Delaware's Oyster Industry: Economic Forecast

Draft Report, Fall 2017

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Abstract: In past decades, Delaware's oyster industry has had issues with diseases, which is common for oyster populations. After slowdown periods and efforts to revitalize the industry, the State of Delaware finally approved new acreage for shellfish aquaculture during the summer of 2017. This new regulation is likely to have significant effects on the development and shape of the industry for years to come. In this report, we discuss the possible economic and environmental impacts for Delaware to consider as the state continues to cultivate this new market. We report that significant growth is likely for Delaware's oyster industry in the future. Based on the data available from other neighboring states, we expect that the new Delaware acreage could initially yield around $300,000-$500,000 in oyster sales, potentially growing to $1-$2m. Further, Delaware could enjoy up to 100 new full-time, year-round jobs and approx. 150 part-time or seasonal jobs. Delaware's inland bays will likely see improved water quality; up to 20-48 percent of the water in Delaware's inland bays may be filtered per day.

Introduction

In the past, Delaware's oyster industry has had issues with diseases, which is common for oyster populations. After slowdown periods and efforts to revitalize the industry, the State of Delaware finally approved new acreage for shellfish aquaculture during the summer of 2017. This new regulation is likely to have significant effects on the development and shape of the industry for years to come. In this report, we discuss the possible economic and environmental impacts for Delaware to consider as the state continues to cultivate this new market. The introduction provides background information and a summary of our results, Sections 2, 3, and 4 provide more detailed analyses, and the discussion section concludes. References and the Appendix follow.

The new acres available for shellfish aquaculture are located in the Little Assawoman Bay, the Rehoboth Bay, and the Indian River Bay, all of which are south of Rehoboth Beach. The total area was divided into rectangular subspaces with "navigational corridors" in between so lessees will each be able to reach their acres, and disputes regarding acreage borders will be minimized. Interested parties can investigate the available spaces to determine their preferences based on the species of shellfish they wish to pursue.

The State of Delaware will then host a lottery system to allocate (i.e. lease) the acreage to the interested parties; individuals and/or companies submit applications, and then each is randomly assigned a lottery number. The party assigned #1 gets to designate their desired acreage first. Then, the party assigned #2 gets to designate their desired acreage second. And so on. Finally, the state will either approve or reject each application. The acreage is available for lease to commercial parties only; recreational shellfish aquaculture is not allowed.

The total area available is 343 acres (Division of Fish and Wildlife 2016); however, not every application will be approved, and not all acres are suitable for oyster aquaculture[1]. We estimate the likely usage of this acreage based on that of similar states and subsequently forecast the economic impact this development will have on the local community and environment. Specifically, our analysis is categorized into three areas: (1) the economic impact of the market based on projected oyster sales, (2) the economic impact on the labor/employment market, and (3) environmental considerations. Our primary sources of data include the U.S. National Oceanic and Atmospheric Administration (NOAA) / National Marine Fisheries Service and surveys completed by other states, such as Massachusetts (University of Massachusetts Dartmouth) and Maine (Cole et al. 2017), which allow us to extrapolate and infer projections for Delaware.

We report that Delaware's current oyster industry is quite small compared to neighboring states; however, growth appears optimistic. All of the comparison states similar in size to Delaware showed significant growth between 2010 and 2016. Given Delaware's newly approved acres for lease, the oyster industry could initially yield around $300,000-$500,000 in sales, potentially growing to $1-$2m. Further, Delaware could enjoy up to 100 new full-time, year-round jobs and approx. 150 part-time or seasonal jobs. Delaware's inland bays will likely see improved water quality; up to 20-48 percent of the water in Delaware's inland bays may be filtered per day.

[1] Each application is subject to an assessment; among other factors, the density of hard clams in the proposed acreage may lead to a rejection, given that Delaware hosts one of the last viable natural hard clam populations on the East Coast (Division of Fish and Wildlife 2014).

Economic Impact: Projected Sales

In this section, we first present summary data on oyster industries in Delaware and neighboring states for the past 6-7 years. We discuss historical growth rates and Delaware's likely potential based on the newly approved 343 leasable acres. Finally, using multiple possible selling prices, we estimate a range of projected oyster sales. Figure 1 below illustrates the production of oysters in Delaware between 2010 and 2016, along with prices per pound (U.S. National Oceanic and Atmospheric Administration 2017). Between 2010 and 2016, oyster production remained fairly constant. Likewise, the nominal price of oysters per pound remained steady. In 2016, Delaware produced 72,240 lbs. of oysters for a market value of $498,499 ($6.90/lb.).

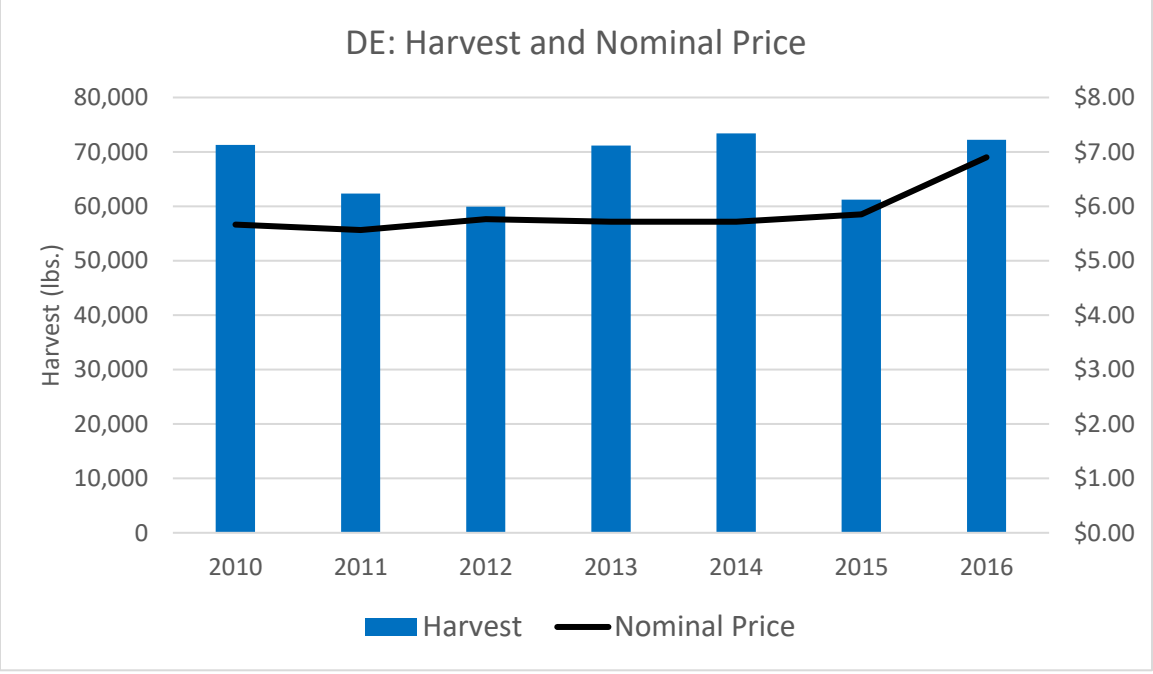

Figure 1: Harvest and Nominal Price in Delaware, 2010-2016. Source: Annual Commercial Landing Statistics (NMFS).

Figure 2 displays the production of oysters in other states on the East Coast between 2010 and 2016. (Note that Virginia is the third-largest oyster producing state in the U.S. with an average harvest of almost 3 million pounds per year between 2010 and 2016. For scaling reasons, the comparison graph does not include Virginia.) These states are all located in the Northeast or Mid-Atlantic with similar sizes to Delaware (with the exception of Virginia and North Carolina). On average, between 2010 and 2016, harvests increased in Maine, Maryland, Massachusetts, New York, Rhode Island, and Virginia, whereas harvest decreased in North Carolina between 2010 and 2016. (In the Appendix, Table 1 contains the raw data.) All comparison states except North Carolina experienced average growth rates between 15.9% (Maine) and 39.2% (New York), suggesting a significantly prosperous oyster industry.

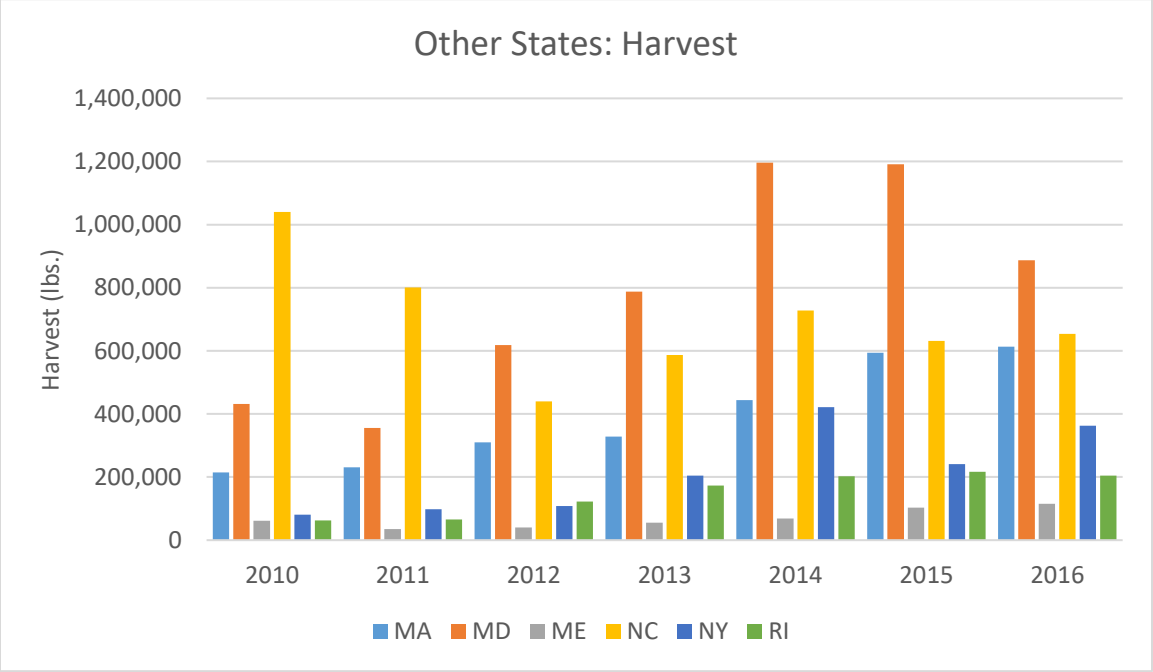

Figure 2: Harvest in MA, MD, ME, NC, NY, and RI, 2010-2016. Source: Annual Commercial Landing Statistics (NMFS).

Notice that Maine and Rhode Island are relatively small production states with similar harvest rates to Delaware in 2010. Between 2010 and 2016, Maine almost doubled its annual harvest, and Rhode Island *more than tripled* its annual harvest with a significant growth in harvest beginning in 2012 (85.4% growth between 2011 and 2012). This suggests that small states like Delaware have the potential for serious growth, given favorable conditions.

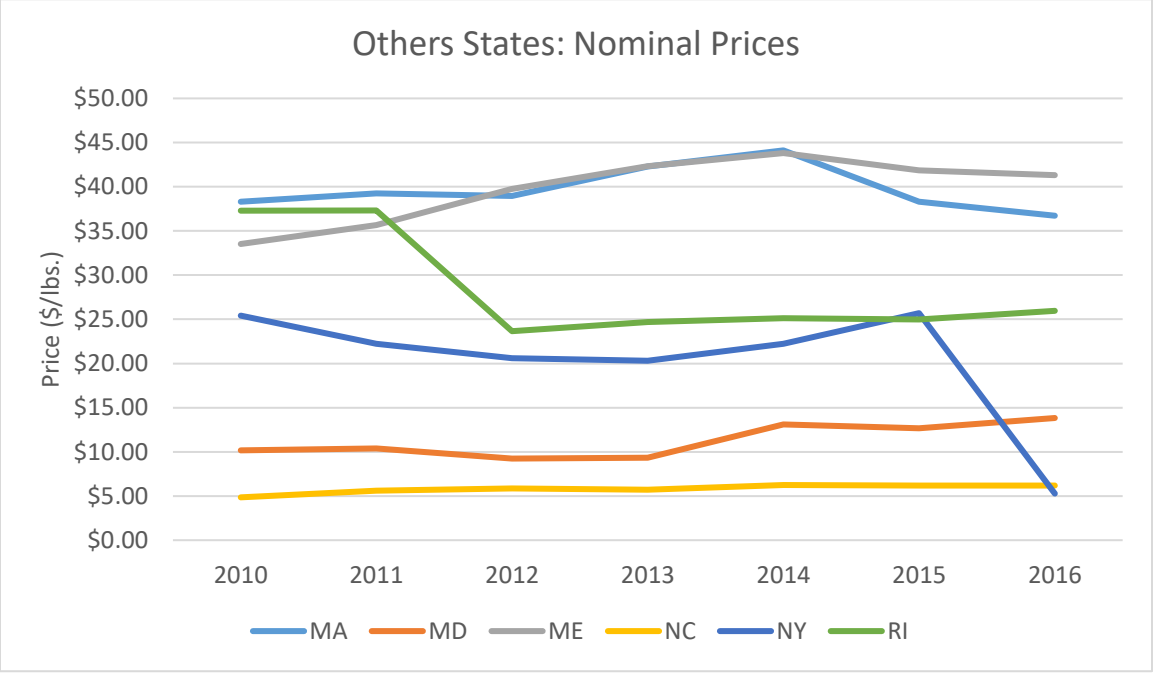

Figure 3: Nominal Oyster Prices in MA, MD, ME, NC, NY, and RI, 2010-2016. Source: Annual Commercial Landing Statistics (NMFS).

Figure 3 provides nominal oyster prices for the range of 2010 to 2016 for the comparison states. On average, prices are high in states in the Northeast: Maine, Massachusetts, and Rhode Island. Prices are relatively low in states located further south: Maryland and North Carolina. Interestingly, the nominal price dropped significantly in Rhode Island in 2012 by more than $10/lb.

and remained around $25/lb. In 2016, the nominal price in New York dropped by $20/lb. compared to 2015, a 79.5% price drop, while harvest increased by 50.6% between 2015 and 2016. The New York example suggests that a sharp increase in supply drove the price down; demand likely remained somewhat constant, while supply shifted right. (In the Appendix, Table 2 contains the raw data.) Overall, market prices for oysters are fairly volatile; there is no clear trend in nominal prices across comparison states.

The best prediction for Delaware's selling price is likely the state of Maryland; Maryland is directly adjacent to Delaware and has similar tourist patterns at neighboring beaches (e.g. Ocean City, MD and Rehoboth Beach, DE). Initially, there may be some inclination that consumers would pay a "local" premium for oysters, given that local oysters clean local waters. However, Kecinski et al. (2017) conducted an experimental study on consumer purchasing preferences for oysters in Delaware and found that "consumers do not exhibit preferences for 'local' oysters". Thus, we would not expect Delaware consumers within the state of Delaware to pay significantly different prices from tourists or market rates in other states. The same study also reported that experienced oyster consumers are willing to pay a significant premium for aquaculture oysters over wild-caught oysters (although, overall, study participants preferred wild-caught oysters). Regardless, we would not expect these aquaculture versus wild-caught preferences to vary by state[2].

Next, we use data from Maine and Massachusetts to project possible oyster sales for the newly approved shellfish acreage in Delaware. Given the variable growth rates in the oyster industry over time, this projection is a rough estimate, but may provide some indication of

[2] In this analysis, we do not consider the possibility that Delaware oysters may be exported to states with higher market prices. However, this is an important consideration for future work.

Delaware's potential. According to a January 2017 Maine aquaculture impact report (Cole et al. 2017), which partially sourced data from the Maine Dept. of Marine Resources, the total leased shellfish acreage was about 577 acres in 2014. NOAA data indicates that 68,418 lbs. of oysters were sold from those 577 acres[3]. In Delaware, 343 new acres have been approved for possible leases. Based on this, we would expect 40,671.36 lbs. of new oysters in Delaware[4].

The value of these oysters depends on the selling price. While the selling price of a pound of oysters in Maine in 2014 was $43, the price in Delaware in 2014 was only $5.71 (U.S. National Oceanic and Atmospheric Administration 2017). In 2016, the price in Delaware was $6.90/lb., and the price in Maryland was $13.83/lb. Delaware prices are likely to change in the future for several reasons. An increase in supply typically lowers prices. However, an increase in demand raises prices. If Delaware oysters become popular as the industry develops and grows, the demand increase may offset (or outweigh) the supply increase. To be thorough, we report possible Delaware sales using both a $6.90/lb. price and a $13.83/lb. price (i.e. the price in Maryland, a neighboring state). Based on 40,671.36 pounds, new Delaware sales could be between $280,632 and $562,484. We might expect this to be a starting point for Delaware. As we will see from the Massachusetts data, the projected sales could be much higher.

According to a Massachusetts study by the University of Massachusetts Dartmouth (Univ. of Massachusetts 2015), the leased shellfish acreage was 1,030 acres in 2013. However, in a survey of the leaseholders, only 35% responded, representing 528 acres. We will assume that the survey

[3] It is unclear what proportion of the 577 shellfish acres are actually used for oyster aquaculture. However, this proportion is also unclear for Delaware; we do not know how many of Delaware's 343 acres will be used for oysters. We temporarily assume that the proportions for Maine and Delaware are similar; later, we acknowledge that the discrepancies between states could be due to different proportions of oyster usage.

[4] This calculation is: $(68{,}418 * 343)/577$.

sample was representative of Massachusetts, though we acknowledge that the non-respondents may have had systematically different sales. For the 528 acres represented, 19,135,928 oysters were sold in 2013 for prices ranging from $0.51-$0.60 per oyster. This represents between $9,759,323 and $11,481,556 in total sales. Based on a price of $42.28 per pound of oysters in Massachusetts in 2013 (U.S. National Oceanic and Atmospheric Administration 2017), this translates to between 230,826 lbs. and 271,560 lbs. Given Delaware's new 343 acres, we might expect Delaware to sell between 149,949 lbs. and 176,411 lbs.[5]. Finally, we calculate sales based on the prices of $6.90 and $13.83 per pound, same as before. New projected sales for Delaware (based on Massachusetts' 2013 successes) are between $1,034,648 and $2,439,764.

Why does the Massachusetts data predict much higher sales than the Maine data? There are several possible reasons. First, Maine may use a smaller proportion of their shellfish leases for oyster aquaculture. Other shellfish may have stronger populations or greater demand in Maine than in Massachusetts. Only time will tell what proportion of Delaware's 343 acres will be used for oysters. Second, Massachusetts may be harvesting many more oysters per acre due to climate conditions, technology, or general development of the industry. It's unlikely that the demand for oysters (relative to supply) is much different in Maine versus Massachusetts, given that their selling prices for oysters are very similar. Given the strong oyster industry growth rates reported previously, we propose that Delaware might eventually rise to Massachusetts' level of production (and, given Delaware's likely selling prices, somewhere in the range of $1m - $2m in sales).

[5] This calculation is: $(271{,}560 * 343)/528$.

Economic Impact: Employment

Similar to sales, the economic impact on the labor market is difficult to predict in Delaware. However, given Delaware's new proposed acreage and historical survey data from a similarly-sized East Coast state, we estimate a range of possible employment outcomes. First, there are a number of important factors to consider, including seasonal employment.

While larger shellfish aquaculture farms may employ year-round staff, smaller operations are often run solely by the owner or with the help of seasonal employees. There are no seasonal limitations for Delaware's newly approved acreage (Division of Fish and Wildlife 2014), but many employees may still work only seasonally. According to the University of Massachusetts Dartmouth study (2015), which surveyed leaseholders in Massachusetts, 769 direct shellfish farmer jobs existed in 2013 for a total of approximately 1,030 acres. About 40% of those jobs were thought to be full-time throughout the year, 29% were thought to be part-time on a seasonal basis, 17% were thought to be part-time throughout the year, and 14% were thought to be full-time on a seasonal basis. Given Delaware's location relative to Massachusetts (i.e. further south), it's possible that Delaware's shellfish industry will be more active throughout the year due to the warmer weather. Aside from direct aquaculture conditions, Delaware beaches bring significant demand for oyster consumption during warmer months.

In addition to the 769 direct jobs referenced above, the Massachusetts survey also estimated an additional 140 jobs through "indirect and induced" activity, resulting in a total of 909 jobs, or about 0.8825 jobs per acre (i.e. 909 jobs / 1,030 acres = 0.8825 jobs/acre). Further, these shellfish farmers paid approximately $11.9m in wages in 2013, and their economic activity (i.e. purchases

by shellfish employees) accounted for another $8.2m of labor income, for a total of approx. $20.1m of labor income in Massachusetts. Of course, we will be cautious when interpreting these estimates for Delaware. One important caveat is that the Massachusetts survey had a response rate of 35%. This is actually high compared to similar studies (according to the authors), but it still means there is room for possible statistical error (the authors estimate +/- 6.5%). Another important note is that Massachusetts has a more established and larger shellfish industry than Delaware. Economies of scale (i.e. the effect of operating on a larger scale) could mean that Massachusetts has less employees per acre than Delaware will have.

Nevertheless, we can calculate a rough estimate of the new jobs Delaware might expect from the newly approved 343 acres. Using the 2013 estimates from Massachusetts (which is conservative, given that Massachusetts' oyster industry has grown on average by 20% per year over the past four years), we predict that Delaware will gain about 100 full-time, year-round jobs ((769 * 0.40) / 1,030 acres = 0.30 jobs/acre, which translates to 102.4 jobs for 343 acres)[6]. Other types of direct employment (including part-time seasonal, full-time seasonal, and part-time year-round) make up the remaining 60% of all employees. For Delaware, this would be about 150 jobs ((769 * 0.60) / 1,030 acres = 0.45 jobs/acre, which translates to 153.65 jobs for 343 acres). This does not include jobs created from "indirect and induced" activity, which could further boost the local economy. Ideally, we would include additional estimates from other states as a robustness check. However, employment data directly related to oyster aquaculture is somewhat sparse, possibly due to its seasonal nature. This is an area to expand on in future research.

[6] It is unclear how many of these jobs will be directly related to oysters versus other shellfish, but if Massachusetts is any indication, most of the new shellfish farmers will participate in oyster aquaculture (University of Massachusetts Dartmouth 2015).

Environmental Considerations

Delaware is currently the only East Coast state that lacks significant shellfish aquaculture. According to Young 2016, "Oysters serve as filters for cleaning water, provide safe habitat for all types of marine life, help to remove harmful nutrients, and even add valuable calcium carbonate to the waters." Further, an adult oyster filters up to 50 gallons of water a day. Thus, attracting new oyster aquaculture to the state of Delaware will provide substantial environmental benefits.

Kecinski (2017) reported that establishing 160 acres of oyster aquaculture in Delaware may provide environmental benefits by filtering between 9 percent and 22.5 percent of the water in Delaware's inland bays each day. It is currently unclear how many of Delaware's 343 newly approved shellfish aquaculture leases will be dedicated to oysters; if it is more than 160, this could easily amount to an even greater environmental benefit. If all 343 acres are used for oysters, this would translate to about 20-48 percent of the inland bay water cleaned, assuming a linear relationship between the size of the acreage and the oysters' ability to filter water.

Initially, one might be concerned that the water filtering benefit would decrease consumer willingness-to-pay because the oysters absorb polluting nutrients, thus counteracting the economic benefits of the industry. However, recent research indicates that consumers actually have higher willingness-to-pay for oysters grown in moderate-nutrient and high-nutrient waters than low-nutrient waters (Li et al. 2017). It appears that environmental benefits are more important to consumers than eating oysters from cleaner waters. Finally, cleaner waters could yield even greater economic benefits through increased water tourism.

Discussion

Economic forecasts are tricky, and it's impossible to predict exactly what will happen to the oyster industry in Delaware. However, given other states' successes in this market, it is likely that Delaware will also enjoy thriving oyster aquaculture in the future. In this report, we use data from NOAA's database, coupled with extrapolations from other states' historical labor markets and sales to predict Delaware's likely economic impact from the newly approved shellfish acreage.

We find that significant growth is likely for Delaware's oyster industry in the future. Based on the data available from other neighboring states, we expect that the new Delaware acreage could initially yield around $300,000-$500,000 in oyster sales, potentially growing to $1-$2m. Further, Delaware could enjoy up to 100 new full-time, year-round jobs and approx. 150 part-time or seasonal jobs. Delaware's inland bays will likely see improved water quality; up to 20-48 percent of the water in Delaware's inland bays may be filtered per day.

One area for future research is use of IMPLAN software. This software can estimate economic impacts with more precision than simple data analysis. Future researchers could use IMPLAN to predict likely spillover (i.e. indirect or "multiplier") economic effects that reach into other markets and industries. For instance, salaries paid to employees are spent in other markets, increasing the value of shellfish farmer jobs beyond the salaries themselves. A second possible expansion for future work is to consider exports of Delaware oysters. In this analysis, we do not consider the possibility that Delaware oysters may be exported to states with higher market prices, which would increase the value of Delaware's oyster industry.

Finally, future studies could provide deeper insights on the environmental impacts; more research is needed to determine precise values for marginal environmental improvements, such as better water quality. These nonmarket values could be very substantial, thus significantly increasing the economic impact of cultivating oysters. Environmental improvements could further increase water tourism, capitalizing on oyster benefits.

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Appendix

Table 1 below provides raw data and calculated percentage changes year-by-year for oyster harvests. Delaware and the East Coast comparison states are included.

	DE		MA		MD		ME	
	Nominal	**Change**	**Nominal**	**Change**	**Nominal**	**Change**	**Nominal**	**Change**
2010	71,288	.	214,715	.	431,856	.	61,632	.
2011	62,349	-12.54%	230,981	7.58%	356,001	-17.56%	34,700	-43.70%
2012	59,948	-3.85%	309,836	34.14%	618,008	73.60%	40,379	16.37%
2013	71,141	18.67%	328,656	6.07%	787,889	27.49%	55,006	36.22%
2014	73,423	3.21%	443,705	35.01%	1,196,279	51.83%	68,418	24.38%
2015	61,222	-16.62%	593,469	33.75%	1,190,857	-0.45%	102,977	50.51%
2016	72,240	18.00%	613,247	3.33%	886,953	-25.52%	115,127	11.80%
Avg.	67,373	1.14%	390,658	19.98%	781,120	18.23%	68,320	15.93%
	NC		**NY**		**RI**		**VA**	
	Nominal	**Change**	**Nominal**	**Change**	**Nominal**	**Change**	**Nominal**	**Change**
2010	1,040,408	.	80,533	.	62,164	.	1,186,509	.
2011	800,496	-23.06%	97,781	21.42%	65,749	5.77%	1,521,637	28.24%
2012	440,067	-45.03%	108,187	10.64%	121,879	85.37%	1,962,746	28.99%
2013	586,623	33.30%	204,132	88.68%	172,805	41.78%	3,247,815	65.47%
2014	727,774	24.06%	421,555	106.51%	202,826	17.37%	3,764,811	15.92%
2015	631,036	-13.29%	241,145	-42.80%	216,769	6.87%	4,574,151	21.50%
2016	653,895	-4.80%	363,089	36.89%	204,219	31.43%	4,083,231	32.02%
Avg.	697,186	-4.80%	216,632	36.89%	149,487	31.43%	2,905,843	32.02%

Table 1: Oyster Harvest, Pounds per Year and % Change, 2010-2016. Source: Annual Commercial Landing Statistics (NMFS).

Table 2 below provides raw data and calculated percentage changes year-by-year for oyster prices. Delaware and the East Coast comparison states are included.

	DE		MA		MD		ME	
	Nominal	**Change**	**Nominal**	**Change**	**Nominal**	**Change**	**Nominal**	**Change**
2010	$5.67	.	38.30	.	$10.15	.	$33.52	.
2011	$5.56	-1.81%	39.25	2.47%	$10.37	2.11%	$35.67	6.40%
2012	$5.76	3.57%	38.96	-0.75%	$9.24	-10.89%	$39.77	11.50%
2013	$5.71	-0.83%	42.28	8.53%	$9.34	1.07%	$42.31	6.39%
2014	$5.71	0.00%	44.12	4.34%	$13.11	40.44%	$43.81	3.55%
2015	$5.85	2.38%	38.32	-13.14%	$12.67	-3.35%	$41.85	-4.49%
2016	$6.90	17.96%	36.72	-4.16%	$13.83	9.11%	$41.32	-1.26%
Avg.	$5.88	3.54%	39.71	-0.45%	$11.24	6.41%	$39.75	3.68%
	NC		**NY**		**RI**		**VA**	
	Nominal	**Change**	**Nominal**	**Change**	**Nominal**	**Change**	**Nominal**	**Change**
2010	$4.85	.	$25.41	.	$37.28	.	$4.38	.
2011	$5.60	15.58%	$22.23	-12.52%	$37.32	0.10%	$4.49	2.40%
2012	$5.84	4.28%	$20.58	-7.40%	$23.66	-36.61%	$6.09	35.59%
2013	$5.72	-2.20%	$20.32	-1.27%	$24.68	4.33%	$7.80	28.04%
2014	$6.24	9.24%	$22.23	9.39%	$25.12	1.76%	$7.73	-0.85%
2015	$6.18	-1.07%	$25.70	15.58%	$24.97	-0.59%	$7.93	2.58%
2016	$6.19	5.16%	$5.28	0.76%	$25.95	-6.20%	$8.29	13.55%
Avg.	$5.80	5.16%	$20.25	0.76%	$28.42	-6.20%	$6.67	13.55%

Table 2: Oyster Prices, Annual $/lbs. and % Change, 2010-2016. Source: Annual Commercial Landing Statistics (NMFS).