also requires added travel distance, time, and costs, and requires more logistical and marketing efforts on the part of growers, that can erode much of the gains associated with higher prices.

15. AOC is dependent upon a source of hatchery-reared seed. Traditional oyster production relies on cultch and natural recruitment of oysters. There is currently a shortage of hatchery-reared seed across the entire Gulf Coast. There are concerns whether in-state sources can provide seed at the level needed for current and future growers, and whether it can be supplied reliably. There is currently an even greater shortage of triploid seed, an alternative type of seed that does not reproduce, can grow faster, and provide AOC with a growth advantage during summer months. Without triploids, these advantages do not exist.

16. AOC gear and infrastructure are susceptible to storms. It has not been demonstrated that gear can be sunk and retrieved cost-effectively or relocated in time to avoid damage and loss of both gear and crop.

17. Even under the most optimistic assumptions of where production can be in the future, AOC is unlikely to account for more than a very small fraction of total oyster production in the state. I estimate that a future in which Louisiana has 500 acres of AOC would account for less than one-half of one percent of the traditional oyster production footprint. That same level of AOC production would account for an estimated 7% of the value of Louisiana's traditional oyster landings.

18. Current and future AOC activity in Louisiana, including the state's hatchery, is occurring (and is planned to occur) in areas subject to major adverse impacts from large-scale Mississippi River diversions. Once these diversions are operational, these areas are expected to be insupportable for traditional oyster production. These same conditions apply equally to AOC.

Figure ES-1. Initial Capital Investment

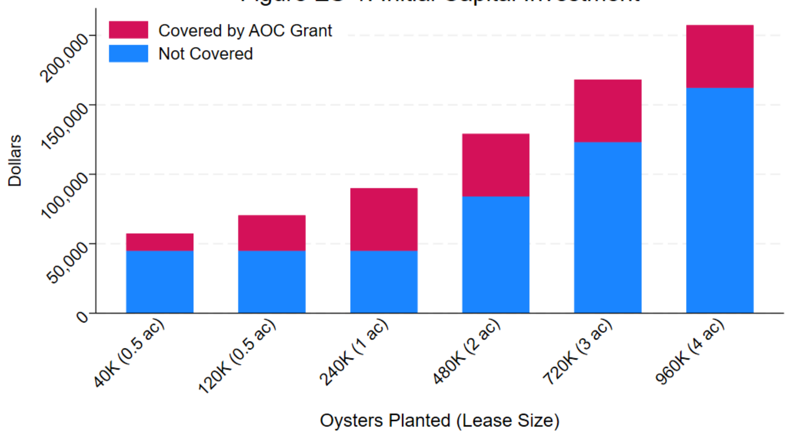


Figure ES-2. Total Annual Cost

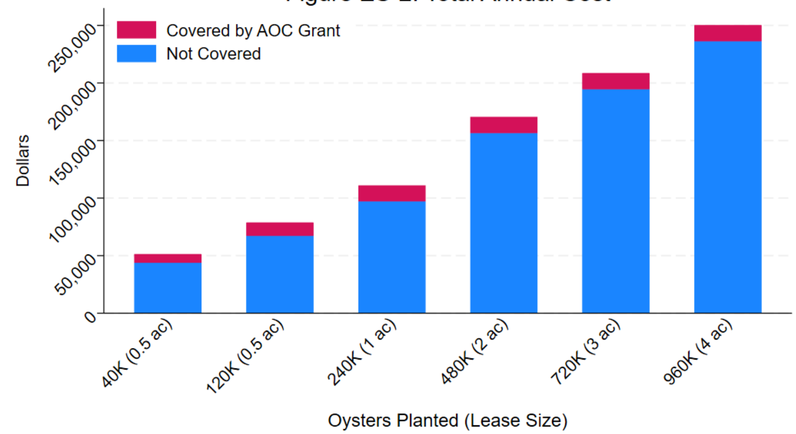


Figure ES-3. Estimated Average Break-even Price

$ per Oyster

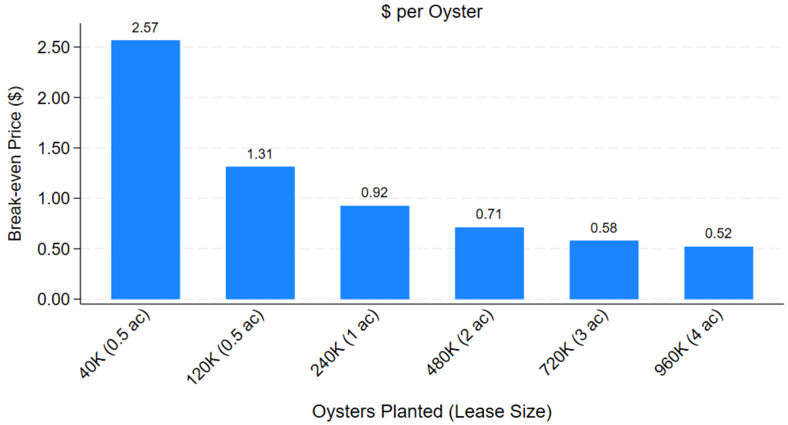
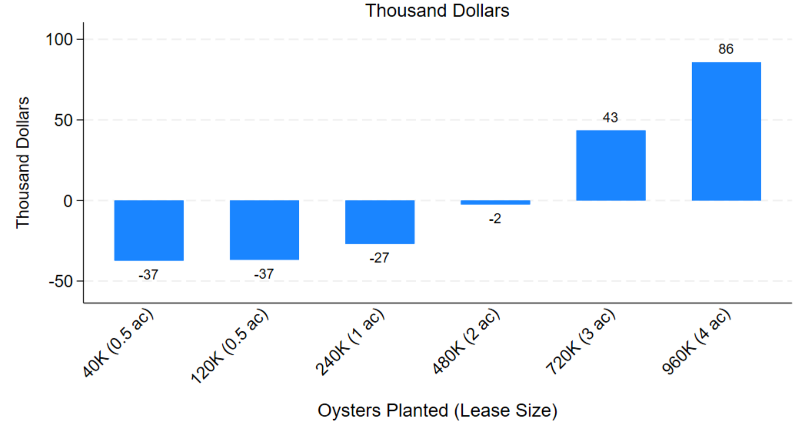


Figure ES-4. Estimated Average Annual Profit

Thousand Dollars



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All errors and shortcomings are my own.

TABLE OF CONTENTS

INTRODUCTION

Alternative Oyster Culture (AOC) is the term used in Louisiana to describe the production of hatchery-set oysters in containers, floating or suspended in the water column or on the sea floor. In other places, this method is called “oyster farming”, “oyster aquaculture”, “container culture”, “off-bottom oyster farming”, or some variation of these terms. This method differs from the traditional method of harvesting oysters from the sea floor that recruit naturally on existing reefs or on cultch (shell, limestone, broken concrete, or some other substrate) placed on the sea floor where oysters can attach. Given the historical loss of reefs worldwide (Beck et al. 2011), limited natural recruitment of oysters, as well as the relative scarcity and cost of substrate for bottom production (Petrolia 2022), AOC has been promoted as a means to supplement or even replace traditional oyster production in places facing some or all of these limitations. AOC has also been touted as providing some of the same ecosystem services as natural reefs (Barrett et al. 2022; Petrolia, Walton, and Cebrian 2022; Petrolia et al. 2020). Another method used elsewhere is the production of oysters on the sea floor using remote-set spat-on-shell.

The Gulf Coast in general, and Louisiana in particular, is one of the few remaining places where naturally recruited oysters are harvested commercially. Natural recruitment of oysters is one of the major advantages that Louisiana oystermen have compared to producers in other states.

Louisiana is a major player in domestic oyster production. Louisiana was the top oyster producing state in 2021, landing 5.9 million pounds and accounting for one-fourth of the U.S. total (NOAA Fisheries 2023). Louisiana has been the top oyster producing state thirty-five out of the past seventy-two years, and has been in the top three every year since 1952. Despite being a perennial leader, Louisiana’s oyster landings have declined in recent years. Louisiana’s oyster landings averaged 11.6 million pounds per year between 2000 and 2019, but has averaged only 4.5 million pounds per year between 2020 and 2021.

AOC has not played a significant role in Louisiana oyster production thus far. According to Melancon (2023), there were nine AOC farms operating on 51.5 acres in 2021, but that number fell to zero post-Ida (August 2021). In 2022, Louisiana began subsidizing AOC by providing grants to jump-start this nascent industry. Funding for the new grants program was provided by the state in anticipation of pending salinity changes from large-scale Mississippi River diversions. Indeed, AOC is one of several oyster impact mitigation strategies outlined in the environmental impact statement for the Mid-Barataria Sediment Diversion (Louisiana’s Seafood Future 2023b, USACE 2022).

Between March 2022 and March 2023, Louisiana Sea Grant announced the awarding of twenty-one grants for grow-out farms ($45,000 each) and eight grants for nurseries ($15,000 each) awarded to twenty-three individuals (Louisiana Sea Grant 2022a, 2022c, 2023b). Additionally, a $225,000 grant was awarded for a hatchery and four $100,000 grants were awarded to established AOC parks (Louisiana Sea Grant 2022b, 2023; Louisiana’s Seafood Future 2023a), although plans for one park have since been tabled (personal communication with Earl Melancon, August 10, 2023). Grants were limited to state residents, and funds could be spent on farm gear, other equipment, and supplies; funds could not be used for the purchase of boats and motors, vehicles, land, buildings, or wages for labor.

Today, there are nineteen funded grow-out farms operating on 49.5 acres, and the state has a total of 219 acres available for AOC (Melancon 2023). There are two oyster hatcheries in the state: the Michael C. Voisin Oyster Hatchery on Grand Isle and a private inland (recirculating) hatchery mentioned earlier as a grant recipient. There are a limited number of hatcheries located in other Gulf states, and those facilities tend to give priority to their own constituents prior to selling seed to Louisiana buyers. Current production data are not available, but nearly all current AOC harvest occurs in the vicinity of Grand Isle.

I was tasked by Louisiana Sea Grant, as part of the duties of the 2023 Laborde Chair, to work on a project titled "Identifying Economic Opportunities and Challenges for Commercial Oyster Production in Louisiana" to help develop targeted economic analysis and outreach for alternative oyster culture (AOC) operations. This report is the economic analysis. I analyze costs, break-even prices, and profits for multiple scales of operation ranging from as few as 35,000 oysters planted on a quarter of an acre to as many as 1.6 million oysters planted on four acres. Leases within existing AOC parks in the state range between a half-acre and two acres.

The analysis focuses on the first five years of operation and accounts for factors such as farm start-up, periodic adverse environmental conditions, variations in stocking and mortality rates, method of sale, and price to grower. Results are provided in two forms. The first set I refer to as "Full Accounting"; these results include all relevant costs (both explicit cash outlays and opportunity costs). This set of results are consistent with economic theory and practice and, to the extent that my findings are used for any decision-making, the "Full Accounting" results are the ones on which I recommend for that purpose. The second set I refer to as "Partial Accounting"; these results exclude owner labor costs and depreciation of certain capital likely owned by an experienced grower. This second set of results are provided because they were requested and deemed by some to be more realistic and the type of results that some growers would want to see. Because these latter results ignore certain major cost components, their results appear much more favorable. I do not recommend them for decision-making.

These results are meant to represent an "average" AOC operation under a range of reasonable and realistic assumptions on production, environmental conditions, and markets that are likely to hold, particularly during the first five years of operation. Certainly, some growers will be profitable at even low production levels, because they are able to keep costs down and capitalize on favorable market conditions. Growers are doing this now in Louisiana and other states, and will continue to do so. Others will fare much worse than my results indicate, as they will experience costs that are higher than assumed here, environmental conditions worse than assumed here, and market conditions more challenging that what is assumed here.

OBSERVATIONS FROM OTHER STATES

Each state is unique in how they refer to AOC, in what and how they measure AOC activity, and the degree to which they make information available to the public. In this section, I examine the data available from other Gulf Coast and South Atlantic states to gain insights into AOC production levels, average farm size and productivity, the share of oysters planted relative to those sold, and how growers are marketing their oysters and the prices received. Because each state reports data very differently and provides unique insights, most of the analysis examines each state individually. This analysis should not be taken as definitive. What is occurring in one state is not necessarily true of other states and not necessarily indicative of what might occur in Louisiana. Furthermore, some states' data are based on surveys of a sample of growers, so not necessarily indicative of all the activity in those states. Some states have almost no data available and some states have just begun AOC activity and no production data are available yet.

Virginia has the longest record and has published a situation and outlook report covering every production year since 2004 through 2018 (Hudson 2017-2019; Hudson and Murray 2014-2016; Murray and Hudson 2011-2013; Murray and Oesterling 2006-2010). Harvest data are available for North Carolina going back to 2010 (Herbst et al. 2022). Maryland goes back to 2012 (Parker 2023) and South Carolina goes back to 2014 (Herbst et al. 2022). Alabama has published situation and outlook reports the past several years, with production data going back to 2016 (Grice and Tarnecki 2022, 2023; Grice and Walton 2019, 2020). Florida data are available back to 2016 (Herbst et al. 2022), and Mississippi data are available for 2021 (Herbst et al. 2022).

Figure 1 reports the annual farmed oyster production totals available for the aforementioned states. Of the data available, it appears that Virginia (where AOC is referred to as "intensive oyster culture") is the dominant state for AOC production in the Southeast region, harvesting more than 30 million oysters annually during the six most recent years with data available. North Carolina (where AOC is referred to as "farmed oysters") has the second-longest record and the second-highest harvest level, at 17.6 million oysters harvested in 2021. Maryland ("water column harvest") is third (8.2 million in 2021); Alabama ("oyster aquaculture") and Florida ("cultured oysters") are nearly tied for fourth place (5 million in 2021); then South Carolina ("mariculture singles", 1 million in 2021); and finally Mississippi ("off-bottom", 213,900 in 2021).

I now turn to analysis of the individual states for which additional information is available. Beginning with Virginia, Table 1 reports the available production data for 2004-2018, taken from annual situation and outlook reports, which are based on annual surveys of growers (Hudson 2017-2019; Hudson and Murray 2014-2016; Murray and Hudson 2011-2013; Murray and Oesterling 2006-2010). Intensive oyster culture in Virginia has grown from less than 1 million oysters in 2004 to a peak of over 40 million oysters in 2016, to 31.1 million oysters in 2018. Virginia's data offers two additional insights. The first is that they report both the number of oysters planted and sold. Assuming that oysters planted in year *t* are harvested in year *t + 1*, I calculated the ratio of oysters sold to oysters planted. Although there are likely several factors that go into explaining the drop-off from planted to sold, and should not be interpreted as a mortality rate, it is still informative. I estimate that of the total number of oysters planted, between an average of 38% has reached the market, with a range of 10-60%. The 10% value was during their first year, so is understandable (and consistent with Mississippi's first year, where 6% was harvested, discussed below), but even in recent years, the share has stayed consistently between 30% and 40%. These data make clear that not all oysters planted reach the market, and that the share of oysters lost is substantial. The second insight provided by the Virginia data concerns the range of prices received by growers. Price received varies widely, from a low of $0.10 to a high of $1.20 per oyster. This wide range has been consistent every year, though the upper bound has grown over time, with the most recent year ranging from $0.20 to $1.20. The average price received, however, has remained relatively consistent, ranging between $0.29 and $0.41. Thus, although prices at or above $1 per oyster have been observed repeatedly, the average remains below $0.50 per oyster.

I turned next to Maryland. Although production data for Maryland extends back to 2012, additional information regarding market shares and prices is available back to 2017 only (Parker 2023). Table 2 reports annual harvest of water-column oysters, market shares (half-shell market oysters, sold as "singles", versus sack oysters, sold by the bushel), and prices observed in each market. Harvest ranged between 5.6 million and 8.8 million since 2017. Parker (2023) reports harvests and market shares for both water-column and bottom culture oysters, which allowed me to estimate the shares of water-column oysters going to each market. Assuming that all bottom-culture oysters go to the sack-oyster market, I estimate that between 53% and 60% go to the higher-value half-shell market. Importantly, this implies that 40-47% of the water-column harvest goes to the lower-value sack-oyster market. Regarding prices, the average price to growers in the half-shell market is $0.40-0.50 per oyster (consistent with average prices observed in Virginia). For those oysters going to the sack-oyster market, growers are getting an average price of $55 per bushel. Assuming 300 oysters per bushel (based on MD Dept. of Natural Resources conversion factor of 300 oysters per bushel, Parker 2023), that works out to $0.18 per oyster.

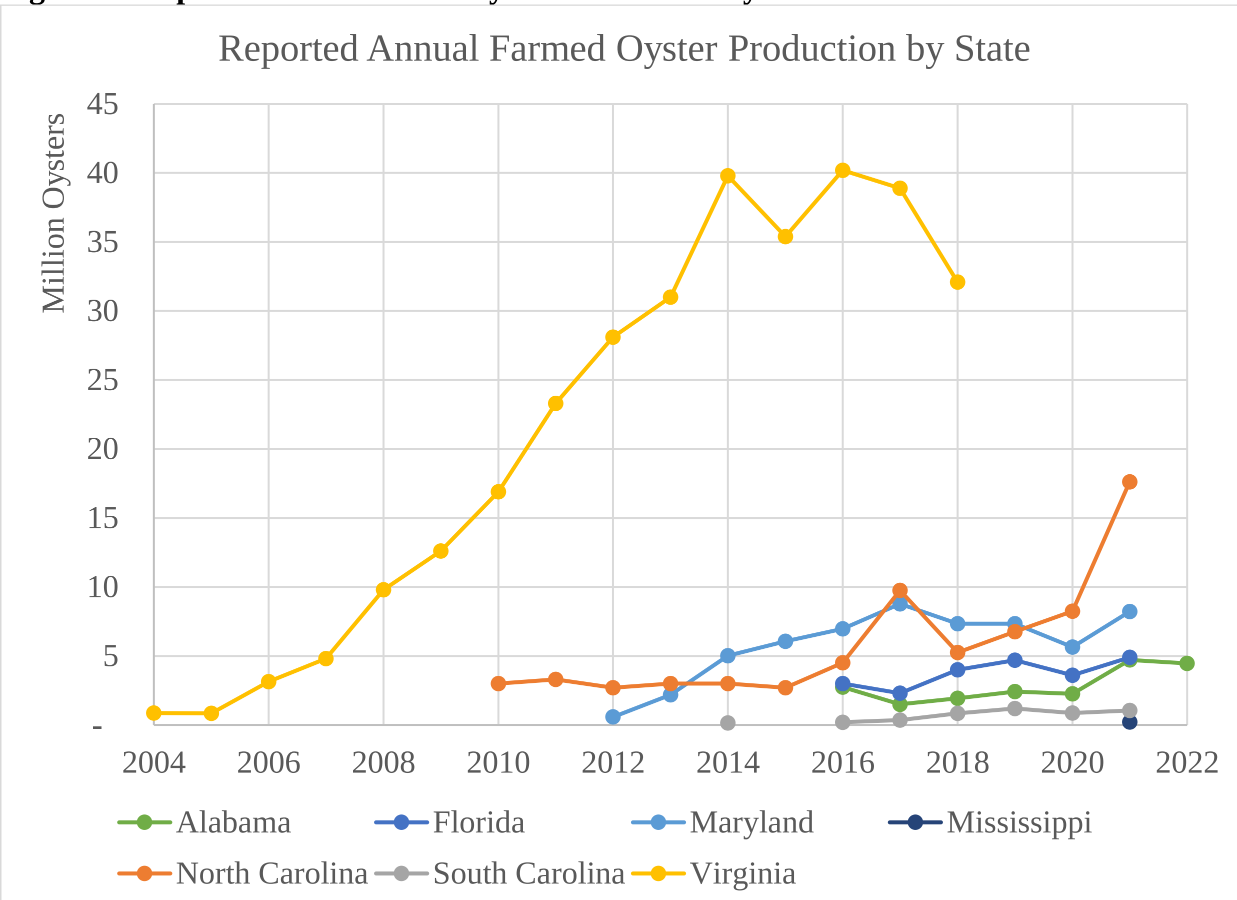
I now turn to Alabama. Table 3 reports annual oyster aquaculture production data for Alabama, taken from annual situation and outlook reports published in 2018, 2019, 2021, and 2022 (Grice and Tarnecki 2022, 2023; Grice and Walton 2019, 2020). Reports are based on annual surveys of growers. Oyster aquaculture sales has grown from 1.9 million in 2018 to a peak of 4.7 million in 2021, to 4.5 million in 2022. Alabama data provide additional insights regarding farm size and productivity. Although total production has grown, the number of farms has declined, from a high of 22 in 2018, to 10 farms in 2022. The number of acres permitted has not changed much, and the number of acres in production has increased slightly, from 37 in 2018 to 45 in 2022. Increased production with a decline in the number of farms implies that the average farm size has increased over time, from 1.7 acres per farm in 2018 to 4.5 acres per farm in 2022. Similarly, average productivity has increased, from 87,345 oysters sold per farm in 2018 to 445,102 in 2022. In terms of productivity per acre, that's an increase from 51,935 oysters sold per acre in 2018 to 98,911 oysters sold per acre in 2022. Alabama also reports price information for 2018 and 2019. During those years, the price received by growers ranged from $0.30 to $0.70 per oyster, with average price ranging between $0.46 and $0.59 per oyster.

Table 4 reports all other available state AOC oyster production data. Number of farms and farm size as of 2021 is available for Florida, Maryland, Mississippi, North Carolina (also 2022), and Texas. Of the states reporting farm and acreage data, Florida reports the highest number of farms/leases at 125, followed by North Carolina (119) and Maryland (109). Maryland has the highest acreage, at 568 acres, followed by Florida (400), and North Carolina (365). Mississippi has the smallest farm size; they have an oyster park located just offshore of Deer Island, which is just offshore of Biloxi. The park has 516 acres permitted with two-acre leases available for growers. Farms in Florida and North Carolina average just over three acres, whereas in Maryland it is 5.5 acres. Georgia and Texas began in 2022, with farm sizes ranging between 7.5 and ten acres. For the states reporting number of farms, acreage, and harvest data, I can calculate farm productivity estimates. North Carolina has the highest average productivity; in 2021, they averaged 148,134 oysters harvested per farm and 48,296 oysters harvested per acre. Their 2020 productivity was a little over half of 2021's. Maryland had the second-highest average productivity, at 79,727 oysters harvested per farm and 14,458 per acre. Florida's per-farm productivity was much lower, at 39,200, and their per-acre productivity was also lower, at 12,250. Mississippi had its first harvest in 2021, where it planted 3.3 million oysters. Of these, 213,907 were harvested (6%).

Key Takeaways

- **Average farm sizes in other states range from two to ten acres. Among the newest entrants into AOC, Mississippi has an oyster park with two-acre slots, whereas new farms in Georgia and Texas range between eight and ten acres. In Alabama, average farm size has grown to 4.5 acres. States with longer track records – Florida, Maryland, and North Carolina - have average farm sizes of 3-6 acres.**
- **Not all AOC oysters that are planted make it to market. Data from Virginia indicate that only 30-40% of the oysters that are planted get sold, implying an average loss rate of 60-70% across the sector. During Mississippi's inaugural production year, only 6% of the oysters planted made it to market.**
- **Not all AOC oysters are sold to the half-shell market. Data from Maryland indicate that 40-47% end up in the lower-value sack-oyster market, where prices are below $0.25 per oyster.**
- **Prices received by growers vary widely. Although prices at or above $1 per oyster have been observed, the average price is in the $0.40-0.59 range. For oysters going to the sack-oyster market, growers are receiving prices below $0.25 per oyster.**

Figure 1. Reported Annual AOC Oyster Production by Other States.*



* North Carolina's data converted from bushels to oysters assuming 300 oysters per bushel (Parker 2023).

Source: Grice and Tarnecki (2022, 2023); Grice and Walton (2019, 2020); Herbst et al. (2022); Hudson (2017-2019); Hudson and Murray (2014-2016); Murray and Hudson (2011-2013); Murray and Oesterling (2006-2010); Parker (2023)

Table 1. Annual Intensive Oyster Culture Production Data for Virginia.

Year	Oysters Planted	Oysters Sold	Ratio of Oysters Sold to Oysters Planted*	Min Price (Cents)	Max Price (Cents)	Average Price (Cents)
2004	8,090,000	853,980		20	50	29
2005	6,158,000	843,842	10%	20	50	30
2006	16,098,000	3,145,282	51%	20	50	30
2007	18,456,000	4,800,900	30%	15	58	30
2008	27,800,000	9,800,000	53%	10	45	29
2009	28,300,000	12,600,000	45%	17	50	26
2010	76,600,000	16,900,000	60%	20	60	31
2011	65,500,000	23,300,000	30%	17	50	30
2012	66,700,000	28,100,000	43%	11	95	34
2013	106,000,000	31,000,000	46%	13	70	32
2014	107,100,000	39,800,000	38%	22	100	40
2015	135,600,000	35,400,000	33%	20	100	40
2016	106,300,000	40,200,000	30%	15	100	41
2017	111,100,000	38,900,000	37%	23	75	41
2018	103,900,000	32,100,000	29%	20	120	41

*Assumes oysters planted in year t are sold in year t+1.
Source: Hudson (2017-2019); Hudson and Murray (2014-2016); Murray and Hudson (2011-2013); Murray and Oesterling (2006-2010)

Table 2. Annual Water Column Oyster Harvest and Sales Data for Maryland.

Year	Water Column Oysters Harvested*	% Sold to Half-Shell Market	Avg Price to Grower (Cents, Half-Shell Market)	% Sold to Sack Oyster Market	Avg Price to Grower (Cents, Sack Oyster Market)
2017	8,778,300	60%	40	40%	18
2018	7,342,500	53%	40	47%	18
2019	7,342,500	58%	50	42%	18
2020	5,641,200	53%	50	47%	18
2021	8,211,900	59%	50	41%	18

*Based on MD Dept. of Natural Resources conversion factor of 300 oysters per bushel.
Source: Parker (2023)

Table 3. Annual Oyster Aquaculture Production Data for Alabama.

Year	2018	2019	2021	2022
Farms	22	21	10	10
Acres Permitted	64	74	75	61
Acres in Production	37	40	40	45
Average Farm Size (Acres)	1.7	1.9	4.0	4.5
Oysters Sold	1,921,586	2,425,000	4,711,166	4,451,015
Oysters Sold per Farm	87,345	115,476	471,117	445,102
Oysters Sold per Acre	51,935	60,625	117,779	98,911
Min Price (Cents)	30	50		
Max Price (Cents)	70	70		
Avg Price (Cents)	46	59		

Source: Grice and Tarnecki (2022, 2023); Grice and Walton (2019, 2020)

Table 4. Other Available State AOC Oyster Production Data.

State	Year	Farms / Leases	Acres	Average Farm Size (Acres)	Oysters Planted	Oysters Harvested	Oysters Harvested per Farm	Oysters Harvested per Acre
FL	2021	125	400	3.2		4,900,000	39,200	12,250
GA	2022	7		7.5-10				
MD	2021*	103	568	5.5		8,211,900	79,727	14,458
MS	2021	17	34**	2.0	3,300,000	213,907	12,583	6,291
NC	2020	97	296	3.1		8,250,000	85,052	27,872
NC	2021	119	365	3.1		17,628,000	148,134	48,296
TX	2022	3	25	8.3	2,100,000			

*Lease and acreage data are as of July 2023; harvest data are for 2021.

** Mississippi has 516 acres permitted; acres reported here is estimated assuming 2 acres per lease.
Source: Herbst et al. (2022); Parker (2023)

LOUISIANA AOC FARM COST AND PROFIT ANALYSIS

Production Assumptions

This section describes all production, cost, and revenue assumptions.

The number of oysters planted and harvested varies according to the acreage, gear type and quantity, market-size stocking rate, and expected mortality rate. I consider six production levels characterized by the number of containers, lease size (acres), number of oysters planted assuming 25% expected mortality, and expected number of oysters harvested (Table 5). Acreage requirements are based on the space requirements described by Walton et al. (2012), Pruente, Grice, and Chaplin (2023), and observations of current AOC operations.

Table 5. Production Levels Analyzed.

Lines (200 bags each)	Lease Size (Acres)	Oysters Planted	Expected Oyster Harvest
1	0.5	26,667-53,333	20,000-40,000
3	0.5	80,000-160,000	60,000-120,000
6	1	160,000-320,000	120,000-240,000
12	2	320,000-640,000	240,000-480,000
18	3	480,000-960,000	360,000-720,000
24	4	640,000-1,280,000	480,000-960,000

Gear

There are a variety of gear types for container-based oyster aquaculture, including an adjustable longline system, floating cages, semi-automated floating baskets, and floating bags. Based on discussions with Louisiana AOC farmers and Louisiana Sea Grant personnel, it was determined that most farmers in Louisiana use either floating cages or floating bags. I decided to choose floating bags as the basis for the analysis. Based on the work of Pruente, Grice, and Chaplin (2023), per-acre costs are similar between these two types, and based on their calculations using default gear spacing and stocking rates, floating bags can accommodate more oysters for the same amount of space. With the floating cage system, the bags are inside the cages, usually with three or six bags per cage, and thus offer more protection to the bags.

Following Pruente, Grice, and Chaplin (2023), Walton (2021), and Walton et al. (2012), I include the following items for the floating gear system, assuming R6 seed (that is, seed that will retain on 6mm mesh) is purchased:

- large mesh bags equal to the number of lines x number of bags per line (200);
- small mesh bags equal to one-eighth of the number of large mesh bags;
- bag closures equal to twice the sum of small and large mesh bags;
- anchor lines equal to the number of lines;
- screw anchors equal to twice the number of anchor lines;
- floating buoys equal to twice the number of anchor lines;

Figure 2 presents a representation of a two-acre lease with a floating bag system. Following Pruente, Grice, and Chaplin (2023) and Walton et al. (2012), I assume that a line of floating bags is 300 feet long and two feet wide, with each line holding 100 bags on each side, for a total of 200 bags per line, with a 20-foot boat lane required between lines. Under these assumptions, Pruente, Grice, and Chaplin (2023) indicate that six lines can fit within one acre and that thirteen lines can fit within two acres, but Walton et al. (2012) assume five lines per acre. I compromise and assume a flat rate of six lines per acre so that twelve lines can fit within two acres, acknowledging that an individual farmer may deploy more or less gear. Figure 3 shows a photograph of a single floating bag (Top panel) and lines of floating bags deployed in the water (Bottom panel). Figures 4-6 are photographs of example oyster farm configurations in Louisiana, Alabama, and Mississippi.

Other Equipment

I include the following additional equipment:

- Power washer ($300)
- Harvest baskets ($35 each, one per 100 12mm floating bags)
- In the case of a farmer operating within an AOC park, I assume that a tumbler/sorter/washer is provided by the park at no additional cost to the farmer ($3,900, Shell Game Products 2023) (Figure 7, Top)

I add 24.2% to the cost of all gear and other equipment to account for sales tax and shipping cost. I used the sales tax rate for Grand Isle, which is 9.2%. For comparison, in Thibodaux it is 9.4%; in New Orleans it is 9.45%; in Baton Rouge it is 9.95%. I assume an additional 15% for shipping cost. Actual shipping cost could be more or less. Maxwell and Supan (2010) reported shipping costs that were 20-26% of gear value. Shipping costs observed for current AOC growers ranged from less than 10% to over 30%.

Boat, Motor, Truck, and Trailer

I assume the farmer will require a boat with a motor and trailer. I assume that farm work is feasible with a Class A vessel (less than 16 ft) with a minimum 15-HP motor, but that some growers may already own a Class 1 vessel (16-26 ft) and use that. I conducted online searches of used boats for sale to determine a reasonable cost. To provide some idea of the kinds of results obtained from such a search, I provide one example here: I searched on BoatTrader.com on May 22, 2023 using filters: state, Louisiana; length, 15-20 feet; year, 2010 or newer. The site returned 232 hits, ranging from $12,995 for a 2017 18-foot Weldbuilt with a 25-HP Tohatsu, to $84,995 for a 2018 20-foot Beavertail Skiff with a 225-HP Mercury. Based on this and other searches, I assumed a cost of $20,000 for a used boat, motor (50-HP), and trailer, with a useful life of ten years and straight-line depreciation. Given the saltwater environment, the assumption of a ten-year life for a used outboard motor may be somewhat optimistic. Motor lifespan will also be a function of running hours, which this analysis does not factor in. I assume a salvage value of $2,500 for the combined boat, motor, and trailer. Following Johnson (2018), an annual cost of taxes, insurance, and housing for the boat, motor, and trailer is included using the formula (total sales price of boat, motor, and trailer / 2) x 1.5%. I base boat, motor, and trailer repair costs on Johnson (2018), using a modified formula: 1% x purchase price x motor running hours. I base boat motor lubrication and filter costs on Johnson (2018), assuming 15% of fuel costs.

The farmer will require some form of transportation to commute from home to the dock nearest the farm. However, AOC in Louisiana, particularly in Grand Isle in the short-run, will also entail direct delivery to buyers, likely to larger cities such as New Orleans, Baton Rouge, Lafayette, and the Mississippi Coast. This will require a reliable vehicle with mechanical refrigeration to make weekly trips to and from buyers. I assume a used truck can be purchased for $25,000 depreciated over ten years, with a $2,500 salvage value. For reference, a new base-model Ford F-150 starts at $33,695 before taxes, title, and license, although the cheapest new 2023 F-150 found in a recent search of new truck inventory within 100 miles of New Orleans was $36,295. Following Johnson (2018), an annual cost of taxes, insurance, and housing for the truck is included using the formula (total sales price of truck) / 2) x 1.5%. For truck maintenance (including oil, lubrication, tires, and repairs), I use the Bureau of Transportation Statistics (2023) rate of $0.097 per mile per year.

For mechanical refrigeration, I assume a mobile refrigeration trailer using an AC window unit, a CoolBot, and retro-fit insulated trailer (Perkins-Veazie 2012; Store It Cold, LLC 2021). The estimated cost is $3,471; to this I add $129 to cover the cost of an AC/DC inverter to power the unit from the truck, for a total of $3,600. (Alternatively, the unit could be powered with a gas generator at similar cost.) Figure 7 (Bottom) is a photo of a similar unit installed in the bed of a pickup truck. I assume a five-year useful life on the refrigeration unit.

Other One-Time Start-up Costs

A grower can establish his own lease or he can lease a plot within one of Louisiana's AOC oyster parks. If he leases a plot within an AOC park, I assume that the plot is pre-permitted and approved and no further surveying or permit work is required. If the grower establishes his own lease, he must hold an oyster lease. Once a lease is obtained, he must apply for an AOC permit, which costs $100 (good for ten years). As part of the AOC permitting process, a Coastal Use Permit is required, which has its own $100 application fee (one-time fee). The AOC permit process may also require permits from the US Army Corps of Engineers, a state water-quality certification, completion of a US Coast Guard Private Aids to Navigation Application, and any other state or federal approvals that may apply.

A surety bond is also required if the farm is to be located on a state oyster lease, based on the estimated cost of gear removal and the bond rate. A reasonable cost for the bond is $1,000. A surety bond is not required if a grower operates within an AOC park or on private water bottom.

Given direct sales, I include a one-time $390 cost for HACCP training.

AOC Grant

Some AOC growers received grants in the amount of $45,000, that could be spent on gear, modifications to a boat, HACCP training, etc. In this section, I report what the effect of the grant would be. I limit the grant's applicability to gear, other equipment, other upfront costs, lease fees and permits, seed, and retail containers.

Figure 2. Representation of a Two-Acre Lease with 12 Lines of Floating Bags, with 200 bags Per Line. NOT TO SCALE.

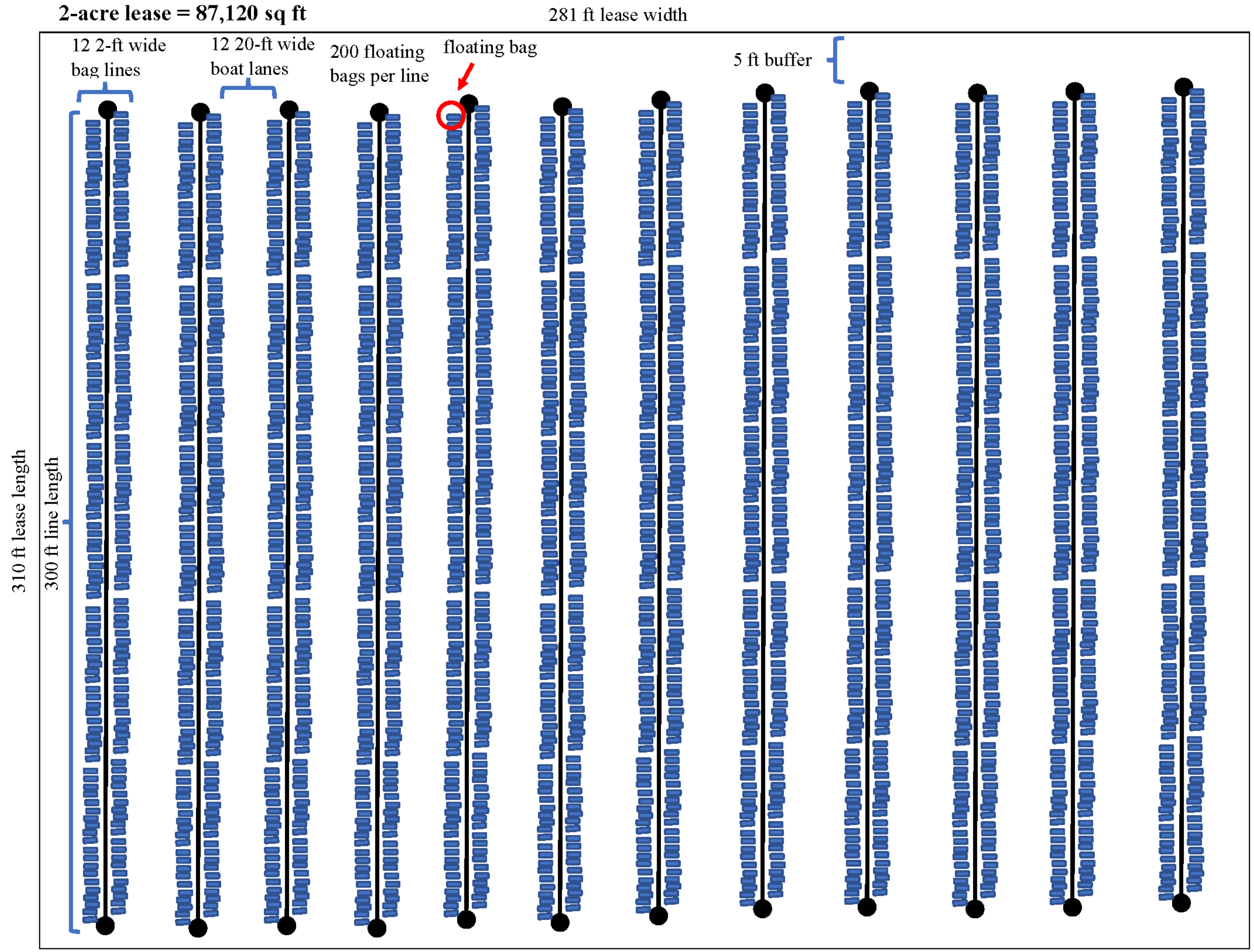


Figure 3. Photograph of a Single Floating Bag (Top); Floating Bags Deployed at an AOC Farm in Louisiana (Bottom).

Figure 4. Aerial View of the Michael C. Voisin Oyster Hatchery in Grand Isle (Top); Proposed Layout of AOC Park Leases at South End of Calcasieu Lake in Cameron (Bottom).

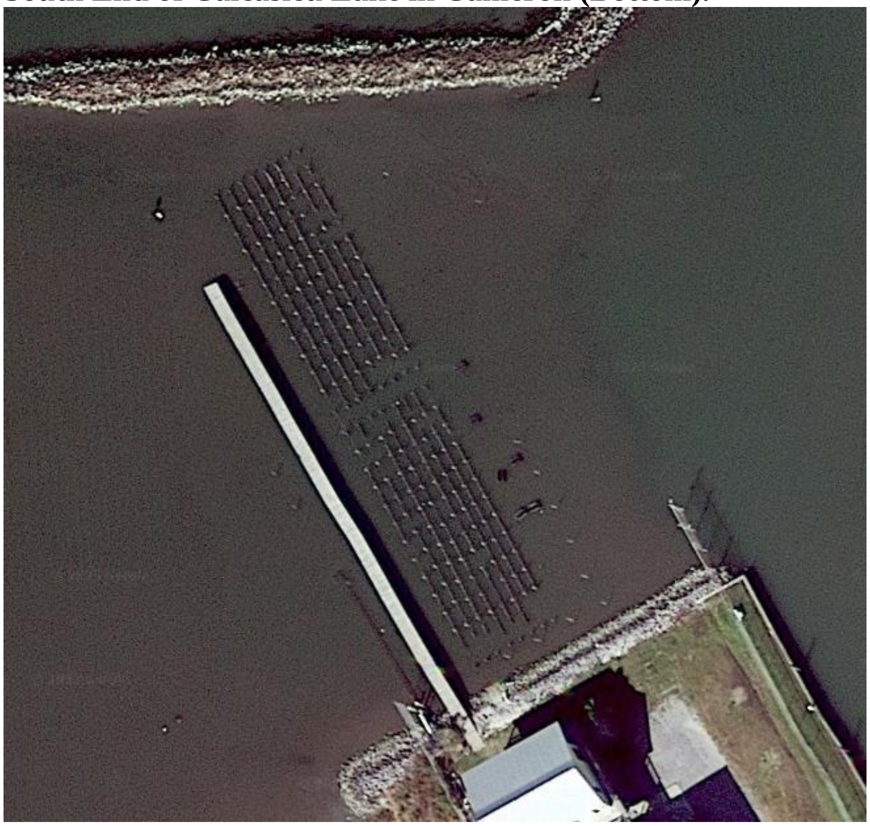


Figure 5. Photo of Oyster Farm in Alabama with Suspended Gear Sited within 12 Acres (Top, Enclosed within Yellow Box Only); Oyster Farm in Alabama with Floating Gear Sited within 2 Acres (Bottom).

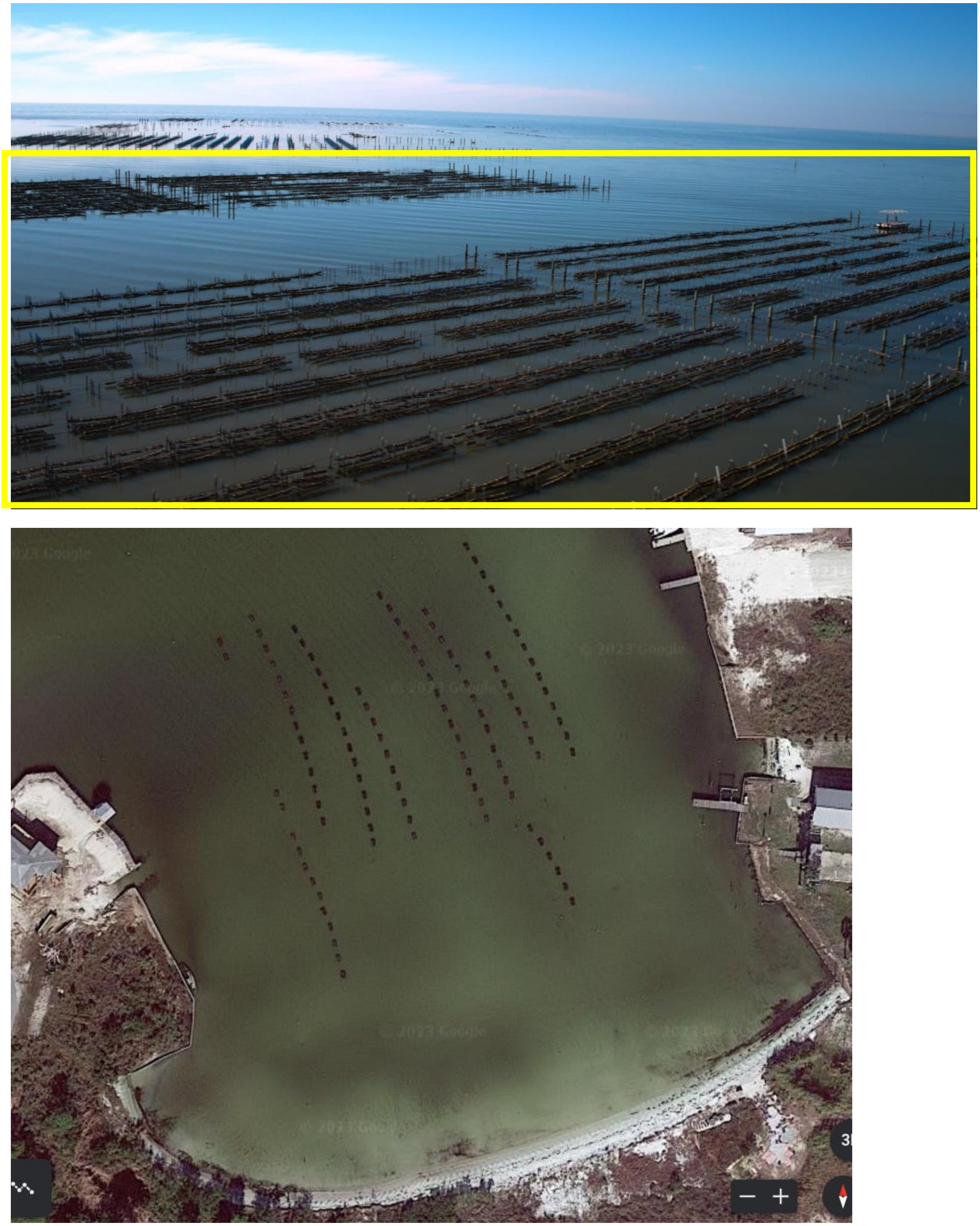


Figure 6. Aerial Photo of Oyster Park Located Off of Deer Island in Biloxi, Mississippi, with Floating Gear Sited within 40 Acres (Top, Park Located within Yellow Box); Zoomed-In View (Bottom).

Figure 7. Photograph of a Tumbler/Sorter/Washer (Top); Photograph of a Refrigeration Unit Installed in Bed of Pickup Truck (Bottom).

“Partial” versus “Full” Cost
I present two sets of results that I label as “Partial Accounting” and “Full Accounting”. “Partial Accounting” includes out-of-pocket costs only. Specifically, it excludes managerial labor cost under the assumption that the farm manager is also the owner and thus managerial wages are not paid explicitly. It also excludes depreciation and interest associated with the boat, motor, truck, and trailer under the assumption that these are already owned, and thus monthly notes are not paid explicitly. In so doing, it is also ignoring wear and tear on these items. “Partial Accounting” is closer to the case of an experienced grower, who may not be concerned with the opportunity cost of his own time, and also likely already owns a boat, motor, truck, and trailer and is not concerned with wear and tear.

“Full Accounting” includes all relevant costs. Specifically, it includes managerial labor at the rate of $20 per hour, and includes depreciation and interest on the boat, motor, truck, and trailer. “Full Accounting” is closer to the case of a new grower who is concerned with the opportunity cost of his own time and likely must purchase and finance a boat, motor, truck, and trailer.

Note that Partial Accounting estimates are provided because they are often requested; but they are not recommended for decision-making. I recommend that if any decisions are made based on the information in this report, they should be made based on “Full Accounting”. “Full Accounting” is the theoretically correct cost estimate according to economic theory, which holds that all costs, both explicit (out-of-pocket) and implicit (opportunity cost), be included. Profit under Partial Accounting should not be interpreted as pure economic profit, strictly speaking. Rather, those are funds available to the grower to pay himself, that is, as income to cover his own household/family living expenses and to put toward the eventual replacement of his own boat, motor, truck, and trailer. For example, if profit under Partial Accounting are $10,000, the grower should interpret that figure as his salary, and compare that value to what he could earn if he devoted his time and efforts elsewhere. If he were accustomed to living off of a $50,000 salary, then he should target an enterprise that yields at least $50,000 in profit under Partial Accounting. I ask the reader to interpret Partial Accounting estimates with caution.

Table 6 summarizes all key assumptions.

Initial Capital Investment

Table 7 shows estimated initial capital investment and depreciation calculations for one production line. *Results do not include any AOC grant funds.* Italicized items are those excluded under “Partial Accounting”. I estimate that a boat, motor, truck, and trailer will cost $45,000. I estimate the cost of farm gear, including bags, anchors and anchor lines, and buoys, to be $6,431. Other equipment, including a refrigeration unit for direct delivery, a powerwasher, and baskets, is estimated to cost $4,931. Other costs, including HACCP trailing and a fixed $625 contingency cost, are estimated at $1,015.

Figure 8 shows total initial capital investment under Full Accounting and Partial Accounting. The portion of cost that would be covered by up to $45,000 in AOC Grant funds is shown in red. Total initial capital investment under Full Accounting is estimated to range from approximately $57,000 for a single line of floating bags (40,000 oysters planted) to over $200,000 for twenty-four lines (960,000 oysters planted). Under Partial Accounting, it ranges from less than $15,000 for one line to over $150,000 for twenty-four lines. Under Partial Accounting, an AOC grant would cover all capital costs up to six lines (240,000 oysters planted).

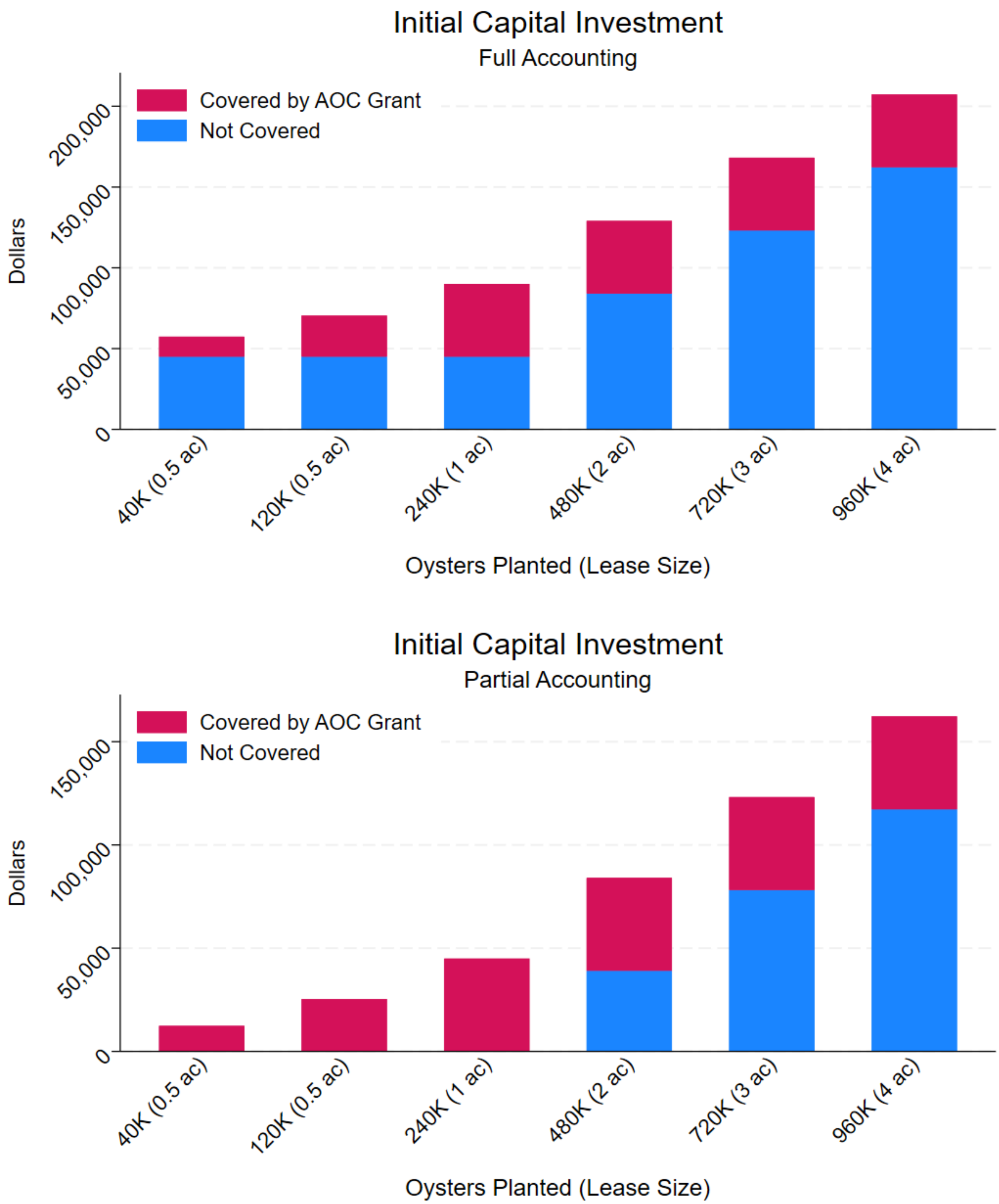
Table 6. Summary of Key Production Assumptions.

Assumption	**Value**
Gear Type	Floating bags
Floating bag lines (lease size in acres)	1 (0.5 acre), 3 (0.5 acre), 5 (1 acre), 10 (2 acres), 15 (3 acres), 20 (4 acres)
Floating bags per line	200
Market-size oysters per bag	100, 150 (baseline), 200
Expected seed mortality from planting to harvest (R6)	25%
Seed price ($ per 1,000, R6)	$28.75
Hourly wage, supervisory labor	$20.00
Hourly wage, general labor	$12.50
Fuel price per gallon (gasoline)	$3.20
Boat motor horsepower	50
Motor fuel use, gallons per hour	HP / 10 = 5
Motor running hours, as % of labor hours	10%
One-way travel distance in miles, home to dock (Thibodaux to Grand Isle)	81
One-way travel distance in miles, dock to delivery (Grand Isle to New Orleans)	107
Delivery travel days per week / weeks per year	1 / 52
AOC park lease rent, dollars per acre per year	$1,000
General liability insurance, dollars per acre per year	$1,000
Retail container cost, dollars per 100-count container	$1.00
Marketing/promotion cost, dollars per year	$2,500
Expected price per oyster	$0.50, $0.75 (baseline), $1.00
Interest rate on loans	11.75%

Table 7. Estimated Capital Costs and Annual Depreciation for One Line of Floating Bags. Italicized Items Excluded under "Partial Accounting".

	Quantity	Cost Per Unit	Tax & Shipping	Total Cost	Useful Life (Years)	Salvage Value	% Dedicated	Annual Depreciation
Boat, Motor, Truck, Trailer								
Boat, Motor (50 HP), Trailer	*1*	*$20,000.00*	*0.0%*	*$20,000*	*10*	*$2,500*	*100%*	*$1,750*
Truck	*1*	*$25,000.00*	*0.0%*	*$25,000*	*10*	*$2,500*	*100%*	*$2,250*
Gear, Floating Bag System								
Sleeve, 2 mm mesh, 1.5 mL (R2 seed)	0	$6.75	24.2%	$0	4	$0	100%	$0
Bags, 4mm mesh, 2 mL (R4 seed)	0	$7.00	24.2%	$0	4	$0	100%	$0
Bags, 6mm mesh, 4.5 mL (R6 seed)	25	$22.00	24.2%	$683	4	$0	100%	$171
Bags, 12mm, 9.5 mL (R12 seed)	200	$22.00	24.2%	$5,465	4	$0	100%	$1,366
Bag Closures	450	$0.034	24.2%	$19.00	4	$0	100%	$5
Screw Anchors	2	$39.00	24.2%	$97	4	$0	100%	$24
Floating Buoys	2	$40.00	24.2%	$99	4	$0	100%	$25
Anchor Lines, 300'	1	$54.49	24.2%	$68	4	$0	100%	$17
Other Equipment								
Truck Refrigeration Unit	1	$3,600.00	24.2%	$4,471	5	$0	100%	$894
Powerwasher	1	$300.00	24.2%	$373	5	$0	100%	$75
Harvest Baskets	2	$35.00	24.2%	$87	5	$0	100%	$17
Other Costs								
HACCP Training	1	$390.00	0.0%	$390	5	$0	100%	$78
Contingency				$625	5			$125
Total Boat, Motor, Truck, Trailer Cost				***$45,000***				***$4,000***
Total Farm Gear Cost				**$6,431**				**$1,608**
Total Other Equipment Cost				**$4,931**				**$986**
Total Other Cost				**$1,015**				**$203**
Grand Total				**$57,377**				**$6,797**

Figure 8. Initial Capital Investment, Showing Portion Covered by an AOC Grant; Full Accounting (Top), Partial Accounting (Bottom).



Estimated Operating Costs

Seed

Seed (baby) oysters can be purchased from a hatchery or nursery as either diploid or triploid, and at different sizes. Although they are hatchery-reared, diploid oyster seed are the type typically found in the wild (for the Gulf and Atlantic coasts, the Eastern oyster, *Crassostrea virginica*). Triploid oyster seed are the same species, but produced artificially through a patented process that crosses a wild diploid female with a patented tetraploid male. Triploid oysters are mostly sterile and tend to grow faster because they do not expend as much energy on reproduction. Consequently, they tend to remain “fat” all year long as opposed to a diploid oyster that may become “watery” or “milky” during spawning.

Seed can be purchased at various sizes. Sizes are often denoted by an “R” value, where the “R” stands for “retained” meaning the mesh screen size on which seed will be retained, that is, will not fall through. This lets the grower know the size of mesh bags needed to contain a given size of seed. (The issue is that, for example, 2mm seed will not be retained on 2mm mesh, so the numbers are a source of confusion and lost seed. The R value fixes this problem, because an R2 seed is larger than 2mm, and will thus be retained on 2mm mesh.) Thus, R2 seed will be retained on 2mm mesh; R4 seed will be retained on 4mm mesh, etc. Growers face a tradeoff when purchasing seed. Smaller seed are cheaper, but require additional handling and generally have higher mortality rates. Some growers will operate their own nurseries, either in an upweller system or in a “field” nursery, which means growing the seed in small-mesh sleeves within the regular gear. Observations of current Louisiana AOC growers indicate they are purchasing a variety of seed sizes (R2, R4, or R6).

I assume the farmer purchases R6 seed at a cost of $28.75 per 1,000.

Mortality

Parker, Lipton, and Harrell (2020) cite several studies to support their assumption of 50% mortality from seed (5-10 mm triploid) to market-size, and describe this as “a medium level of mortality based on the published data and discussions with commercial operations” (p. 8). Dame et al. (2019), whose analysis relied partly on grower input, assumed that 80% of oysters survived from planting to harvest, and of those, 90% were marketable, implying 28% mortality from planting to market. Bodenstein, Walton, and Steury (2021) found mortality rates between near-zero and 40% for diploid oysters, and between 5% and 60% for triploids. Sturmer, Cyr, and Markham (2018) report mean mortality rates for diploid and triploid oysters of 18% and 15%, respectively. Walton et al. (2013) report a mean mortality rate of 29%, with no significant difference between diploids and triploids. Sturmer et al. (2022) investigate unexplained spring and summer mortality events in 2018 and 2019 in two counties in Florida that resulted in 50-80% mortality. Wadsworth (2018) reports mortality rates at four farms across the Gulf Coast ranging from around 25% to above 50% for triploids and less than 25% for diploids. Walton et al. (2012) assume 10% mortality.

I assume 25% expected mortality from seed purchase to harvest, and I assume that growers account for expected mortality by purchasing an amount of seed equal to the ratio of expected annual production and (1 - expected mortality rate). For example, if expected annual production is 60,000 oysters and expected mortality is 25%, then the grower will purchase 60,000 / (1 - 0.25) = 80,000 oyster seed.

Stocking Density

Pruente, Grice, and Chaplin (2023) and Walton et al. (2012) use a stocking density based on market-size oysters per bag of 150 oysters for the floating bag system. Other sources and discussions with growers and other individuals indicate that stocking densities as high as 250 oysters per bag are possible, but that 200 is the highest that a typical farmer is likely to use. Higher stocking densities tend to require additional maintenance and may run the risk of higher mortality. A seed shortage may also lead to lower stocking densities.

Fuel

I base boat fuel requirements on Johnson (2011), who recommends dividing horsepower for a gasoline outboard motor by ten to determine gallons per hour. I assume motor running hours are equal to 10% of labor hours.

I base truck fuel requirements on the city miles per gallon reported for a 2023 Ford F-150 (19 mpg). I assume a home location of Thibodaux (81 miles one-way to Grand Isle) and a direct delivery location of New Orleans (107 miles one-way from Grand Isle). I assume travel to the farm three to seven days per week, depending on production level, 52 weeks per year. I assume oyster delivery to New Orleans once per week, 52 weeks per year.

I assume $3.20 per gallon of gasoline, which is the average monthly retail gasoline price over all grades and formulations for the Gulf Coast over the past twelve months (August 2022-July 2023) (EIA 2023).

Lease Rent, Permits, and Licenses

Current Louisiana AOC parks have lease fees ranging from $200 per year (flat rate), to $2,000 per year for a two-acre lease, to $3,000 per year for a half-acre lease. I use the median of these three rates ($1,000 per acre per year). If he operates on his own lease, he is required to pay an annual permit fee to the state of $2 per acre or portion of acre, but must take care of the permitting process, surveying and marking, obtain a surety bond, have his own tumbling/sorting equipment and staging area, etc.

An Oyster Harvester License is required, at a cost of $100 (resident) per year, and a Commercial Fisherman License is required, at a cost of $75.50 (resident non-senior). Given the need for direct sales, an AOC grower must also hold a Wholesale/Retail Seafood Dealer License ($400 per year) and a Seafood Transport License ($56.50 per year per vehicle).

Insurance

I include the cost of general liability insurance at the rate of $1,000 per acre. This rate is based partly on Parker, Lipton, and Harrell (2020), who use a rate of $1,000 per $150,000 in sales. At $0.75 per oyster, production of 200,000 oysters would yield $150,000 in sales, and approximately one acre is needed to grow that number of oysters. There are at least two USDA crop insurance products potentially available for oysters: Group Risk Plan – Oysters (GRP) and Whole Farm Revenue Protection (WFRP). Based on feedback from some existing growers and other knowledgeable people in Louisiana and other Gulf states, I concluded that growers are not subscribing to these products, so I exclude them from the analysis.

Labor

The literature contains a handful of labor estimates. Figure 9 summarizes the various estimates of labor hours required. Hudson, Kaufmann, and Murray (2013) report estimated labor hours required for operations ranging from less than 100,000 to two million oysters planted per year. Their estimates are based on four years (2008-2011) of grower data from the Virginia Sea Grant Marine Extension Program's annual shellfish aquaculture crop reporting survey. Their estimates range from 960 combined full-time and part-time hours for less than 100,000 oysters planted to 12,000 hours for up to two million oysters planted. Parker, Lipton, and Harrell (2020) adapted those estimates to analyze larger-scale operations in Maryland, ranging from 500,000 to 2.5 million oysters per year. They assumed a fixed 2,080 supervisory labor hours per year. For general labor hours, they added office labor hours to those of Hudson, Kaufmann, and Murray (2013). Engle and van Senten (2021) report labor cost per unit sold rather than reporting number of hours and hourly wage for their bottom container culture analysis. They report labor cost of \$15 +/- \$11 per 100-count box of oysters sold for an operation producing 600,000 or more oysters per year. Maxwell and Supan (2010) provide labor requirements for both construction/installation and operation for an adjustable longline system on a one-acre lease producing between 60,000 and 120,000 oysters. They report 15 hours of labor for construction and installation. They report between 30 and 109 days of labor for seeding, maintenance, and harvest at a rate of \$100 per day (equivalent to \$12.50 per hour for an eight-hour day, which is assumed here); and 250 hours at a rate of \$6 per hour for bag cleaning. Converting days to hours assuming an eight-hour day yields between 490 and 1,122 hours.

I decided to use the estimates of Hudson, Kaufmann, and Murray (2013) because they covered the full production range analyzed here. Both Parker, Lipton, and Harrell (2020) and Engle and van Senten (2021) focused on larger operations and their results may not translate directly to smaller operations. Thus, the estimates used here are lower than those of Parker, Lipton, and Harrell (2020) and very similar to those of Maxwell and Supan (2010). For comparison to Engle and van Senten (2021), estimated labor cost under the baseline scenario (discussed later in the report) for the two highest production levels is \$21-24 per 100-count of oysters, thus within the upper range of Engle and van Senten (2021).

I assume two labor types: supervisory labor (which can be interpreted as the owner-operator) and general labor. The labor hours used, as taken from Hudson, Kaufmann, and Murray (2013) are reported as is in Table 8. In terms of full-time equivalent (FTE) days per week spent working at the farm, assuming 52 weeks per year and an eight-hour day, planting up to 100,000 oysters requires one person working 2.3 days per week. Planting between 100,000 and 200,000 oysters requires one person working five days per week (or two people working 2.5 days each). Producing up to one million oysters requires 17.3 FTE days, implying that three people working nearly six days per week is required.

Their estimates are a function of number of oysters planted and stops at the farm gate, assuming that a wholesale distributor does the marketing. Thus, their labor requirements exclude marketing and transportation needed for direct delivery. I add 25% to labor hours to account for direct sales, which appears to be the most likely option for growers in Louisiana, at least in the short run. Note that even with this increase, labor requirements used by Parker, Lipton, and Harrell (2020) are still 16-28% higher.

I assume rates of $20 per hour for supervisory labor and $12.50 per hour for general labor (equivalent to $100 per day for an eight-hour day) (Parker, Lipton, and Harrell (2020). I allocate hours as follows: first, I determine total hours required for a given number of oysters planted from Hudson, Kauffman, and Murray (2013) and multiply that number by 1.25 to account for added labor for direct sales. I then allocate hours to supervisory labor first at the rate of $20 per hour, assuming that in the owner-operator case, the owner-operator will carry out as much work himself as possible, up to the annual full-time maximum of 2,080 hours (8 hours per day x 5 days per week x 52 weeks per year). Remaining hours, if any, are then allocated to general labor at the lower $12.50 per hour rate.

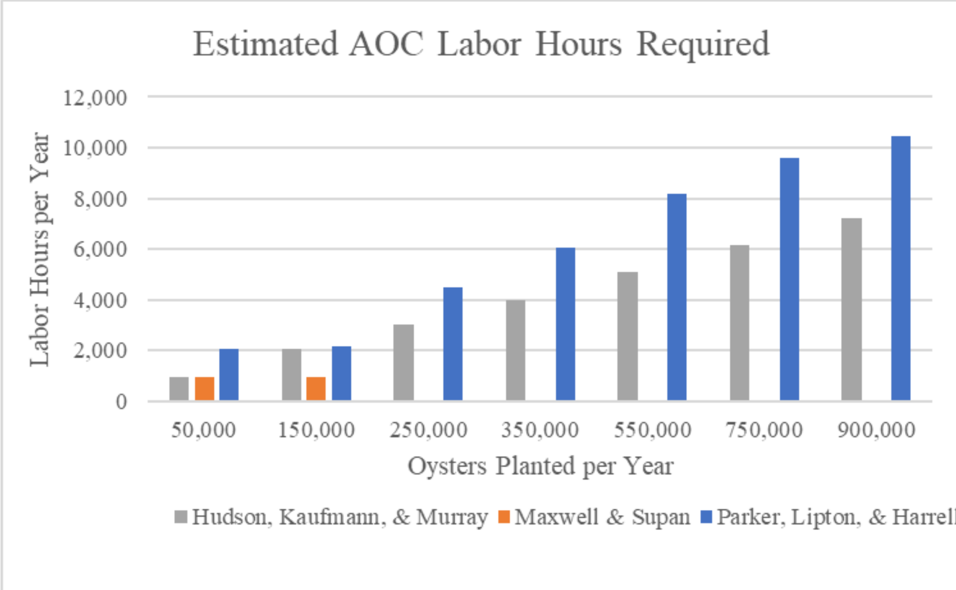
Employer-paid taxes are then added to general labor costs at the rate of 13.8% (federal payroll tax / FICA, 6.2%; workmen's compensation, 5.0%; unemployment insurance, 2.6%). Employment taxes are not charged on supervisor labor because I assume an owner-operator arrangement, so supervisory wages are an implicit cost and would not incur taxation.

Marketing and Sales
I assume that the cost of retail container material (mesh bags, cardboard boxes, and/or styrofoam boxes) is $1 per 100 oysters destined for the half-shell market (Parker, Lipton, and Harrell 2020). I assume a fixed $2,500 cost for marketing, promotion, website maintenance, etc.

Loans and Interest
I assume that the farm will finance farm gear and other equipment, and where applicable, will finance a boat, motor, truck, and trailer. I also assume that the farm will need to obtain an operating loan for cash-on-hand to pay expenses prior to harvest.

Following Johnson (2018), annual interest on gear is calculated as (principle / 2) x interest rate. The annual interest on operating capital is calculated as one-half total annual cost x interest rate. The interest rate used is the current rate for a Small Business Administration loan for under seven years on $25,001-$50,000, which is 11.75% (SBA 2023; NerdWallet 2023).

Figure 9. Comparison of Estimated Labor Hours Required by Production Scale, as Reported in Other Sources.



Source: Hudson, Kaufmann, and Murray (2013), Maxwell and Supan (2010), and Parker, Lipton, and Harrell (2020).

Table 8. Estimated Labor Hours Required, Based on Number of Oysters Planted.

Oysters Planted Range		Full-time hours	Part-time hours	Total hours	Days per Week (Full-Time Equivalent 8-Hour Day)
1	100,000	0	960	960	2.3
100,001	200,000	2,080	0	2,080	5.0
200,001	300,000	2,080	960	3,040	7.3
300,001	400,000	2,080	1,920	4,000	9.6
400,001	700,000	4,160	960	5,120	12.3
700,001	800,000	4,160	2,000	6,160	14.8
800,001	1,000,000	6,240	960	7,200	17.3
1,000,001	1,500,000	6,240	3,840	10,080	24.2
1,500,001	2,000,000	6,240	5,760	12,000	28.8

Source: Hudson, Kauffman, and Murray (2013)

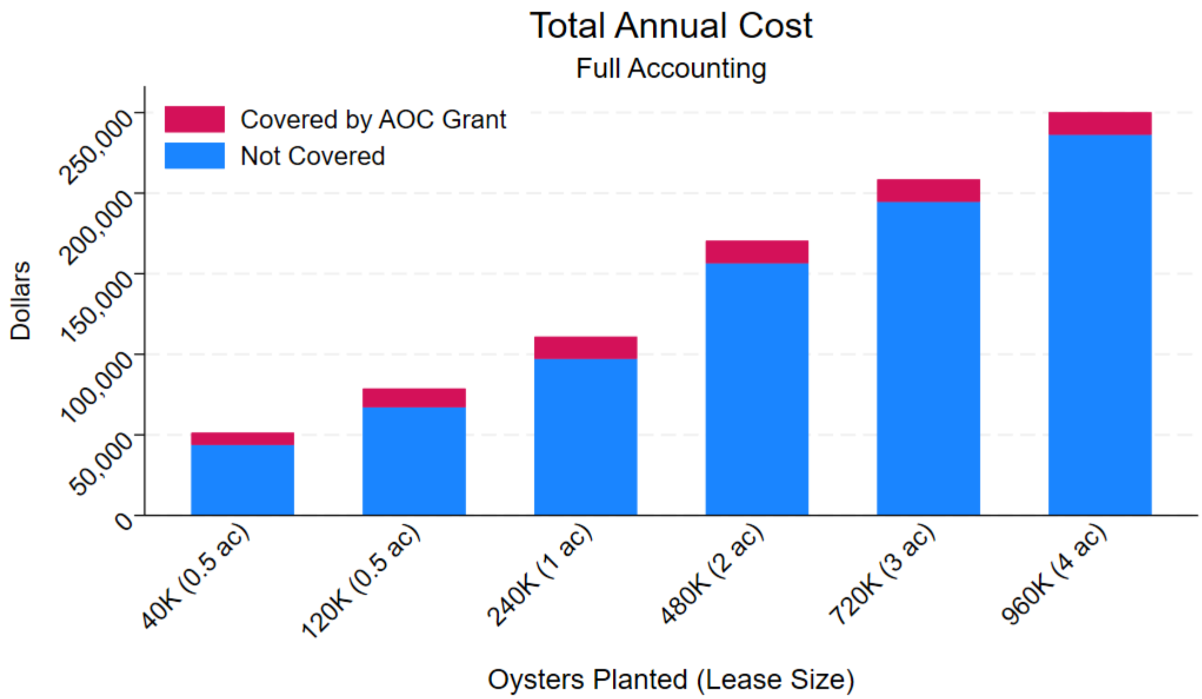
Total Annual Cost

Figure 10 shows the estimated total annual cost by production level. The portion that would be covered by up to $45,000 in AOC grant funds is shown in red. Under Full Accounting, total annual cost is estimated to range from approximately $50,000 to operate a single line of floating bags to approximately $250,000 to operate twenty-four lines. Under Partial Accounting, total annual cost is estimated to range from approximately $20,000 to operate a single line of floating bags to over $200,000 to operate twenty-four lines. Only a small fraction of annual cost is offset by an AOC grant because grant dollars offset capital, the cost of which is spread out (depreciated) over five years, and is relatively small compared to other annual costs.

Figure 11 shows the breakdown of annual cost by cost category for four production levels. *Result do not include any AOC grant funds.* Under Full Accounting, at the lowest production level (40,000 oysters planted on 0.5 acre), the largest cost category is supervisory labor; followed by fuel and boat/truck maintenance; then boat and truck depreciation; then lease, insurance, and administrative costs; then gear and equipment; then seed; then other costs. There are no general labor costs at this production level, as all labor is assumed to be carried out by a single individual (the supervisor/owner). At 240,000 oysters planted on one acre, supervisory labor is still the top cost category and general labor is the third-highest cost category. At 480,000 oysters planted on two acres, general labor and supervisory labor are the highest cost categories, respectively. At 960,000 oysters planted on four acres, general labor is the top cost category and supervisory labor is the third-highest cost category. Fuel and boat/truck maintenance is one of the top four cost categories at all four production levels. These results highlight the enormous role played by labor and fuel costs in AOC.

Under Partial Accounting, supervisory labor and boat/truck depreciation are ignored. And with an AOC grant, gear cost is reduced. Although these are important cost categories, the figure makes clear that a substantial amount of cost remains in the remaining categories.

Figure 10. Estimated Total Annual Cost by Production Level, Indicating Portion Cover by AOC Grant; Full Accounting (Top), Partial Accounting (Bottom).



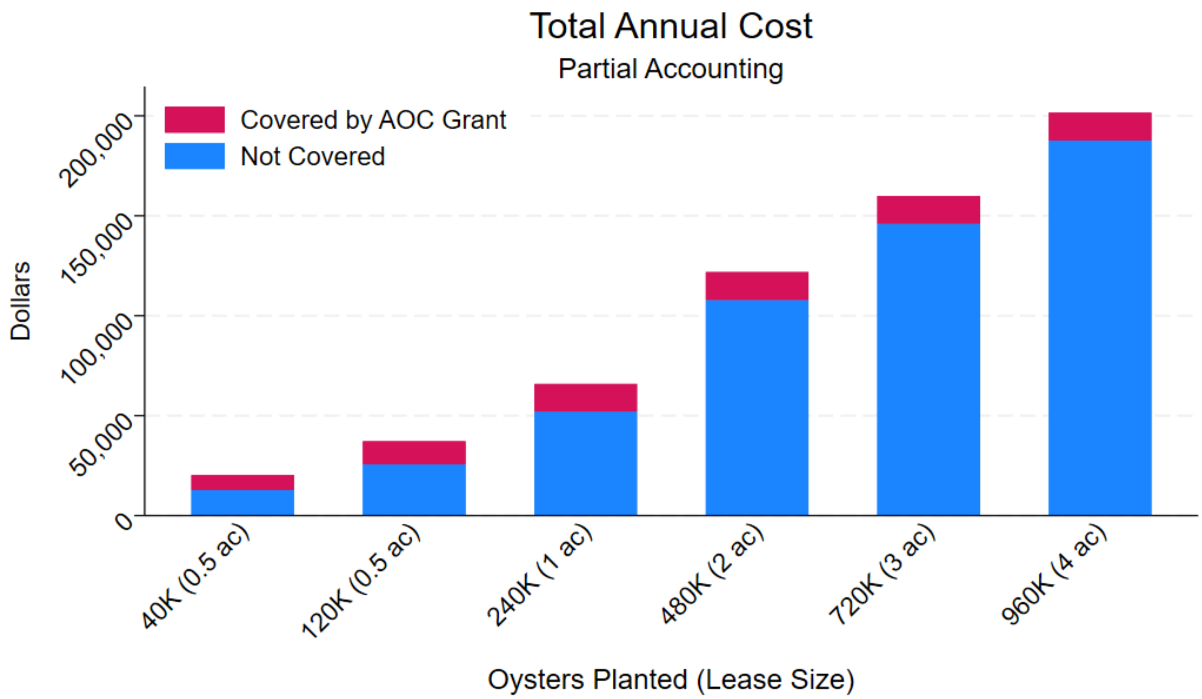
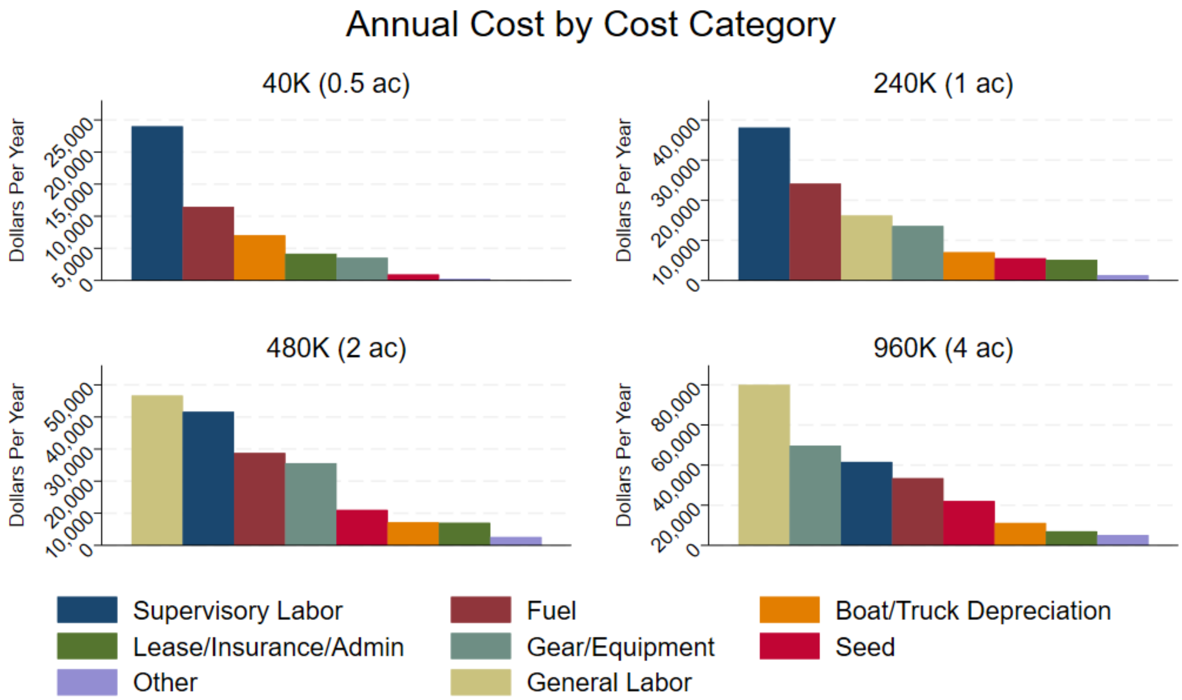


Figure 11. Annual Cost by Cost Category for Four Production Levels.



Key Takeaways

- **AOC is expensive. It requires gear, seed, and labor at levels not associated with traditional oyster production. A single line of 200 floating bags, holding 30,000-40,000 oysters, is estimated to cost over $6,000. Other equipment, including refrigeration for direct delivery, is estimated at nearly $5,000.**
- **Under Full Accounting, which includes the cost of a boat, motor, truck, and trailer ($45,000) and other start-up costs, total initial investment is estimated to range from less than $60,000 for a single line of floating bags to over $200,000 for twenty-four lines. Under Partial Accounting, total initial investment is estimated to range from approximately $12,000 for a single line to over $150,000 for twenty-four lines. Under Partial Accounting, the AOC grant covers all initial investment costs up to six lines of floating bags on one acre.**
- **Under Full Accounting, total annual cost, including depreciation and interest on invested capital, labor, fuel, seed, and other expenses, is estimated to range from approximately $50,000 to operate a single line of floating bags to approximately $250,000 to operate twenty-four lines. Under Partial Accounting, total annual cost is estimated to range from approximately $20,000 for a single line on half an acre to approximately $200,000 for twenty-four lines on four acres.**

Five-Year Projections

The five-year projections are meant to provide realistic estimates of the annual average break-even prices and profits during the first five years of operation. The analysis accounts for a farm start-up period. It is expected that the first year will be used in setting up the farm, including construction, training, etc., as well as purchasing and assembling gear, obtaining seed, and finally deploying gear and seed. Following Parker, Lipton, and Harrell (2020), I assume the farm ramps up gradually to full capacity over the first two years of operation: seed planted is at 25% of full capacity during the first year and 75% of full capacity during the second year. It is reasonable to assume that because production is lower, costs would also be lower. Consequently, labor costs follow the lower levels associated with the lower number of oysters planted.

Baseline Scenario

I present the results of a "baseline scenario", that is, a scenario based on what I believe to be the most likely assumptions regarding the occurrence of adverse environmental events, stocking rate, and price to grower. In the subsequent section, I test the sensitivity of the results under alternative assumptions. The baseline scenario assumptions are as follows.

- There is a high likelihood that some type of adverse environmental event, such as a hurricane, a drought, a freshwater influx event, and/or an unexplained mortality event will occur at some point in time, or multiple times, during the first five years of operation. To approximate the impact of a moderate form of such an event, I assume that <u>50% of a single year's expected harvest</u> will be lost during the five-year period. I chose Year 4 arbitrarily to apply this loss. I refer to this case as the "Moderate Loss Case".
- Stocking rate of 150 market-size oysters per bag. This is the level recommended for floating bags by Pruente, Grice, and Chaplin (2023) and Walton et al. (2012).
- Direct-sale price to grower in the branded-oyster market is $0.75 per oyster. Ten percent of harvest is sold to the lower-value sack-oyster market at $0.25 per oyster.

Break-Even Analysis

Break-even analysis estimates the per-unit price at which revenue just equals cost over some period of time. Break-even price to grower is calculated as:

$$BreakEven\ Price\ to\ Grower = \frac{Cost}{Quantity\ Sold}$$

Figure 12 reports the Baseline Scenario results of the break-even analysis at six levels of production for both Full Accounting and Partial Accounting, with and without an AOC grant. Without an AOC grant, at the lowest level of production, the break-even direct-sale price to grower is \$2.57 per oyster under Full Accounting and \$1.02 under Partial Accounting. As production increases, the estimated break-even price to grower generally declines, and falls below \$1 per oyster at the 240,000 oysters planted level under Full Accounting. At the highest production level considered, the estimated break-even price to grower is still above \$0.50 under Full Accounting but below \$0.50 for Partial Accounting.

With the AOC grant, differences are more pronounced at lower production levels but small at higher production levels. At the lowest level of production, the break-even direct-sale price to grower is \$2.19 per oyster under Full Accounting and \$0.64 under Partial Accounting. As production increases, the estimated break-even price to grower generally declines, dropping below \$1 per oyster at the 240,000 oysters planted level under Full Accounting. At the highest production level considered, the estimated break-even price to grower is \$0.49 under Full Accounting and \$0.39 under Partial Accounting.

Figure 12. Estimated Average Break-even Price, with (Top) and without (Bottom) AOC Grant.

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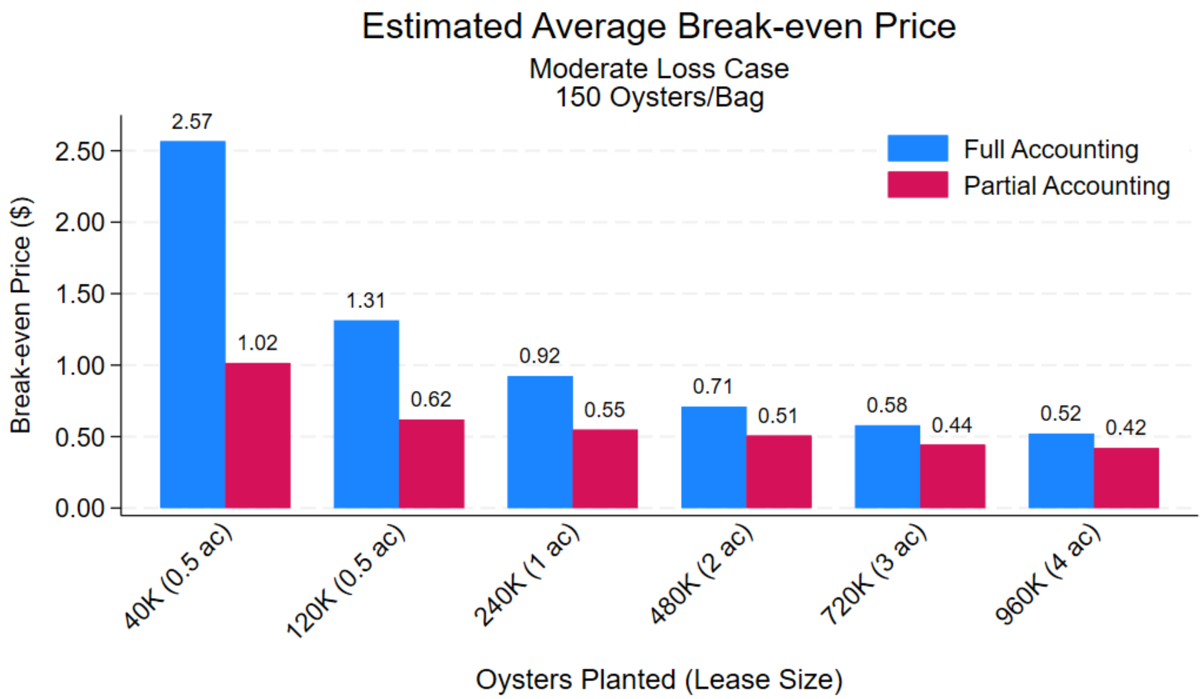
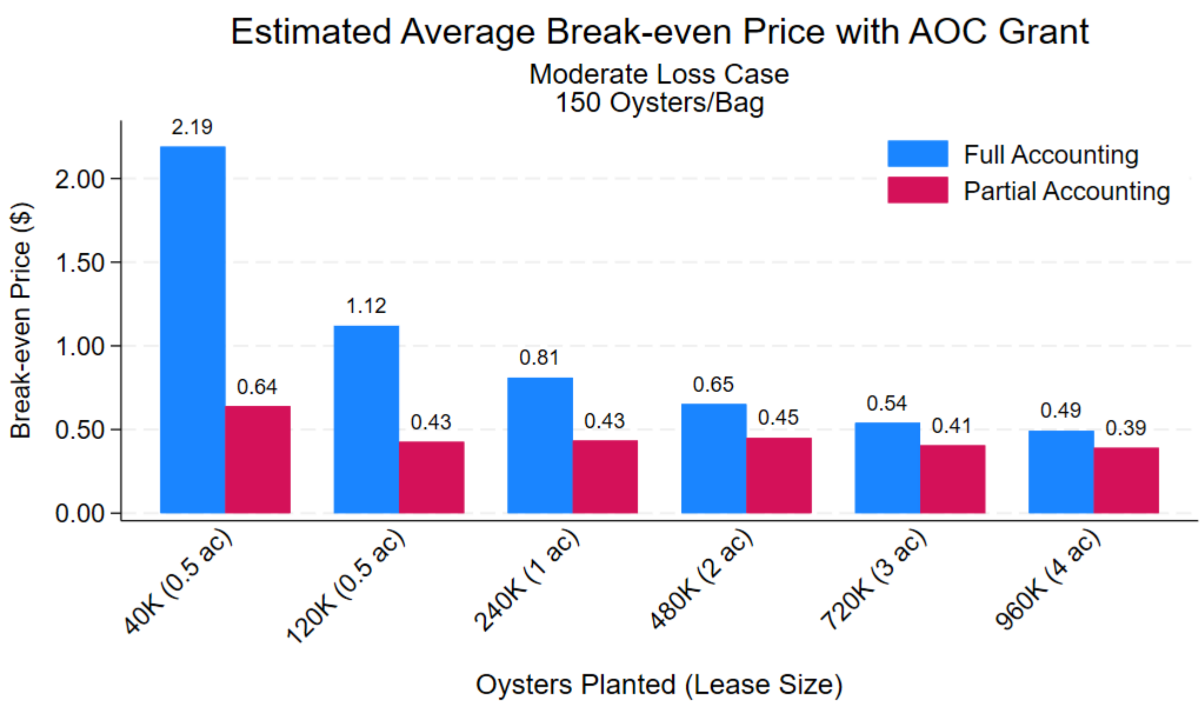




Revenue

Market Price Considerations

Market price tends to be misunderstood. I consulted with experienced growers, wholesalers, and restaurant owners to develop an approximate outline of prices along the farmed oyster supply chain. The price observed on a menu in an oyster bar is not what is paid to the grower. An oyster that sells for $3 each at an oyster bar was likely purchased from a wholesaler or a grower that sells directly for $0.75-$1. If the oyster bar purchased it from a wholesaler, the wholesaler likely purchased that oyster from a grower for approximately $0.50.

So, if selling to a wholesaler, a grower should expect a price in the neighborhood of $0.50 per oyster, and if selling directly, should expect a price in the $0.75-$1.00 range. As indicated in earlier in this report, however, prices observed in other states ranged from $0.10 to $1.20 per oyster, with state averages ranging between $0.40 and $0.59 per oyster. Keep in mind that direct sale entails substantial additional cost and effort that will offset, at least partially, the additional revenue due to the higher price. At this time, it appears that AOC growers in Louisiana have very limited options for selling to a wholesaler and so must sell directly.

The traditional sack-oyster market will likely serve as the "backstop" market for AOC, that is, the market that AOC growers will need to fall back on in times of excess supply (e.g., limited buyers). This appears to already be the case in other states, where as much as 47% of AOC oysters are going to the lower-value sack-oyster market. In this market, it was reported that growers were receiving less than $0.25 per oyster, which is consistent with NOAA commercial landings data. Using commercial oyster landings data for Louisiana (NOAA Fisheries 2023), which is in pounds of meat, converted to number of oysters assuming 6.47 pounds of meat per sack (Keithly and Kazmierczak 2006) and 180 oysters per sack (Banks et al. 2016), I calculate average dockside prices of sack oysters at $0.27 (2020) and $0.28 (2021) per oyster.

Below are some notable anonymous quotes from the growers, wholesalers, and restaurant owners interviewed between March and April 2023:

- "Pricing is entirely misunderstood in aquaculture because few people understand the distribution (supply) chain."
- "While [95¢] sounds great, most people aren't thinking about how many customers they can actually accommodate due to logistical issues."
- "Farmers can expect a distributor to pay between $0.55-$0.75/oyster, depending on the oyster. Other price factor to keep in mind is the cost of getting that product to the distributor."
- "50¢/oyster is a much more realistic expectation of price if selling to distributor. "
- "It's very hard to get 95¢ for an oyster unless they distribute themselves."
- "95¢ or $1 per oyster is at the restaurant level… distributor is not going to pay that since they have to pay for transportation costs."
- "We have had some direct to restaurant relationships in the past that we paid 75¢ to 85¢ for. Of course, that required the farmer to bring the oysters to the restaurant."
- "In LA…a grower must also be a certified dealer to sell their oysters to restaurants."

I assume direct delivery, using New Orleans as the representative delivery location. Given the evidence from other states that at least some share of harvest is likely to be sold in the lower-value sack-oyster market (in Maryland, it was 40-47%), I assume that 90% of harvest is sold in the high-value branded half-shell market at a baseline price of $0.75 per oyster, and 10% is sold in the lower-value sack-oyster market, at an average price of $0.25 per oyster.

Profit Analysis

Profit analysis introduces an assumption on price to grower to estimate revenue, and combined with costs, to estimate profit. Profit is defined as:

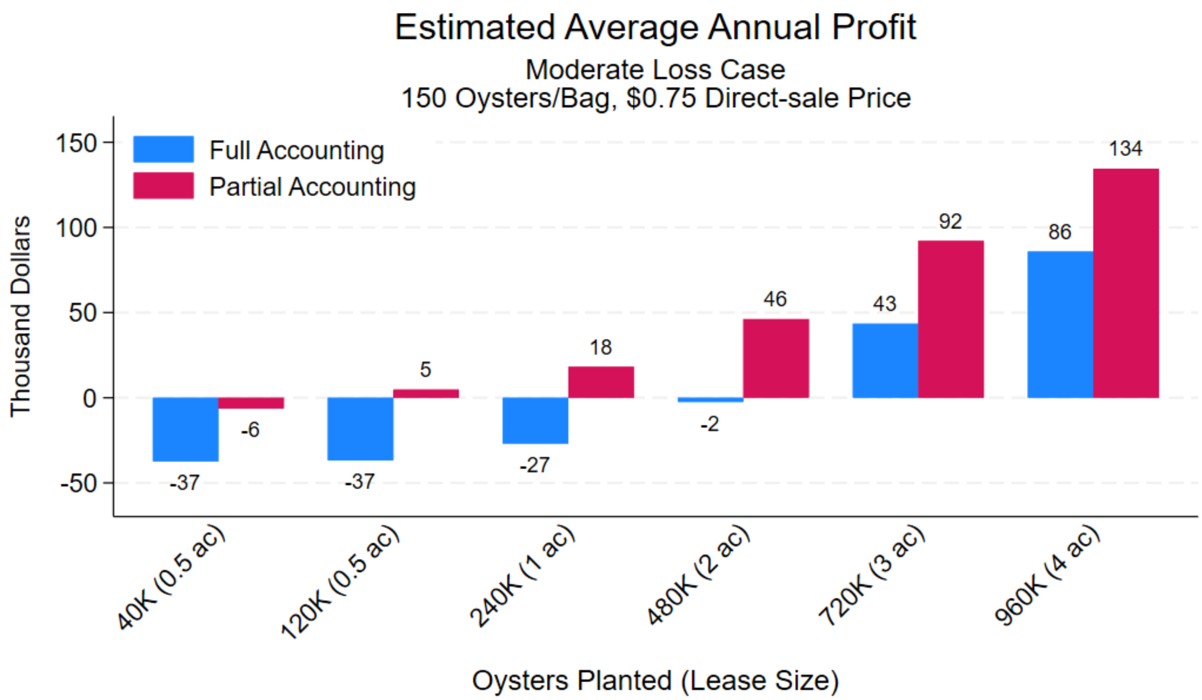
$$Profit = Price \ x \ Quantity - Cost$$

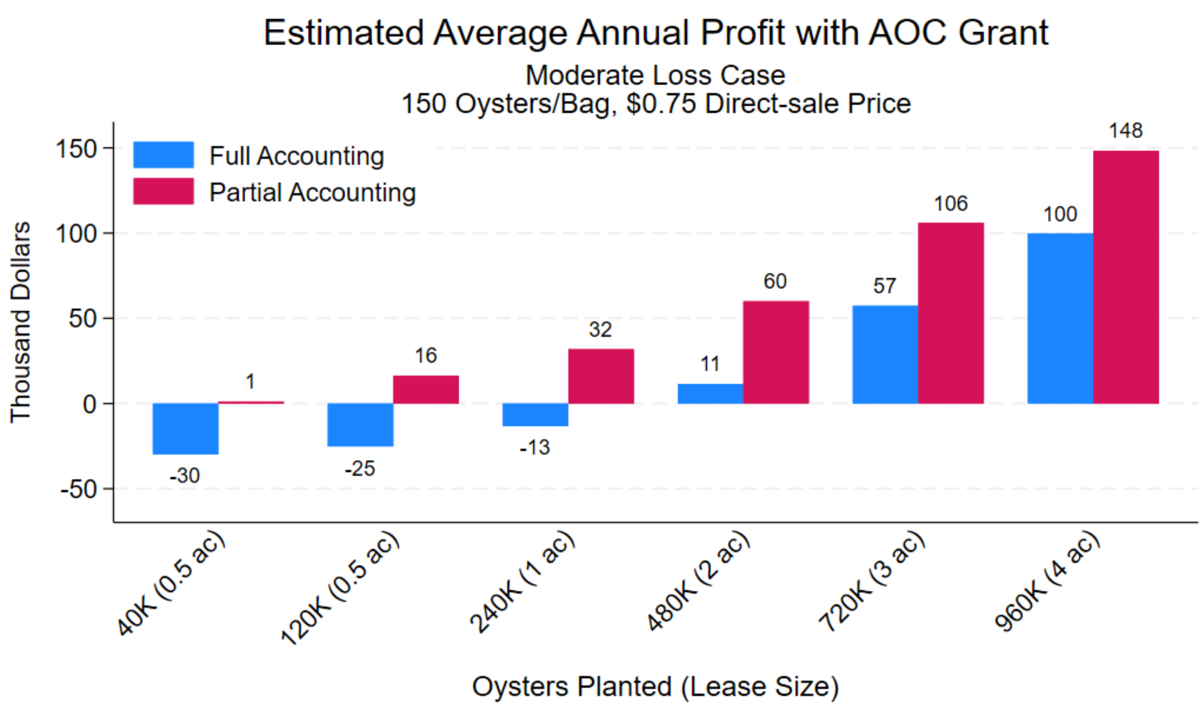
$$= Revenue - Cost$$

Figure 13 reports the results of the profit analysis, with and without an AOC grant. Without a grant, I estimate that profit will be negative for four of the six production levels under Full Accounting. Under Partial Accounting, profit is negative for the lowest production level but positive for production of at least 240,000 oysters planted on one acre.

With a grant, I estimate that profit will be negative for three of the six production levels under Full Accounting. Under Partial Accounting, profit is slightly positive for the lowest production level, and increasingly positive for production of at least 120,000 oysters planted on half an acre.

Figure 13. Estimated Annual Profit, Moderate Loss Case Scenario, with (Top) and without (Bottom) AOC Grant.





Sensitivity Analysis

This section revisits the profit estimates shown above by re-estimating them under alternative assumptions. *This supplementary analysis considers cases without an AOC grant.* Table 9 summarizes the alternative levels for each key assumption.

Table 9. Scenarios Considered for Five-Year Projections; Baseline Scenario Assumptions Italicized.

Mortality Case	Stocking Rate	Direct-Sale Price to Grower
Best Case	100	$0.50
Moderate Loss Case	*150*	*$0.75*
Severe Loss Case	200	$1.00

I consider three alternative mortality cases:

- Best Case: No adverse mortality events, such that harvest is as expected every year.
- Moderate Loss Case (baseline assumption): As described previously, I assume 75% of a single year's expected harvest is lost. I chose Year 4 arbitrarily.
- Severe Loss Case: I interviewed one experienced Gulf Coast grower who recommended that growers should plan for a catastrophic loss (loss of both crop and gear) every three years. I include a less-drastic case, which I called the "Severe Loss" Case that approximates the impact of a bad but not catastrophic scenario. I assume 100% of one year's expected harvest is lost, and that, due to lingering effects (e.g., partial gear damage/loss, seed scarcity, farm closures or water quality issues), 50% of the following year's expected harvest is also lost. I chose Year 4 arbitrarily as the year with 100% loss.

I consider three alternative stocking rates. Up to this point, I have assumed that seed is available on demand. In reality, there is a Gulf-wide shortage of seed and there is no guarantee that a grower can obtain all the seed that he wants. To approximate such a scenario, I include a stocking rate of 100 market-size oysters per bag. At the other extreme, I include a higher rate of 200 oysters per bag:

- 100 (to approximate a year of seed scarcity)
- 150 market-size oyster per bag (baseline assumption)
- 200.

I consider three alternative direct-sale branded-oyster prices to grower:

- $0.50
- $0.75 (baseline assumption)
- $1.00.

Because there are three levels for each of the four sets of assumptions, there are $3^3 = 27$ possible combinations for each production level. Additionally, there are Full Accounting and Partial

Accounting results for each production level. Thus, there are 27 scenarios x 6 production levels x 2 cost types = 324 profit estimates. Figures 14-25 summarize these results. Each figure reports the 27 profit estimates for a given production level under either Full Accounting or Partial Accounting. Note that the number of oysters planted varies according to stocking rate, so each figure reports the range of oysters planted in the subtitle. Each row shows a particular scenario according to stocking rate and price. Each dot on a given row indicates the estimated profit under the Best, Moderate Loss, and Severe Loss mortality cases. Scenarios are listed in order from lowest to highest profit level under the Moderate Loss case.

Figure 14 shows the estimated average annual profit by scenario for the lowest production level (26,667-53,333 oysters planted) on 0.5 acre under Full Accounting. Estimated profit is negative under all scenarios considered, indicating that this production level is not likely to be profitable, even under the most favorable conditions. Figure 15 shows the results under Partial Accounting. Even under Partial Accounting, estimated profit is negative except for four of the two most-favorable scenarios, requiring either a 200-oyster stocking rate and a $0.75 price or a lower stocking rate but higher price, combined with "Best Case" mortality; or the highest stocking rate and highest price under "Moderate Loss" mortality. But even here, profit is less than $10,000 at best.

Figure 16 shows the estimated average annual profit by scenario for the second-lowest production level (80,000-160,000 oysters planted) on 0.5 acre under Full Accounting. Estimated profit is negative under all scenarios except the very best one, with profit of approximately $3,000. Under Partial Accounting (Figure 17), estimated profit is negative at all of the $0.50 scenarios except one. Profit is positive under all mortality cases if price is $1 or if stocking rate is 200 and price is at least $0.75.

Figure 18 shows the estimated average annual profit by scenario for the third production level (160,000-320,000 oysters planted) on one acre under Full Accounting. Profit is negative under most scenarios. Profit is generally positive under only the scenarios with a $1 price or a $0.75 price combined with some other favorable outcomes. However, profit is not robust at this level; in all cases at least one of the profit estimates lies to the left of zero. As before, results are better under Partial Accounting (Figure 19). Scenarios with a $0.50 price perform the worst.

Figure 20 shows the estimated average annual profit by scenario for the fourth production level (320,000-640,000 oysters planted) on two acres under Full Accounting. Profit is only partly robust to the various scenarios, requiring a $1 price and a mid-to-high stocking rate. Profit is generally negative under any scenario with a $0.50 price. As before, results are better under Partial Accounting (Figure 21). Profit is generally positive, and price tends to be the leading factor.

Figure 22 shows the estimated average annual profit by scenario for the second-highest production level (480,000-960,000 oysters planted) on three acres under Full Accounting. Again, profit is only partly robust to the various scenarios. With one exception, profit is still negative under scenarios with a $0.50 price. Profit is generally positive under a mid-to-high stocking rate and at least a $0.75 price, or a $1 price. As before, results are better under Partial Accounting (Figure 23). With some exceptions, profit is generally positive.

Figure 24 shows the estimated average annual profit by scenario for the highest production level (640,000-1,280,000 oysters planted) on four acres under Full Accounting. Profit still struggles under a $0.50 price. Profit is generally positive under higher price scenarios combined with at least a stocking rate of 150. As before, results are better under Partial Accounting (Figure 25). With some exceptions under the $0.50 price scenarios, profit is generally positive.

Comparison to Other Economic Analyses

These findings are consistent with those of other recent analyses. Engle et al. (2021) analyzed the profitability of container oyster culture at two production scales among Maryland growers: ≤ 600,000 oysters sold and > 600,000 oysters sold. They found that production was profitable, on average, when annual depreciation and opportunity cost of capital were ignored (similar to the Partial Accounting results presented here, except that Partial Accounting also excludes supervisory labor), but found that only large-scale production (> 600,000 oysters sold) was profitable, on average, when all relevant costs were included (consistent with the Full Accounting results presented here). Note that their *small* production level of ≤ 600,000 oysters sold corresponds approximately to the two *largest* production levels considered in this report, implying that none of the production levels considered in this report would be considered profitable – when all relevant costs are included – by their standards. Similarly, Parker, Lipton, and Harrell (2020) analyzed the net present value (discounted profit over a ten-year period) of water-column oyster culture for Maryland growers at four production levels: 500,000, one million, two million, and 2.5 million oysters sold per year. Note that their analysis ignores depreciation and opportunity costs of capital. They found that the two smaller production levels had negative net present values, on average, whereas the two larger production levels had positive net present values. Again, their two *smaller* production levels correspond approximately to the *largest* production levels considered in this report, again implying that none of the production levels considered in this report would be expected to be profitable by their standards.

Key Takeaways

- **Under Full Accounting, the break-even price exceeds $1 per oyster for production levels at or below 120,000 oysters planted. Under Partial Accounting, it exceeds $1 for the lowest production level only.**
- **The break-even price exceeds $0.50 per oyster for all baseline cases under Full Accounting and for the four lowest production levels under Partial Accounting.**
- **Under Full Accounting, estimated average annual profit is negative for production levels at or below 480,000 oysters planted. Under Partial Accounting, profit is negative under the lowest production level.**

- **There was no production level considered whose estimated average annual profit was fully robust (i.e., always positive) to the various sensitivity analysis scenarios.**
- **Under Full Accounting, estimated profit for the lowest two production levels was negative under 53 of 54 scenarios. Under the next-highest production level, it is positive only for four out of 27 scenarios. For the two-acre production level, profit is negative under more than half of the scenarios, and is fully robust (i.e. positive under all three mortality cases) under only the scenarios with $1 price and mid-to-high stocking rates.**
- **Under Partial Accounting, estimated average annual profit for the lowest production level is negative for 23 out of 27 scenarios, while the higher production levels fare better, with estimated profit being positive under several scenarios.**
- **Of all the various assumptions tested in sensitivity analysis, price to grower tended to be the most important. Scenarios assuming a $0.50 price tended to yield the lowest estimated profits regardless of stocking rate and mortality case.**
- **Consistent with the findings of previous analyses in the literature, I find that small-scale operations are not expected to be profitable. In my analysis, I estimate that it is generally necessary to operate at or above levels of 720,000 oysters planted on three acres to realize positive average annual profit. The other analyses in the literature estimate the threshold to be in the same range or higher.**

Figure 14. Estimated Average Annual Profit by Scenario, 26,667-53,333 Oysters Planted (1 Line, 0.5 Acre), Full Accounting.

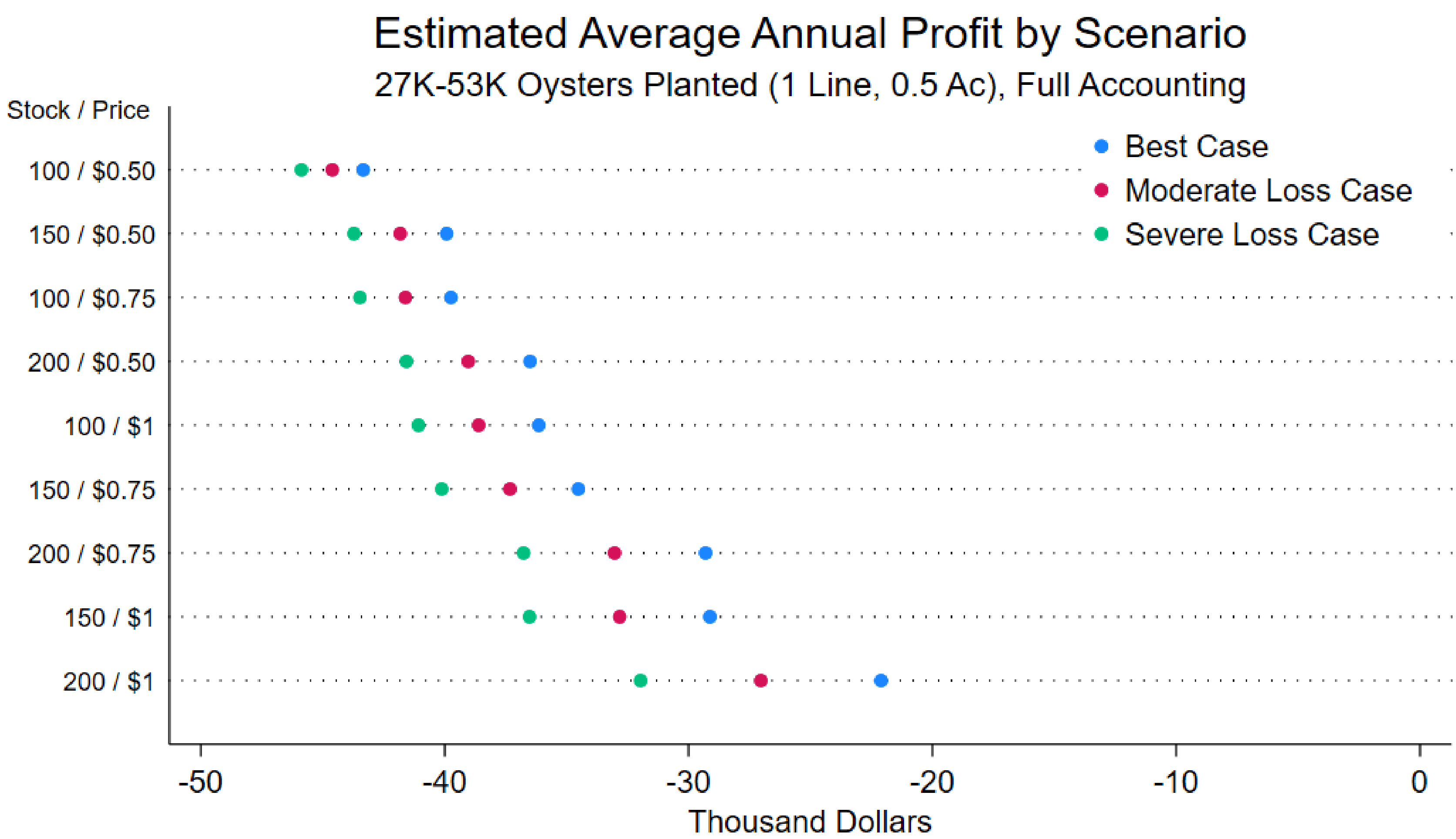


Figure 15. Estimated Average Annual Profit by Scenario, 26,667-53,333 Oysters Planted (1 Line, 0.5 Acre), Partial Accounting.

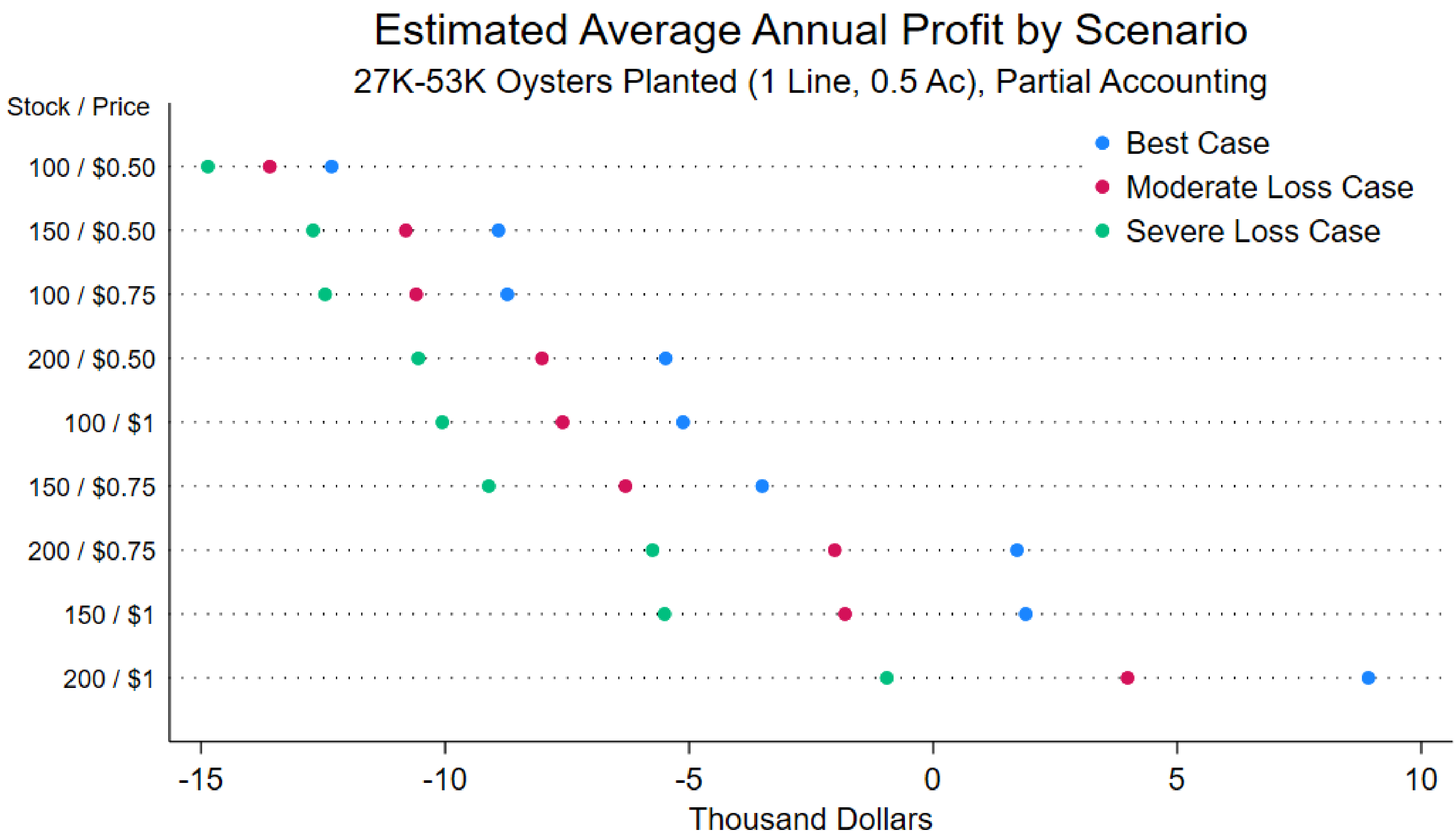


Figure 16. Estimated Average Annual Profit by Scenario, 80,000-160,000 Oysters Planted (3 Lines, 0.5 Acre), Full Accounting.

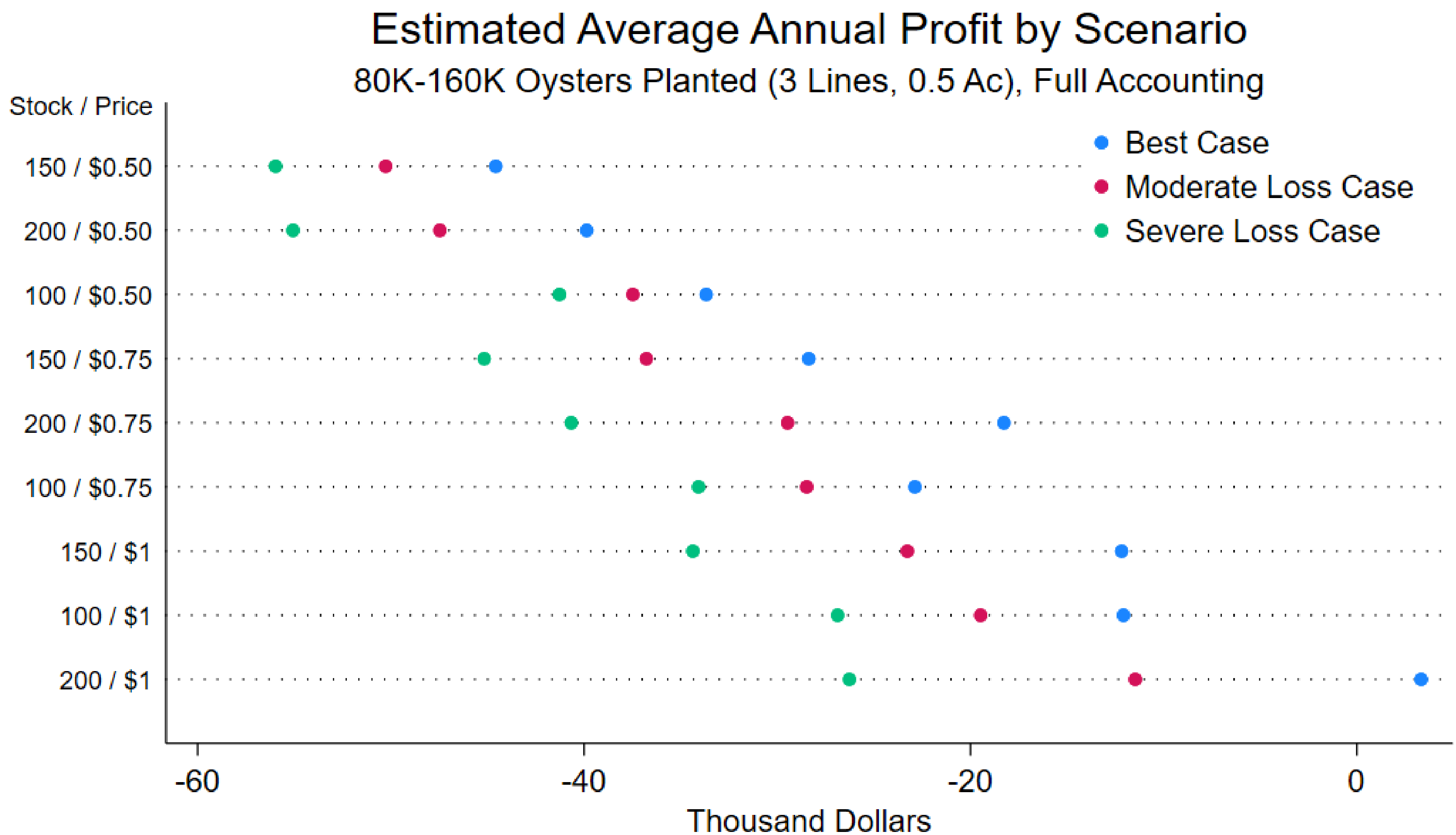


Figure 17. Estimated Average Annual Profit by 80,000-160,000 Oysters Planted (3 Lines, 0.5 Acre), Partial Accounting.

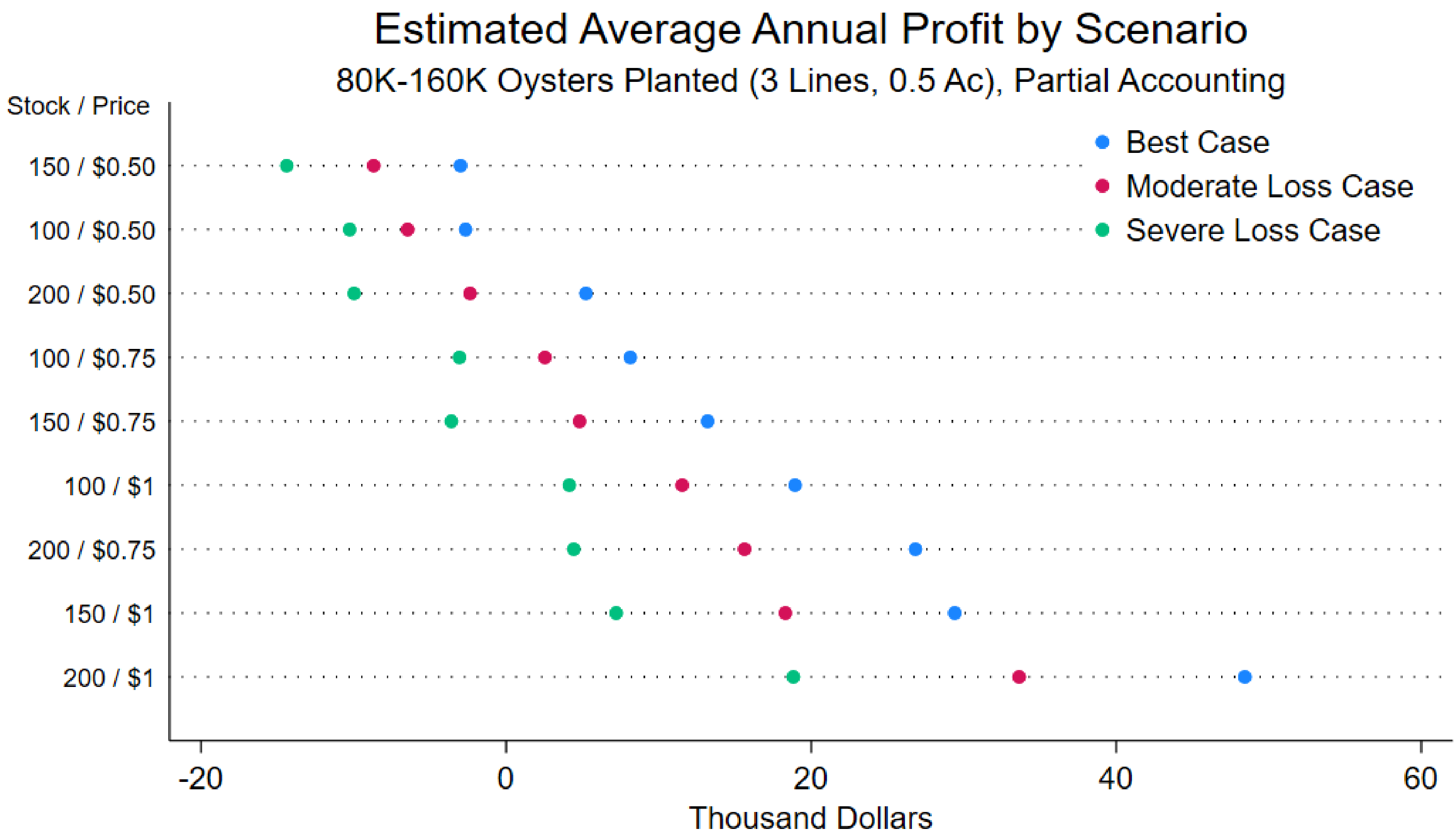


Figure 18. Estimated Average Annual Profit by Scenario, 160,000-320,000 Oysters Planted (6 Lines, 1 Acre), Full Accounting.

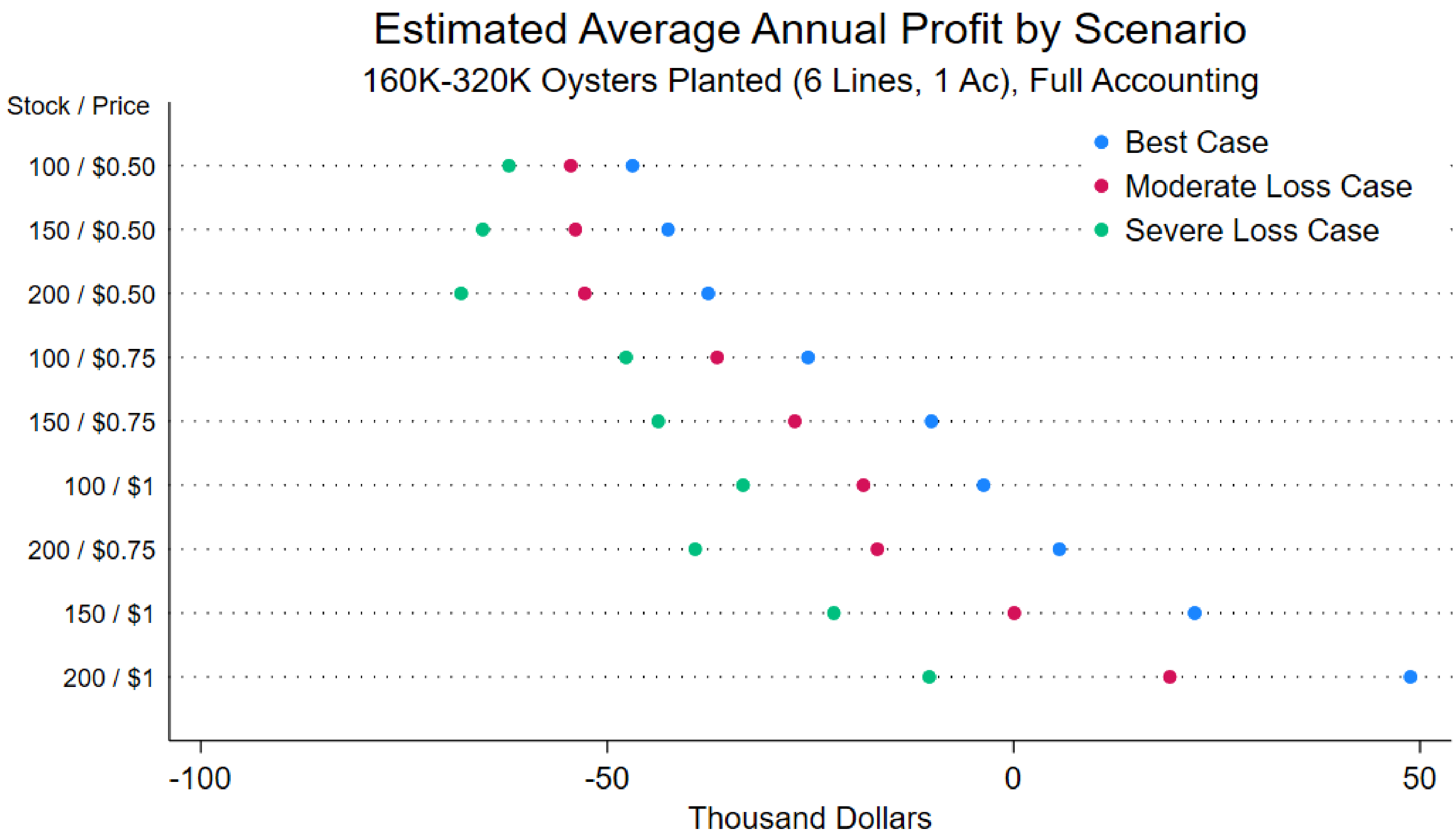


Figure 19. Estimated Average Annual Profit by Scenario, 160,000-320,000 Oysters Planted (6 Lines, 1 Acre), Partial Accounting.

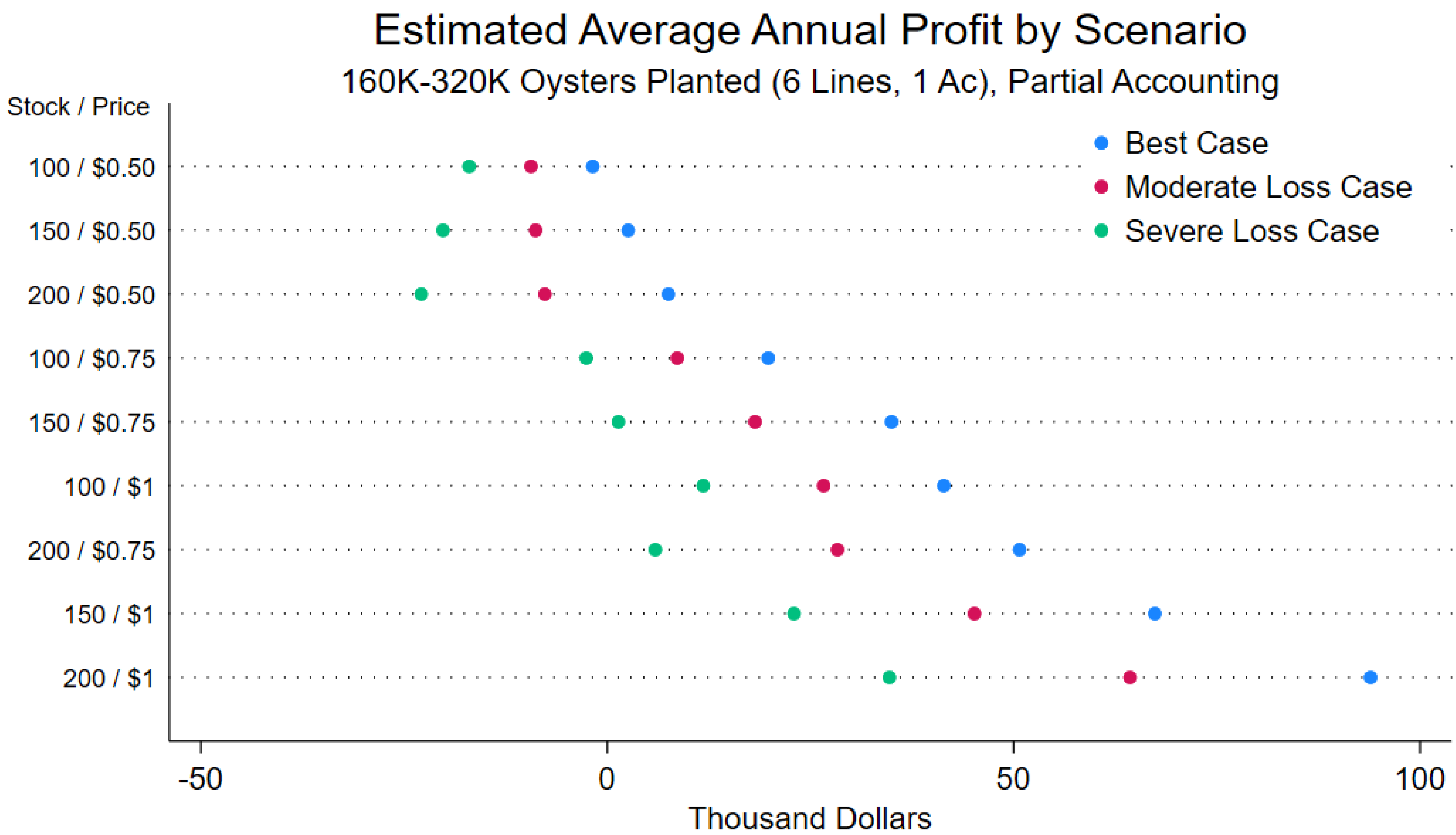


Figure 20. Estimated Average Annual Profit by Scenario, 320,000-640,000 Oysters Planted (12 Lines, 2 Acres), Full Accounting.

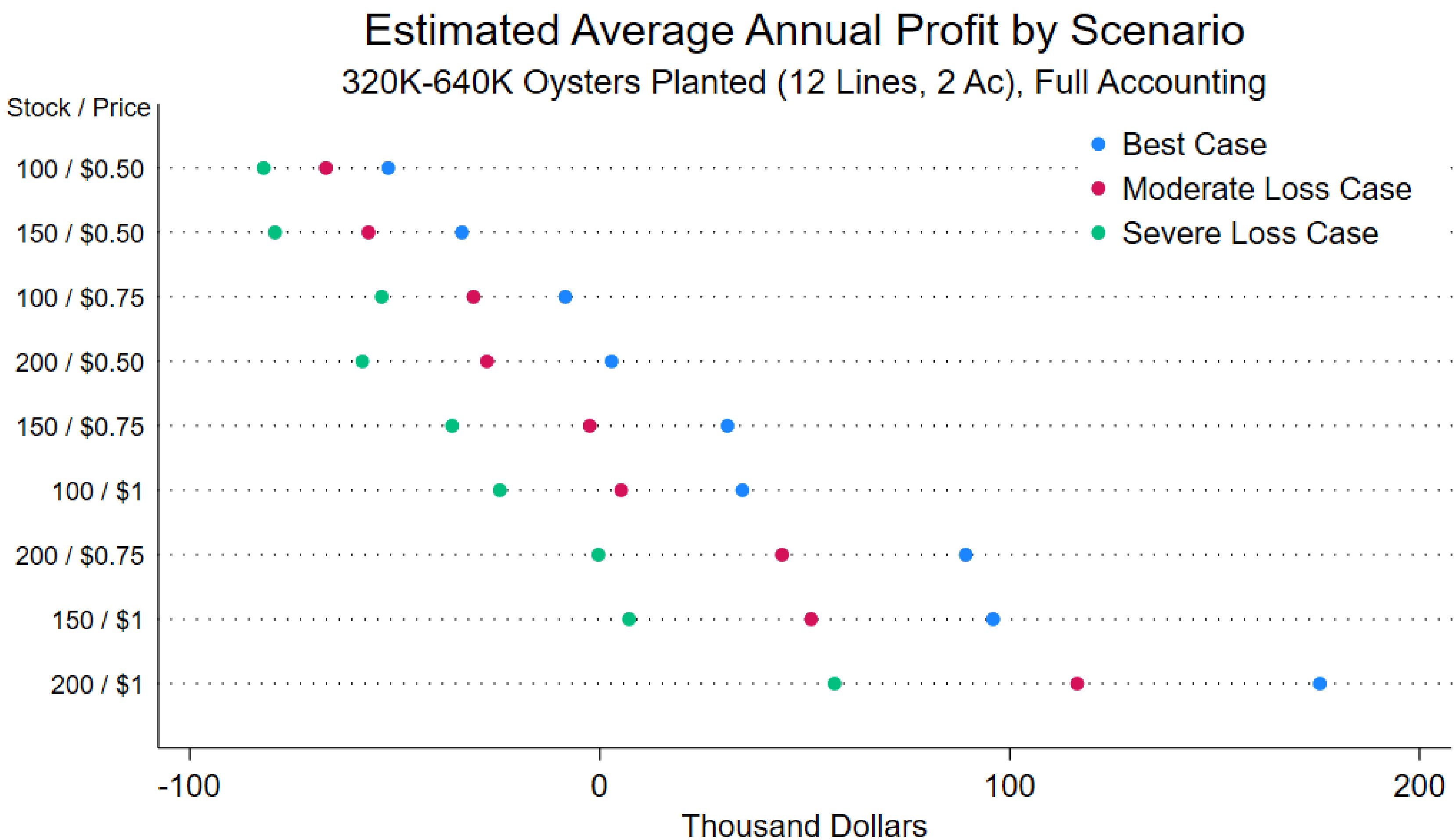


Figure 21. Estimated Average Annual Profit by Scenario, 320,000-640,000 Oysters Planted (12 Lines, 2 Acres), Partial Accounting.

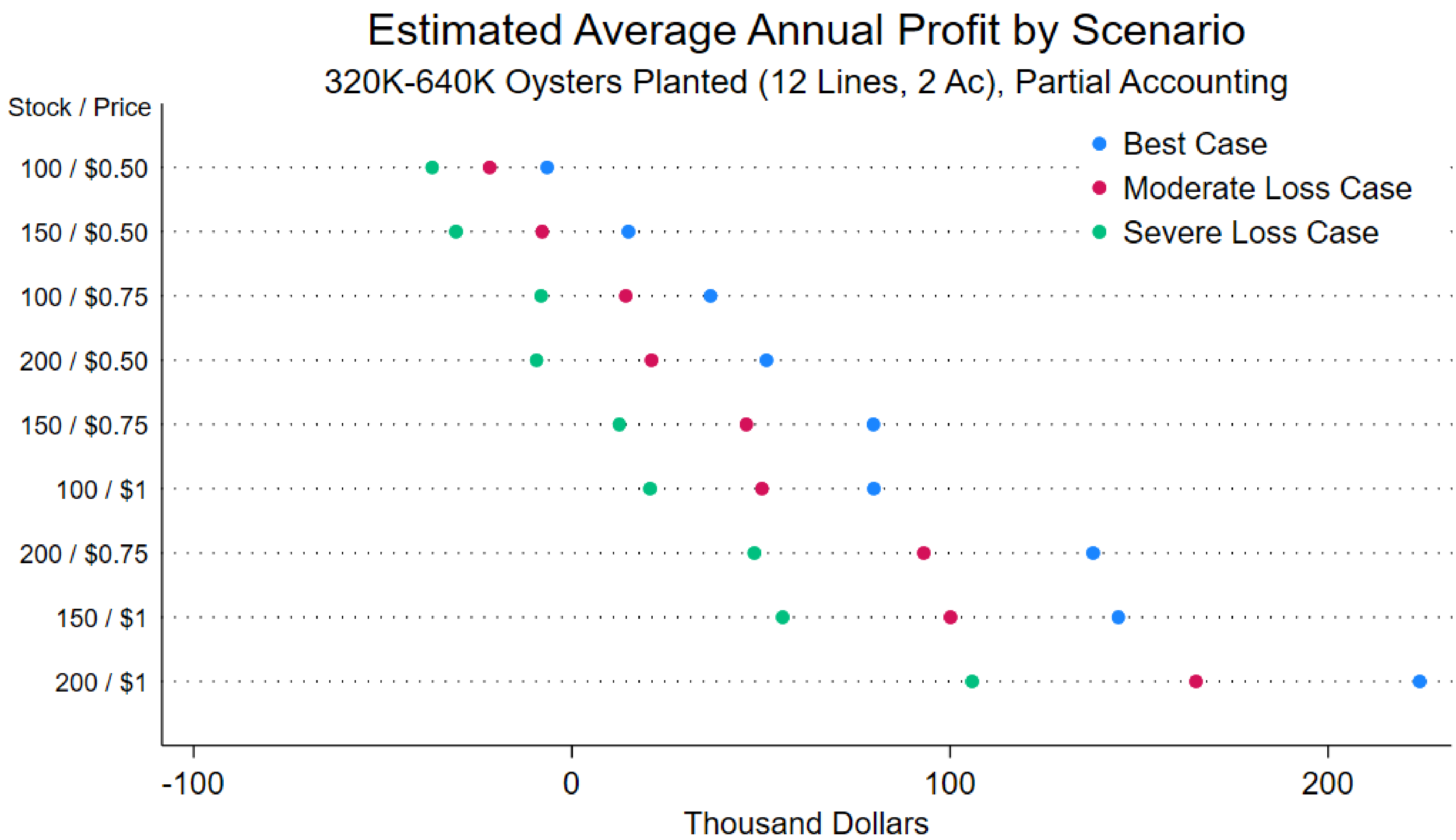


Figure 22. Estimated Average Annual Profit by Scenario, 480,000-960,000 Oysters Planted (18 Lines, 3 Acres), Full Accounting.

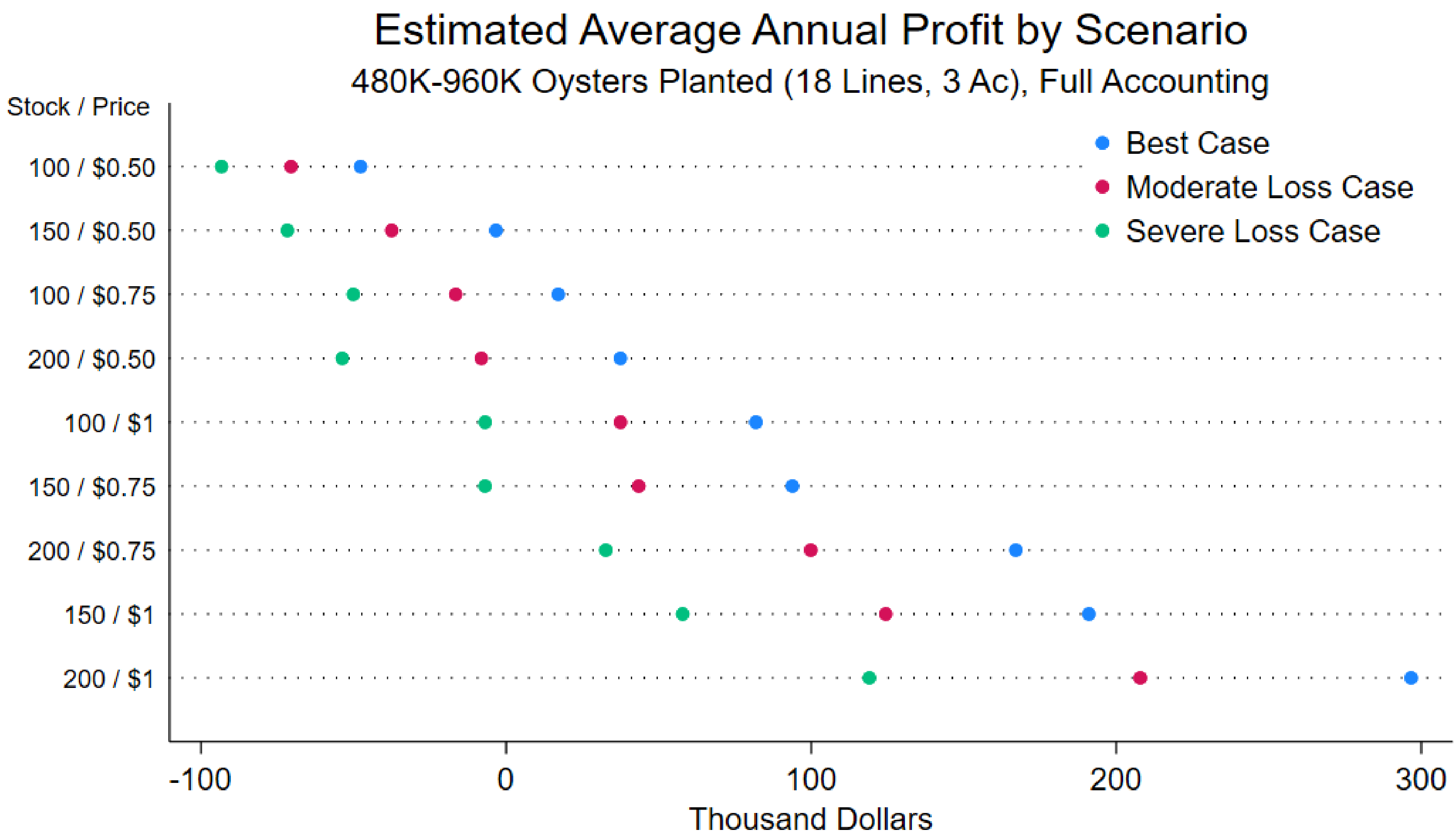


Figure 23. Estimated Average Annual Profit by Scenario, 480,000-960,000 Oysters Planted (18 Lines, 3 Acres), Partial Accounting.

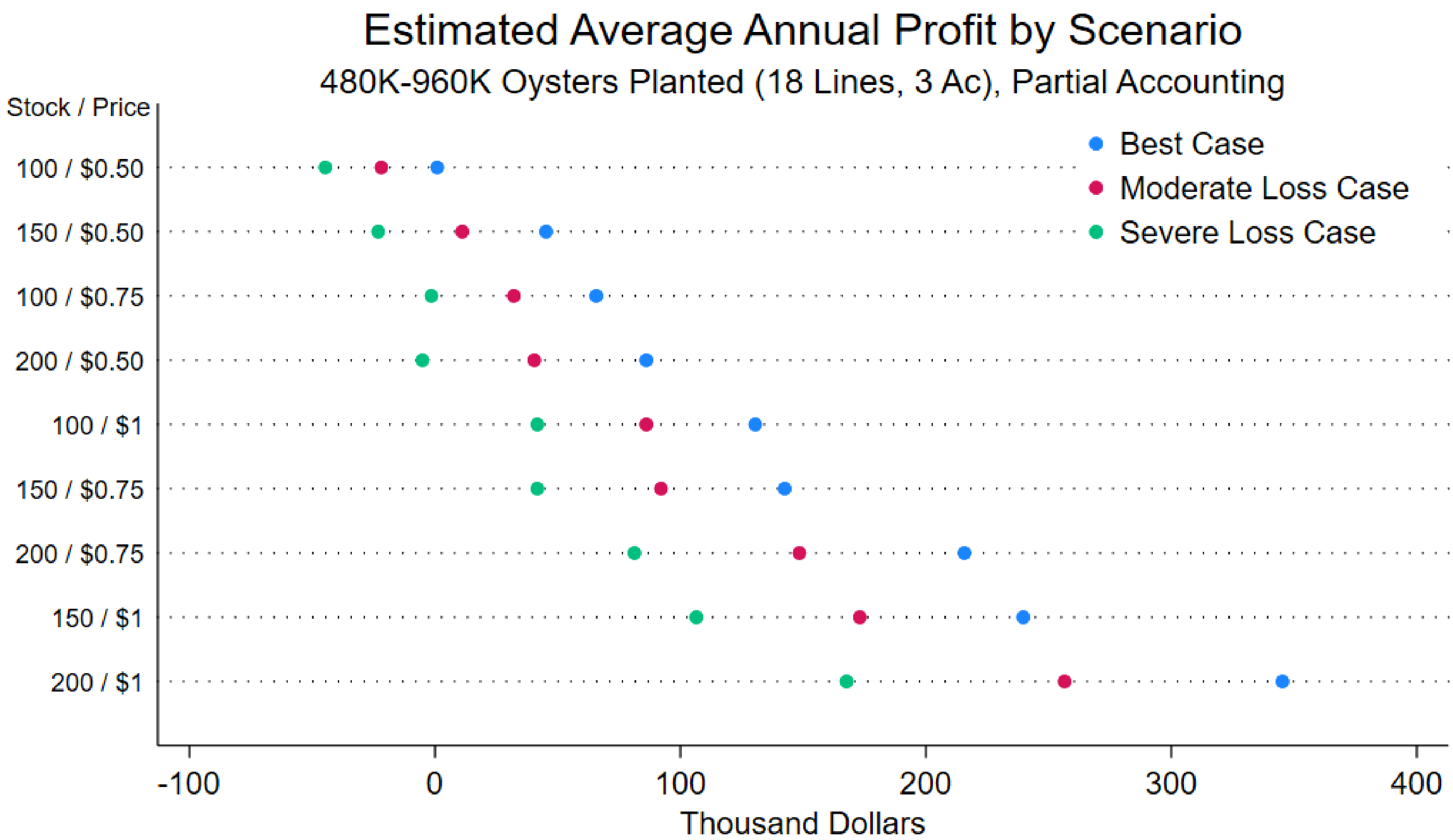


Figure 24. Estimated Average Annual Profit by Scenario, 640,000-1,280,000 Oysters Planted (24 Lines, 4 Acres), Full Accounting.

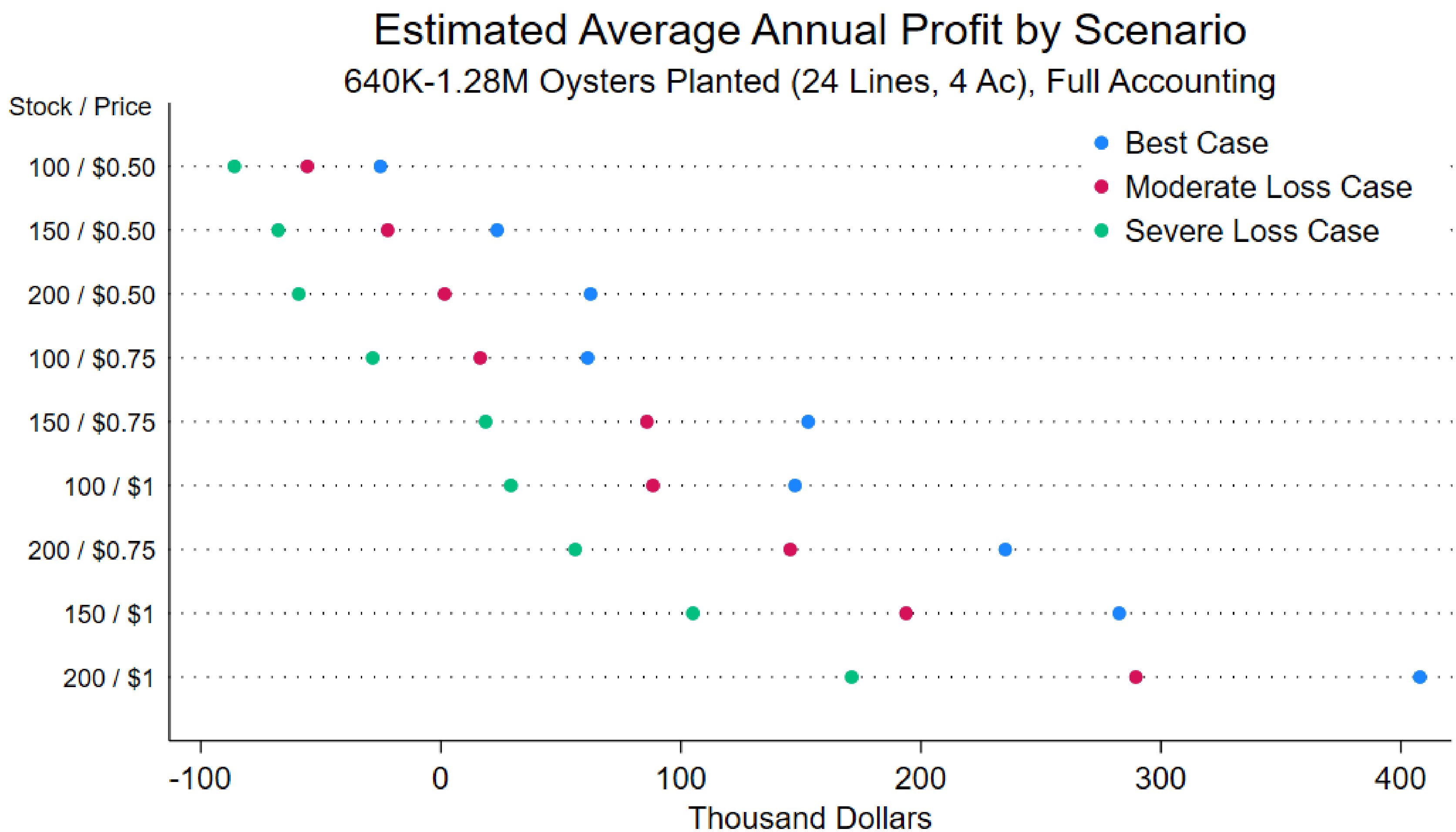
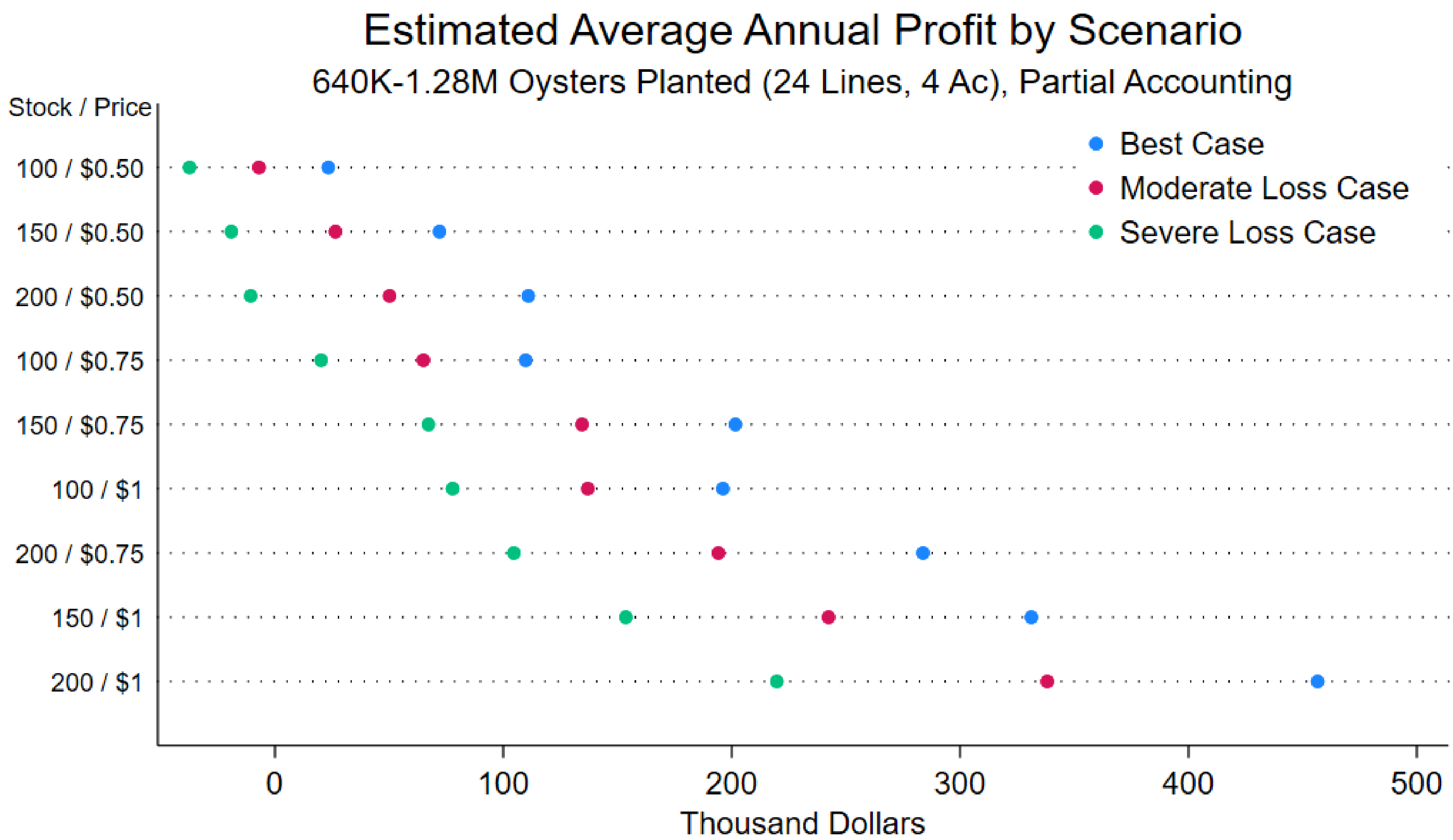


Figure 25. Estimated Average Annual Profit by Scenario, 640,000-1,280,000 Oysters Planted (24 Lines, 4 Acres), Partial Accounting.



MARKET DEMAND AND FARM SIZE ANALYSIS

Although there are hundreds, if not thousands, of establishments selling oysters in the northern Gulf region, most establishments do not sell AOC / off-bottom / branded oysters. Establishments in the South Louisiana/Coastal Mississippi region, for example, market their oysters generically and focus on the preparation rather than on the source (Petrolia, Walton, and Yehouenou 2017). Based on personal communications with some Louisiana AOC growers and chefs, internet searches, in-person visits, and previous research (Petrolia 2018), I estimate that there are between ten and fifteen establishments that do. Examples include:

- New Orleans
  - Chemin à la Mer (Four Seasons Hotel)
  - Dickie Brennan's Bourbon House
  - Elysian Seafood
  - Le Chat Noir
  - Luke
  - Pêche
  - Seaworthy
  - Sidecar Patio & Oyster Bar
- Baton Rouge
  - Jolie Pearl Oyster Bar
- Lafayette
  - Vestal
- Biloxi
  - White Pillars

In most cases, these restaurants feature multiple varieties of oysters, often from all three coasts (Gulf, Atlantic, and Pacific), and including Canada. Figure 26 shows photographs of recent oyster selections from various New Orleans restaurants and oyster bars.

Based on data collection via personal communication, I estimate that restaurants and oyster bars that sell branded AOC / off-bottom oysters (as opposed to those that sell oysters as a commodity) have a wide range of sales volumes. I estimate that these establishments sell from as few as 4,000 oysters per month to as many as 17,000 per month.

Using the estimates of the number of restaurants serving branded AOC oysters and range of sales volumes, I can arrive at an approximate number of oyster farms that can be supported (Table 10). Using the mid-point sales volume between 4,000 and 17,000 oysters per restaurant per month (10,500), multiplying by twelve months to get an annual estimate, and multiplying by number of restaurants, I arrive at an approximate total number of oysters needed in a year. For example, under an assumption of ten restaurants, I get a demand for 1.26 million branded oysters (10,500 x 12 x 10 = 1.26 million). Given that these types of oyster bars specialize in offering a variety of specialty oysters, I assume that one-third of the total oysters needed are from Louisiana (currently, the fraction appears to be much lower, see menus in Figure 26). Thus, under the case of ten restaurants, an estimated 415,800 branded oysters are needed from Louisiana growers in a year. If the average sales volume for an individual AOC oyster farm is 30,000 oysters per year

(40,000 oysters planted), then approximately fourteen oyster farms could be supported by the aforementioned level of demand for boutique oysters. If there were twenty oyster bars, then twenty-eight farms could be supported, and if there were fifty such oyster bars, then sixty-nine farms could be supported.

The farm-level analysis of cost and profit above, however, indicates that profit is expected to be very low or negative at low farm production levels. For example, Figure 13, which reports baseline annual profit, shows that profit is non-positive under both Full Accounting and Partial Accounting for 120,000 oysters planted or lower (corresponding to 90,000 oysters sold or fewer). Estimated profit is positive only when farms are producing at higher levels, such as at least 240,000 oysters planted per year (180,000 oysters sold) under Partial Accounting, and at least 720,000 oysters planted (540,000 oysters sold) under Full Accounting. Under either case, a much smaller number of farms can be supported. If average farm sales is 180,000 oysters per year, the production level estimated to be profitable under Partial Accounting, then only two farms could be supported by ten oyster bars; and, at best, twelve farms could be supported by fifty oysters bars. If average farm sales is 540,000 oysters per year, the production level estimated to be profitable under Full Accounting, then only one farm could be supported by ten oyster bars; and, at best, three farms could be supported by fifty oysters bars.

More markets can be accessed if growers can connect with a wholesaler, but wholesalers will require a lower price in the neighborhood of $0.50 per oyster. Alternatively, farmers could sell to the sack-oyster market, but this will likely require a price well below $0.50 per oyster.

It should be noted that some growers also sell direct to households, offering an additional sales outlet, but this is not expected to represent a significant share of total sales.

The key takeaways from this analysis are:

- **At the estimated current number of oyster bars specializing in AOC half-shell oysters in the region (10-20), between fourteen and sixty-nine oyster farms can be supported if farms are producing at the lowest production level considered. But the profitability analysis in the previous section indicates that profit is unlikely to be positive at such low levels of production.**
- **At production levels where profit is estimated to be positive, even at a very optimistically high number of oyster bars (50), between three and twelve farms can be supported.**
- **Overall, the local market is unlikely to support more than handful of farms unless farms are able to operate profitably at low levels of production.**
- **More markets can be accessed if growers can connect with a wholesaler, but wholesalers will require a lower price in the neighborhood of $0.50 per oyster. Alternatively, farmers could sell to the sack-oyster market, but this will likely require a price well below $0.50 per oyster.**

Figure 26. Photos of Oyster Menus from New Orleans Restaurants Specializing in Branded Oysters. Top Panel, Clockwise from Left: Le Chat Noir (6/7/23), Seaworthy (6/7/23), Pêche (6/29/23), Luke (6/28/23), Luke (6/28/23); Bottom Panel, Clockwise from Left: Elysian (10/25/2018), Luke (10/11/18), Pêche (10/25/18), Luke (10/25/18).

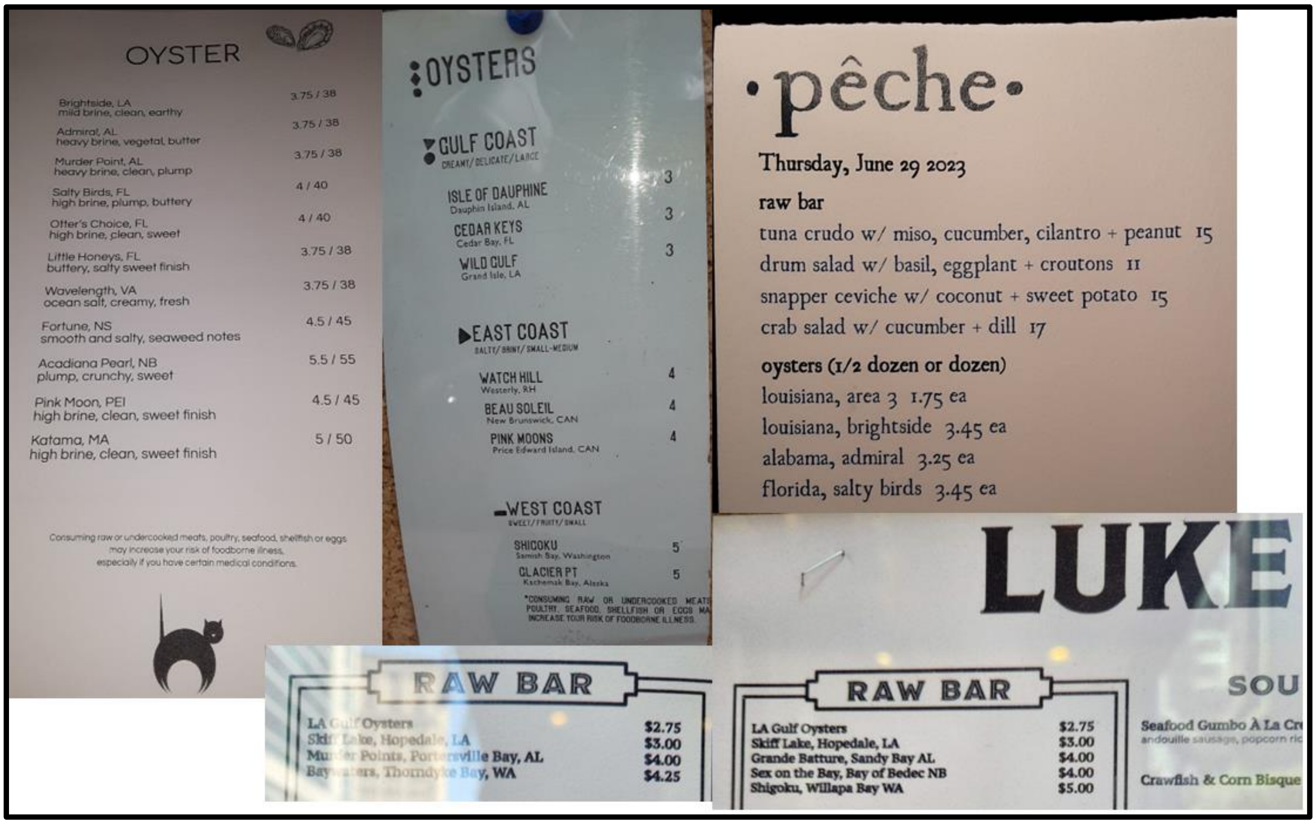


Table 10. Estimated Number of Oyster Farms Supported for a Given Combination of Restaurants and Average Number of Oysters Sold Per Farm, Assuming Average of 10,500 Oysters Sold Per Month Per Restaurant.

Oysters Planted per Farm (Thousands)			40	120	240	480	720	960
Oysters Sold per Farm (Thousands)			30	90	180	360	540	720
Restaurants	**Oysters Needed**	**LA Oysters Needed (33%)**	**Oyster Farms Supported**					
10	**1,260,000**	**415,800**	14	5	2	1	1	1
20	**2,520,000**	**831,600**	28	9	5	2	2	1
30	**3,780,000**	**1,247,400**	42	14	7	3	2	2
40	**5,040,000**	**1,663,200**	55	18	9	5	3	2
50	**6,300,000**	**2,079,000**	69	23	12	6	4	3

COMPARISON TO TRADITIONAL BOTTOM REEF ACREAGE AND MARKET VALUE

Table 11 reports the comparison of traditional Louisiana oyster reef acreage and market value to current, available, and optimistic future AOC scenarios. LDWF (2023) reports a total of 400,445 acres currently under lease for oyster production. Keithly and Kazmierczak (2006) speculate that anywhere from 56% to 78% of leases are unproductive. Taking the mid-point of that range, I assume that 67% of these acres are unproductive, implying that 33% are actually producing oysters in a given year. NOAA Fisheries (2023) reports the dockside value of Louisiana's 2021 oyster landings to be over $53 million.

Louisiana currently has 49.5 acres on active AOC farms. For the purposes of this analysis, I assume that Louisiana has the potential to achieve approximately the same productivity per acre on 49.5 acres as Alabama currently has on 45 acres (~100,000 oysters harvested per acre). Note well that current production in Louisiana is nowhere near this level. This level of production represents less than one-tenth of one percent of current traditional oyster reef acreage. In this particular analysis, I assume a $0.50 per AOC oyster dockside price, which is lower than the $0.75 direct-sale price assumed in the previous section. The reason for the change is that traditional oyster landings values are reported at the dockside level, so this provides a fair comparison. At this production level, harvest value represents less than 5% of the current value of traditional oyster landings.

Next, I scale up to all AOC acreage in Louisiana (219 acres). As more farms and more acres come into production, economic theory dictates that we should expect a decline in average productivity. Under this scenario, I assume that Louisiana would have the potential to achieve approximately the same annual productivity on 274 acres that North Carolina currently has on 365 acres (~25,000 oysters per acre). This level of production represents less than two-tenths of one percent of Louisiana's current traditional oyster reef acreage. Harvest value at this level of production represents 5.2% of the current value of the state's traditional oyster landings.

Finally, I scale up to 500 acres, which is approximately twice that of all available AOC acreage, and approximately the maximum acreage observed in any one state reported earlier in Table 1. At such a high acreage level, we should expect average productivity to decline even further. I assume 15,000 oysters harvested per acre, which is approximately what is observed in Florida, Maryland, and South Carolina. This increased acreage represents less than four-tenths of one percent of current traditional oyster reef acreage. The gains from increased acreage, however, is largely offset by the decline in productivity, such that total harvest increases only marginally, and the value of sales represents 7.1% of the current value of traditional oyster landings.

Key Takeaways

- **Even at the most optimistic AOC acreage levels, AOC would represent less than one-half of one percent of Louisiana's traditional oyster footprint.**
- **The value of AOC harvest has somewhat greater potential, as it could account for as much as 7% of the value of traditional oyster landings, but requires a combination of high market prices and good productivity across all acres.**

Table 11. Comparison of Traditional Louisiana Oyster Reef Acreage and Value to Current, Available, and Optimistic Future AOC Acreage and Value Scenarios.

	Traditional Louisiana Reefs	**Current AOC Acreage**	**All Available AOC**	**Optimistic Future AOC Scenario**
Total Acres	132,147*	49.5	219	500
Oysters Per Acre		*100,000*	*25,000*	*15,000*
Oysters Per Year		4,950,000	5,475,000	7,500,000
Dockside Price Per Oyster		*$0.50*	*$0.50*	*$0.50*
Total Value	$53,053,819	$2,475,000	$2,737,500	$3,750,000
Farmed Acres as % of Traditional Acres		**0.04%**	**0.17%**	**0.38%**
Farmed Value as % of Traditional Value		**4.7%**	**5.2%**	**7.1%**

*Assumes 33% of the 402,866 leased acres are productive

SUMMARY AND IMMEDIATE AND LONG-TERM CHALLENGES

Summary

AOC is expensive. It requires gear, seed, and labor at levels not associated with traditional oyster production. A single line of 200 floating bags, holding 30,000-40,000 oysters, is estimated to cost over $6,000. Other equipment, including refrigeration for direct delivery, is estimated at nearly $5,000. Under Full Accounting, which includes the cost of a boat, motor, truck, and trailer ($45,000) and other start-up costs, total initial investment is estimated to range from less than $60,000 for a single line of floating bags to over $200,000 for twenty-four lines. Under Partial Accounting, total initial investment is estimated to range from approximately $12,000 for a single line to over $150,000 for twenty-four lines. Under Partial Accounting, an AOC grant would cover all initial investment costs up to six lines of floating bags on one acre.

Under Full Accounting, total annual cost, including depreciation and interest on invested capital, labor, fuel, seed, and other expenses, is estimated to range from approximately $50,000 to operate a single line of floating bags to approximately $250,000 to operate twenty-four lines. Under Partial Accounting, total annual cost is estimated to range from approximately $20,000 for a single line on half an acre to approximately $200,000 for twenty-four lines on four acres.

Under reasonable assumptions of a farm start-up period and moderate crop losses due to periodic adverse environmental conditions, the five-year average break-even price under Full Accounting is estimated to range from $2.57 per oyster for 40,000 oysters planted on half an acre, to $0.71 per oyster for 480,000 oysters planted on two acres, to $0.52 per oyster for 960,000 oysters planted on four acres.

Average annual profit under Full Accounting is estimated to be negative for production levels at or below 480,000 oysters planted on two acres. Profit is estimated to be positive at production levels at or above 720,000 oysters planted on three acres. Sensitivity analysis indicates that none of the production levels considered are fully robust to the variety of conditions that an AOC farm is likely to face. Only the largest production level, on four acres, is estimated to be robust to most of the various scenarios considered.

Consistent with the findings of previous analyses in the literature, I find that the average small-scale operation (even with a $45,000 subsidy) is not expected to be profitable. In my analysis, I estimate that it is generally necessary to operate at or above levels of 720,000 oysters planted on three acres to realize positive average annual profit. The other analyses in the literature estimate the threshold to be in the same range or higher. The aggregate production data from Alabama presented at the beginning of this report, which indicates that, over time, farm size is increasing while the number of farms is decreasing, also supports the general conclusions reached here.

Immediate Challenges
AOC is dependent upon a small set of buyers willing to pay high prices. I estimate that there are approximately 10-15 restaurants and oyster bars in the region that feature "named" half-shell oysters on their menu. The expected price to grower for AOC oysters is $0.75-$1.00 if delivered directly to restaurants, and $0.50 if sold dockside to a wholesaler. The larger traditional half-shell (or sack) market can act as a backstop, but that market's price is unlikely to be at a level that can sustain AOC. This market also has more and intense competition, especially in Louisiana, a state that has led the nation in reef-based oyster production.

AOC in Louisiana is located distant from markets. Some AOC growers in Louisiana do not have access to an established wholesaler/distributor, requiring them to market and deliver oysters directly. Delivery can yield higher prices, but also requires added travel distance, time, and costs, and requires more logistical and marketing efforts on the part of growers, that can erode much of the gains associated with those higher prices.

AOC is dependent upon a source of hatchery-reared seed. Traditional oyster production relies on cultch and natural recruitment of oysters. There is currently a shortage of hatchery-reared seed across the entire Gulf Coast, and others states prioritize their own growers, meaning that Louisiana growers are not guaranteed seed. There are concerns whether in-state sources can provide seed at the level needed for current and future growers, and whether it can be supplied reliably. There is currently an even greater shortage of triploid seed, an alternative type of seed that does not reproduce, can grow faster, and provide AOC an advantage during summer months. Without triploids, these advantages do not exist.

AOC gear and infrastructure are susceptible to storms. It has not been demonstrated that gear can be sunk with success or relocated in time to avoid damage and loss of both gear and crop.

Long-Term Challenges

Even under the most optimistic assumptions of where production can be in the future, AOC is unlikely to account for more than a very small fraction of total oyster production in the state. I estimate that a future in which Louisiana has 500 acres of AOC would account for less than one-half of one percent of the traditional oyster production footprint. That same level of AOC production would account for an estimated 7% of the value of Louisiana's traditional oyster landings.

AOC is currently subsidized by grants to AOC parks, hatcheries, and grow-out farms. Although the AOC grant program can indeed provide a hand-up to existing growers, it does distort market signals and may give the impression that economic conditions are better than they actually are. The eventual disappearance of the program will likely have consequences. Once these funds play out, there will be added pressure at all three of the aforementioned points in the production process. Parks may need to raise lease rates to compensate for their lost grant dollars, raising costs to farmers. Hatcheries may need to raise seed prices to compensate for lost grant dollars, also raising costs to growers. And growers that were grant recipients may require higher prices for their crop to compensate for higher lease rates, higher seed costs, and the loss of their own grant dollars.

Acknowledging that I am an economist and not an oysterman, oyster biologist, hydrologist, or coastal scientist, I have serious concerns – merely as a concerned citizen of Louisiana -- that AOC – or oyster production of any kind – is sustainable in Southeast Louisiana. The Bonnet Carré Spillway is an ongoing threat to oyster production in this region. The Mid-Barataria Sediment Diversion is expected to come online within the next five to ten years, and the Environmental Impact Statement released by the USACE forecasts “major, adverse impacts on the Barataria Basin population of eastern oysters…” (p. ES-13, USACE 2022). Most of the current AOC activity, including two existing AOC parks, several individual AOC operations, and the state’s oyster hatchery, are located in Barataria Bay, particularly on or around Grand Isle. The Mid-Breton Sediment Diversion is in planning stage, and it is reasonable to expect similar impacts in Breton Sound and perhaps even in Biloxi Marsh. Growers may wish to consider the use of bottom cages for AOC that may be more tolerable of stratified waters under the forecasted salinity changes. The State may need to consider shifting efforts west, perhaps west of Port Fourchon, into Terrebonne Bay, perhaps around Cocodrie, Sister Lake, and other points west, as earlier LDWF documentation noted (LDWF 2020a, 2020b). Louisiana may also need to consider the cost of sector-wide relocation of AOC infrastructure post-diversions or compensation for growers lured to this area with grant funds.

Finally, might traditional cultching efforts on existing bottom leases prove more cost-effective? Recent work has begun to look into the question of comparative advantages for traditional bottom production versus AOC (Petrolia, Walton, and Cebrian 2022; Engle et al. 2021). This is beyond the scope of the present study, but given the long history and experience of the traditional oyster fishery in Louisiana, as well as its ability to recruit oysters naturally without the need for obtaining seed, and the demonstrated success of the use of cultch in the past, this seems like a worthy direction for further inquiry.

REFERENCES

Banks, Patrick, Steve Beck, Katie Chapiesky, and Jack Isaacs. 2016. "Louisiana Oyster Fishery Management Plan, Louisiana Department of Wildlife and Fisheries, Office of Fisheries, updated November 23, 2106.

Barrett, L.T., S.J. Theuerkauf, J.M. Rose, H.K. Alleway, S.B. Bricker, M. Parker, D.R. Petrolia, and R.C. Jones. 2022. "Sustainable growth of non-fed aquaculture will generate valuable ecosystem benefits." *Ecosystem Services* 53(February): 101396.

Beck, M. W., R.D. Brumbaugh, L. Airoldi, A. Carranza, L.D. Coen, C. Crawford, O. Defeo, G.J. Edgar, B. Hancock, M.C. Kay, H.S. Lenihan, M.W. Luckenbach, C.L. Toropova, G. Zhang, and X. Guo. 2011. "Oyster reefs at risk and recommendations for conservation, restoration, and management." *BioScience* 61(2): 107–16.

Bodenstein, Sarah, William C. Walton, and Todd D. Steury. 2021. "Effect of farming practices on growth and mortality rates in triploid and diploid eastern oysters *Crassostrea virginica.*" *Aquaculture Environment Interactions* 13: 33-40. https://doi.org/10.3354/aei00387.

Bureau of Transportation Statistics. 2023. "Average Cost of Owning and Operating an Automobile." Excel Dataset. U.S. Department of Transportation. https://www.bts.gov/content/average-cost-owning-and-operating-automobilea-assuming-15000-vehicle-miles-year.

Dame, Russel, Leslie N. Sturmer, Charles M. Adams, Richard Weldon, and Kelly A. Grogan. 2019. "Financial Risk in Off-Bottom Oyster Culture along Florida's West Coast." Food and Resource Economics Department, IFAS Extension, University of Florida, Document FE1017, September, https://edis.ifas.ufl.edu/publication/FE1070.

Energy Information Agency (EIA). 2023. "Gulf Coast (PADD 3) Gasoline and Diesel Retail Prices." https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r30_a.htm.

Engle, Carole R. and Jonathan van Senten. 2018. "Economic Analysis of Oyster Production in Maryland." https://repository.library.noaa.gov/view/noaa/37917.

Engle, Carole, Jonathan van Senten, Matthew Parker, Donald Webster, and Charles Clark. 2021. "Economic tradeoffs and risk between traditional bottom and container culture of oysters on Maryland farms." *Aquaculture Economics & Management* 25(4): 472-503.

Grice, Russell and William Walton. 2019. Alabama Shellfish Aquaculture Situation & Outlook Report 2018." Alabama Cooperative Extension Report ANR–2467 and MS–AL Sea Grant Publication MASGP–19–026, July. https://www.aces.edu/wp-content/uploads/2020/04/ANR-2467_Shellfish_Aquaculture_2018-Report_082319L-G.pdf.

Grice, Russell and William Walton. 2020. Alabama Shellfish Aquaculture Situation & Outlook Report: Production Year 2019." Alabama Cooperative Extension Report ANR–2674 and MS–

AL Sea Grant Publication MASGP–19–026, September. https://www.aces.edu/wp-content/uploads/2020/09/ANR-2674-Ala-Shellfish-Aquaculture-Report-2019_090120L-G.pdf.

Grice, Russell and Andrea Tarnecki. 2022. "Alabama Shellfish Aquaculture Situation & Outlook Report: Production Year 2021." Alabama Cooperative Extension Report ANR–2915 and MS–AL Sea Grant Publication MASGP–22–036, August. https://www.aces.edu/wp-content/uploads/2022/08/ANR-2915_AlabamaShellfishAquacultureReport2021_081722L.pdf.

Grice, Russell and Andrea Tarnecki. 2023. "Alabama Shellfish Aquaculture Situation & Outlook Report: Production Year 2022." Alabama Cooperative Extension Report ANR–2997 and MS–AL Sea Grant Publication MASGP–23–029, revised April 2023. https://www.aces.edu/wp-content/uploads/2022/08/ANR-2997_AlabamaShellfishAquacultureReport2022_041723L-G.pdf

Herbst, Eric, Sarah Pedigo, Thomas Bliss, Leslie Sturmer, Russell "Rusty" Grice, Jason Rider, Brian Callam, Mario Marquez. 2022. "Oyster South Symposium State Update." Presented at the 2022 Oyster South Symposium, April 5-7, Biloxi, MS.

Hudson, Karen. 2017. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2016 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2017-07. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V51K6T.

Hudson, Karen. 2018. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2017 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2018-9, Virginia Sea Grant VSG-18-3, https://doi.org/10.25773/jc19-y847.

Hudson, Karen. 2019. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2018 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2019-8, Virginia Sea Grant VSG-19-2, https://doi.org/10.25773/jc19-y847.

Hudson, Karen, Dan Kauffman, and Thomas J. Murray. 2013. "Cultchless (Single-Seed) Oyster Crop Budgets for Virginia: 2013 User Manual." Publication AAEC-40P, Virginia Cooperative Extension, Virginia Tech and Virginia State University. https://ncseagrant.ncsu.edu/wp-content/uploads/2019/09/L10_Budget-Tool_User-Manual.pdf.

Hudson, Karen and Thomas J. Murray. 2014. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2013 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2014-05, Virginia Sea Grant Publication No. VSG-14-02. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V52X4T.

Hudson, Karen and Thomas J. Murray. 2015. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2014 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2015-03, Virginia Sea Grant Publication No. VSG-15-01.

Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V56Q74.

Hudson, Karen and Thomas J. Murray. 2016. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2015 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2016-4. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5BD8N.

Johnson, Jeff. 2018. "Farm Machinery Cost Calculations." Publication 3543 (POD-10-20), Mississippi State University Extension Service. https://extension.msstate.edu/sites/default/files/publications/publications/P3543_web.pdf.

Johnson, Terry. 2011. "Saving Fuel on Your Recreational or Charter Boat." Alaska Sea Grant Marine Advisory Program ASG-56. https://seagrant.uaf.edu/bookstore/pubs/ASG-56.html.

Keithly, W.R., Jr. and R.F. Kazmierczak, Jr. 2006. "Economic Analysis of Oyster Lease Dynamics in Louisiana." Report to the Louisiana Department of Natural Resources, October 1.

Louisiana Department of Wildlife & Fisheries (LDWF). 2020a. "Louisiana Oyster Management and Rehabilitation Strategic Plan: Draft – December 2020."

Louisiana Department of Wildlife & Fisheries (LDWF). 2020b. "DRAFT Oyster Management and Rehabilitation Strategic Plan." Presentation, June 2020.

Louisiana Sea Grant. 2022a. "Alternative Oyster Culture Grant Recipients Announced." Newsroom, February 24, 2022. https://www.laseagrant.org/2022/aoc-grant-recipients-01/.

Louisiana Sea Grant. 2022b. "New Cameron Alternative Oyster Culture Park under Development, Now Accepting Grow-out Farm Applicants." Newsroom, September 8, 2022. https://www.laseagrant.org/2022/new-cameron-aoc-park/.

Louisiana Sea Grant. 2022c. "Second Round Alternative Oyster Culture Grant Recipients Announced." Newsroom, November 10, 2022. https://www.laseagrant.org/2022/second-round-aoc-recipients/.

Louisiana Sea Grant. 2023. "Third Round Alternative Oyster Culture Grant Recipients Announced." Newsroom, March 21, 2023. https://www.laseagrant.org/2023/third-round-aoc-grant-recipients/.

Louisiana's Seafood Future. 2023a. "Alternative Oyster Culture: AOC Parks." https://www.laseafoodfuture.com/arc-parks.

Louisiana's Seafood Future. 2023b. "Alternative Oyster Culture: LSG Statement of Purpose." https://www.laseafoodfuture.com/lsg-statement-purpose.

Maxwell, Vanessa J. and John E. Supan. 2010. "Economic analysis of off-bottom oyster culture for triploid Eastern oyster, *Crassostrea virginica,* culture in Louisiana." *World Aquaculture* 41(1): 9-14.

Melancon, Earl. 2023. "AOC in Louisiana Present Status & Future Needs." Presentation given to CPRA and LDWF, April 17, 2023.

Murray, Thomas J. and Karen Hudson. 2011. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2010 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2011-11, Virginia Sea Grant Publication No. VSG-11-06. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5TD80.

Murray, Thomas J. and Karen Hudson. 2012. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2011 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2012-04, Virginia Sea Grant Publication No. VSG-12-07. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5PQ7G.

Murray, Thomas J. and Karen Hudson. 2013. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2012 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2013-02, Virginia Sea Grant Publication No. VSG-13-02. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5Z71V.

Murray, Thomas J. and Michael J. Oesterling. 2006. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2004-2006 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2006-5, Virginia Sea Grant Publication No. VSG-06-06. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V52123.

Murray, Thomas J. and Michael J. Oesterling. 2007. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2005-2007 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2006-5, Virginia Sea Grant Publication No. VSG-06-06. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V55Q7T.

Murray, Thomas J. and Michael J. Oesterling. 2008. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2007 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2008-2, Virginia Sea Grant Publication No. VSG-08-02. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V59H8C.

Murray, Thomas J. and Michael J. Oesterling. 2009. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2008 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2009-5, Virginia Sea Grant Publication No. VSG-

09-04. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5F716.

Murray, Thomas J. and Michael J. Oesterling. 2010. "Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2009 Virginia Shellfish Aquaculture Crop Reporting Survey." VIMS Marine Resource Report No. 2010-6, Virginia Sea Grant Publication No. VSG-10-03. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5JX45.

NerdWallet. 2023. "SBA Loan Rates 2023." Accessed August 7, 2023. https://www.nerdwallet.com/article/small-business/sba-loan-rates.

NOAA Fisheries. 2023. "Commercial Fisheries Landings." https://www.fisheries.noaa.gov/foss/f?p=215:240:4422088353212::NO:::.

Parker, Matt. 2023. "Maryland Oyster Aquaculture Industry Summary." https://lookerstudio.google.com/reporting/03f76a85-980f-4b5b-b308-f4ffa938ce8f/page/p_e8ar2gwt6c?s=llZNhdMkel4.

Parker, M., D. Lipton, and R.M. Harrell. 2020. "Impact Financing and Aquaculture: Maryland Oyster Aquaculture Profitability." *Journal of the World Aquaculture Society* 51: 874–95.

Perkins-Veazie, Penelope. 2012. "Mobile Refrigeration Trailer for N.C. Farmers." Plants for Human Health Institute, NC State University. https://plantsforhumanhealth.ncsu.edu/wp-content/uploads/sites/127/2015/06/PackNCool-Manual2.pdf.

Petrolia, Daniel R. 2018. "An Assessment of Market Feasibility for Oysters Produced using The Nature Conservancy's Proposed Production System." Report prepared for The Nature Conservancy - Louisiana.

Petrolia, Daniel R. 2022. "Economic Assessment of a Mississippi Oyster Shell Recycling Program." Report prepared for The Nature Conservancy - Mississippi.

Petrolia, D.R., F. Nyanzu, J. Cebrian, A. Harri, J. Amato, and W.C. Walton. 2020. "Eliciting Expert Judgment to Inform Management of Diverse Oyster Resources for Multiple Ecosystem Services." *Journal of Environmental Management* 268(August): 110676.

Petrolia, D.R., W.C. Walton, and J. Cebrian. 2022. "Oyster Economics: Simulated Costs, Market Returns, and Nonmarket Ecosystem Benefits of Harvested and Non-Harvested Reefs, Off-Bottom Aquaculture, and Living Shorelines." *Marine Resource Economics* 37(3): 325-47.

Petrolia, Daniel R., William C. Walton, and Lauriane Yehouenou. 2017. "Is There a Market for Branded Gulf of Mexico Oysters?" *Journal of Agricultural & Applied Economics* 49(1): 45-65.

Pruente, Vicky, Russell Grice, and Glen Chaplin. 2023. "Estimating Farm Size and Gear Costs for Commercial Oyster Aquaculture Calculator." ANR-2999, Alabama Cooperative Extension

System, Auburn University, and Mississippi-Alabama Sea Grant. https://www.aces.edu/blog/topics/coastal-programs/estimating-farm-size-and-gear-costs-for-commercial-oyster-aquaculture-calculator/.

Small Business Administration (SBA). 2023. "Terms, conditions, and eligibility." https://www.sba.gov/partners/lenders/7a-loan-program/terms-conditions-eligibility#id-interest-rates.

Shell Game Products. 2023. "40" Tumbler". https://www.shellgameproducts.com/oyster-aquaculture-equipment.

Store It Cold, LLC. 2021. "CoolBot Trailer Construction Guide: DIY Trailer Walk-In Cooler," Rev 2021-07A. https://storeitcold.com/wp-content/uploads/2020/03/DIY-Trailer-Guide-2023-06A.pdf.

Sturmer, Leslie, Carter Cyr, and Reggie Markham. 2018. "Application of Triploidy to an Emergent Oyster Culture Industry on Florida's Gulf Coast: Results of Growers' Trials." UF-IFAS Workshops, May 3-4, 2018, St. Teresa and Cedar Key, FL. http://shellfish.ifas.ufl.edu/wp-content/uploads/Growers-Trials-for-Workshops_reduced-size.compressed.pdf.

Sturmer, Leslie N., Andrew S. Kane, Edward J. Philips, Erik Lovestrand, Holden Harris, Natalie Anderson. 2022. "Addressing Oyster Mortalities in Florida's Off-Bottom Oyster Aquaculture Industry." Final Report Covering June 2020-December 2021, UF-IFAS Support for Emerging Enterprise Development Integration Teams (SEEDIT) Program. https://shellfish.ifas.ufl.edu/wp-content/uploads/Oyster-Culture-SEEDIT-Final-Report-3.07.22-compressed.pdf.

U.S. Army Corps of Engineers (USACE). 2022. "Final Environmental Impact Statement for the Proposed Mid-Barataria Sediment Diversion Project, Plaquemines Parish, Louisiana." USACE New Orleans District, prepared by G.E.C. Inc., September 2022.

Wadsworth, Pandora C. 2018. *Comparing Triploid and Diploid Growth and Mortality in Farmed Oysters,* Crassostrea virginica, *in the Northern Gulf of Mexico.* Master's thesis, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University.

Walton, Bill. 2021. "Planting Your First Crop." Lecture included in the Online Oyster Culture Course, University of Florida. https://shellfish.ifas.ufl.edu/news/the-online-oyster-culture-course-is-available-now/.

Walton, Bill, Julie Davis, Glen Chaplin, F. Scott Rikard, D. LaDon Swann, Terry Hanson. 2012. "Gulf Coast Off-Bottom Oyster Farming Gear Types." MASGP Publication No. 12-013-04. https://shellfish.ifas.ufl.edu/wp-content/uploads/Off-bottom-Oyster-Culture-Gear-Types.pdf.

Walton, W.C., F.S. Rikard, G.I. Chaplin, J.E. Davis, C.R. Arias, and J.E. Supan. 2013. "Effects of ploidy and gear on the performance of cultured oysters, *Crassostrea virginica:* Survival, growth, shape, condition index and *Vibrio* abundances." *Aquaculture* 414-415: 260-66.