Supplementary material for **“Developing a bioeconomic framework for scallop culture optimization and product development”**

**Interview Script**

**R&D Requirements**

1. What are the biggest R&D challenges facing sea scallop aquaculture in the Gulf of Maine today?

**Participant characteristics**

1. What type of aquaculture lease or license do you currently possess (if multiple, include all)? 2. For how many years have you been farming scallops?

3. Do you farm any other species?

4. If so, are these other species grown on the same lease as your scallops?

5. Please specify the number of additional laborers you employ and specify their characteristics (i.e., full time, part time, volunteer, etc.)

6. Where is your home dock or pier?

**End Market and Product Specifications**

1. Do you sell whole scallops and/or shucked adductor muscle?

2. What type of end markets do you sell to (direct to consumer, wholesale, etc.)? *If shucked meats:*

3. What is the size range of scallops that you harvest for the adductor muscle market? 4. Do you shuck these scallops yourself?

5. If not, how do you shuck these scallops?

6. What is the expected unit price for this product?

7. How does this price vary across size classes?

8. What is the expected annual sale (in pounds, pieces, etc.) of shucked meats?

*If whole scallops:*

9. What is the size range of scallops that you harvest for the whole scallop market? 10. What is the expected price per scallop for each size class?

11. What is the expected total sales of each size class? Please feel free to estimate these numbers in any way that you would like (individuals / year, dollars per season, etc.).

12. How long is the sale period for each year class of scallops? That is, for how many months are you able to sell scallops within a specific size range before they get too large?

*Biotoxin testing:*

13. How many times per month do you test products for the presence of ASP and PSP?

14. How often are you prevented from selling whole products due to either ASP or PSP levels above the legal limit?

15. What is the price you pay per test?

16. How do you transfer your samples to the appropriate testing site?

**Lease Configuration**

1. How deep is your site?

2. What is the acreage?

3. What is the configuration of your lease: longline, bottom culture, bottom seeding, etc.? *If longline:*

4. How many longlines do you currently have in the water?

5. How long is (are) your line(s) in the horizontal direction?

6. If you have multiple lines, how far apart is each line?

7. How much scope do you use to anchor each line?

8. How much chain do you use at the bottom of each mooring line?

*If bottom culture / cages:*

9. How many bottom cages do you currently have on your site?

10. How far apart do you space each cage?

11. How do you mark each cage?

**Capital expenses**

1. Please refer to table 1. We will now go through the list of capital expenditures and decide whether or not you have purchased the item for your farm (Y/N). If yes, please provide some more information on the specifications of the item (i.e., weight and type of anchor, diameter mooring line, lantern net mesh diameter, type of vessel, type of longline floatation buoys, etc.), and the unit cost of the item. Then, please try to estimate the lifespan of the item in years, and, if multiple items, the percentage of the lot that is replaced at that time. Lastly, if the item is used for other purposes (other species, other business, etc.) please estimate the percentage of time dedicated scallop aquaculture.

2. Are there any items missing from table 1? If so, please refer to table 2 and include all the relevant information.

**Production schedule: spat collection, grading, stocking, thinning, cleaning**

The following interview sections are organized chronologically. The goal is to understand the process of bringing a single year class of scallops to market size. I'm going to start by asking you about your spat collection methods, then your nursery culture (Y1 of grow-out), then your grow-out methods for the following 2 years.

1. With what method do you obtain new spat?

*If spat collection:*

2. How many spat lines do you deploy per year?

3. How many bags do you deploy on each line?

4. What is the depth, roughly, of the water in which you deploy bags?

5. How far apart do you space bags on each line?

6. In what months do you start deploying spat bags?

7. In what months do you start retrieving spat bags? Do you remove spat from the bags at this time? If not, are the bags held on your lease?

8. What is your expected total spat yield per bag (individuals)?

9. What is, roughly, the average size of the collected spat?

10. For clarity, what is your total estimated spat yield per year?

11. Is all of this spat grown out on your farm?

12. If not, do you sell spat?

*If spat purchase:*

13. What time of year do you purchase spat?

14. How much spat do you purchase each year?

15. What is the cost of spat?

16. From whom do you purchase spat?

17. What is the estimated size of the spat you purchase each year?

***Juvenile culture Y1:* Y1 refers to the 12 months following initial stocking of scallops into enclosures from spat collector bags.**

18. In what months do you initially stock nets or cages with spat on your site?

19. What gear type (nets, cages, etc.) do you use for juvenile culture in year 1 (Y1)?

20. With how many individuals / level (cage) do you initially stock your nets (cages) in Y1? 21. How far apart do you space these enclosures on your line (for nets) or lease (cages)?

22. What is the stocking, grading, and cleaning schedule for Y1 scallops?

23. Do you change nets types at any time over the course of this 12 month period?

24. Do you use any equipment to help with grading, cleaning, or thinning in Y1?

25. What is the expected total loss, percentage wise, over the 12 months from initial stocking in juvenile culture enclosures to stocking into Y2 enclosures?

26. Is there a seasonality to this loss? Are there processes specific to Y1 that cause mortality?

***Grow-out Y2:* Y2 refers to the period beginning 12 months from initial stocking of spat into nets or cages and ending 12 months after that time.**

27. In Y2 of grow-out, do you **ear-hang** or use **enclosures** (nets, cages, etc.)?

*If enclosures:*

28. Are the enclosures you use in Y2 different from those in Y1 in size, type, mesh, etc.?

29. If so, in what months do you begin to transfer scallops into these new nets?

30. With how many individuals / level (cage) do you initially stock these new enclosures in Y2? 31. How far apart do you space these enclosures on your line (for nets) or lease (cages)?

32. What is the stocking, grading, and cleaning schedule for Y2 scallops?

33. Do you change net or cage types at any point during Y2?

34. Do you use any equipment to help with grading, cleaning, or thinning in Y2? 35. What is the expected total product loss, percentage wise, over Y2?

36. Is there a seasonality to this loss? Are there processes specific to Y2 that cause mortality? *If ear hanging:*

37. In what months do you start ear-hanging in Y2?

38. How large are your scallops typically once you begin ear-hanging?

39. How many scallops / ear-hanging line do you typically fit?

40. Do you clean scallops before the process?

41. Do you grade scallops before the process?

42. What, if any, special equipment do you use to ear-hang?

43. How far apart on the longline do you space ear-hanging lines?

44. Do you weigh down the bottom of your ear-hanging lines?

45. How often do you clean ear-hung scallops during the course of Y2? 46. Do you use any equipment or machinery to clean ear hung scallops?

47. What is the expected total loss, percentage wise, at the end of Y2?

48. Is there a seasonality to this loss? Are there processes specific to Y2 that cause mortality? ***Grow-out Y3:***

*If enclosures in Y3:*

49. Are the enclosures you use in Y3 different from those in Y2 in size, type, mesh, etc.?

50. If so, in what months do you begin to transfer scallops into these new nets / cages?

51. With how many individuals / level (cage) do you initially stock these new enclosures in Y3? 52. How far apart do you space these enclosures on your line (for nets) or lease (cages)?

53. What is the stocking, grading, and cleaning schedule for Y2 scallops?

54. Do you change net or cage types at any point during Y2?

55. Do you use any equipment to help with grading, cleaning, or thinning in Y2?

56. Do you change net or cage types at any point after thinning during Y3?

57. What is the expected total loss, percentage wise, over the 12 months after Y3 stocking? 58. Is there a seasonality to this loss? Are there processes specific to Y3 that cause mortality?

*If ear hanging in Y3:*

a. If enclosures in Y2:

59. In what months do you start ear-hanging in Y3?

60. How large are your scallops typically once you begin ear-hanging?

61. How many scallops / ear-hanging line do you typically fit?

62. Do you clean scallops before the process?

63. Do you grade scallops before the process?

64. What, if any, special equipment do you use to ear-hang?

65. How far apart on the longline do you space ear-hanging lines?

66. Do you weigh down the bottom of your ear-hanging lines?

67. How often do you clean ear-hung scallops during the course of Y3?

68. What is the expected total loss, percentage wise, at the end of Y3?

69. Is there a seasonality to this loss? Are there processes specific to Y3 that cause mortality?

a. If ear hanging in Y2:

70. How often do you clean ear-hung scallops in Y3?

71. What is the expected total loss, percentage wise, at the end of Y3?

72. Is there a seasonality to this loss? Are there processes specific to Y3 that cause mortality? **Operating expenses**

1. Please refer to table 3 for the following set of questions. Together, we will go through the tasks and try to record the total hours dedicated to each task annually. First, please specify the time unit with which you feel most comfortable describing each task. For example, minutes per net cleaning, days to grade an entire year class, etc. Next, please estimate the time required to complete the task using the units you specified. Finally, please make an annual time requirement estimate for each task. This should represent the total number of hours, days, weeks, or months, dedicated to each task in total.

2. Please refer to table 4. This table presents a list of operating expenses. We will now go through the list, identify the unit in which you would like to present these expenses (hours / week, total hours per month or year, etc.), estimate the cost per unit, and then estimate the total number of units per year, month, week, day, etc.

Table S1.Capital expenditures and associated lifespans

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Item*** | ***In use? (Y/N)*** | ***Type (specify)*** | ***Unit*** | ***Cost / unit*** | ***Lifespan (years)*** | ***Rep. %*** | ***% to scallops*** |
| Anchors |  |  |  |  |  |  |  |
| Horizontal Long Line |  |  |  |  |  |  |  |
| Vertical Mooring Line |  |  |  |  |  |  |  |
| Lease Marker Buoys |  |  |  |  |  |  |  |
| Corner Tension Buoys |  |  |  |  |  |  |  |
| Compensation Buoys |  |  |  |  |  |  |  |
| Boom / Hauler  |  |  |  |  |  |  |  |
| Truck |  |  |  |  |  |  |  |
| Star Wheel |  |  |  |  |  |  |  |
| Spat Line Buoys |  |  |  |  |  |  |  |

Table S1. Continued

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Item*** | ***In use? (Y/N)*** | ***Type (specify)*** | ***Unit*** | ***Cost / unit*** | ***Lifespan (years)*** | ***Rep. %*** | ***% to scallops*** |
| Spat Line Anchors |  |  |  |  |  |  |  |
| Spat Bag Mooring Line |  |  |  |  |  |  |  |
| Spat Bags |  |  |  |  |  |  |  |
| Spat Bag Filling |  |  |  |  |  |  |  |
| Lantern Nets |  |  |  |  |  |  |  |
| Pearl Nets |  |  |  |  |  |  |  |
| Bottom Cages |  |  |  |  |  |  |  |
| Scallop Washer |  |  |  |  |  |  |  |
| Scallop Grader |  |  |  |  |  |  |  |
| Bost Customization |  |  |  |  |  |  |  |
| Fish Tote |  |  |  |  |  |  |  |
| Packaging Supplies |  |  |  |  |  |  |  |
| Business computer |  |  |  |  |  |  |  |
| Longline Weights |  |  |  |  |  |  |  |
| Mooring Chain  |  |  |  |  |  |  |  |
| High Flyers |  |  |  |  |  |  |  |
| Vessel |  |  |  |  |  |  |  |

Table S2.Capital expenditures not included in table 1 and their associated unit costs / lifetimes

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Item*** | ***In use? (Y/N)*** | ***Type (specify)*** | ***Unit*** | ***Cost / unit*** | ***Lifespan (years)*** | ***Rep. %*** | ***% to scallops*** |
|  |  |  |  |  |  |  |  |
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Table S3.Production tasks and their associated time requirements and frequencies

|  |  |  |  |
| --- | --- | --- | --- |
| ***Task*** | ***Unit*** | ***Time / Unit*** | ***Annual Time Requirement*** |
| Spat Bag Deployment |  |  |  |
| Spat Bag Retrieval |  |  |  |
| Cleaning scallops |  |  |  |
| Grading scallops |  |  |  |
| Thinning scallops |  |  |  |
| Stocking nets/cages |  |  |  |
| Ear hanging |  |  |  |
| Other |  |  |  |
| Other |  |  |  |
| Other |  |  |  |

Table S4.Operating expenses and fixed costs

|  |  |  |  |
| --- | --- | --- | --- |
| ***Item*** | ***Unit*** | ***Price / Unit*** | ***Count*** |
| Full Time Labor |  |  |  |
| Part Time Labor |  |  |  |
| Volunteer Labor |  |  |  |
| Boat Fuel |  |  |  |
| Truck Fuel |  |  |  |
| Boat Maintenance |  |  |  |
| Truck Maintenance |  |  |  |
| Equipment Maintenance |  |  |  |
| Boat Insurance |  |  |  |
| Truck Insurance |  |  |  |
| Crop Insurance |  |  |  |
| Business Liability Insurance |  |  |  |
| Other |  |  |  |
| Other |  |  |  |
| Other |  |  |  |
| Other |  |  |  |

**Bioeconomic model parameters**

Table S5. Production model parameters

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| --- |
| *Production model parameters* |
| Spat bags per line | 20 |
| Average spat per collector bag | 1,500 |
| Initial juvenile culture stocking density (6mm nets) | 200 tier -1 |
| Juvenile culture thinning density (12mm nets) | 50 tier -1 |
| Initial grow out thinning density (12mm nets) | 15 tier -1 |
| Final grow-out density (scenario 3 only) | 5 tier-1 |
| Longline spacing | 100ft |
| Lease depth | 60ft |
| Annual mortality | 12.5% |
| Market size (mm) | 75 |
| Time to market from 7mm spat (months) | 19 - 31 |
| Harvest schedule | Year round |

Table S6. Economic model parameters

|  |  |
| --- | --- |
| Labor cost (USD/FTE including benefits, PTO, and payroll tax) | $25.00 |
| Business and startup fees | $1,883.00 |
| Owner debt:equity | 50:50 |
| Discount rate | 7.5% |
| Loan characteristics | 10 year term, annual repayment schedule, 7.5% interest |

Table S7. Depreciable capital items

|  |  |  |  |
| --- | --- | --- | --- |
| *Item* | *Unit* | *Unit Cost* | *Lifespan (years)* |
| Lantern net: 6mm | Each | $21.67 | 8 |
| Lantern net: 12mm | Each | $21.67 | 8 |
| Lantern net dropper lines (11/32") | Foot | $0.07 | 10 |
| Longlines | Lot | $3,178.93 | 8 |
| Lease markers (highflyers) | Each | $79.99 | 15 |
| Vessel (includes hydraulics, jib crane, starwheel (pair), live well, hot tank, and customization for washer and grader) | Lot | $150,000.00 | 25 |
| Truck | Lot | $23,000.00 | 7 |
| Scallop washer (includes sump pump, generator, 24-volt battery, washer pump, fabrication and installation) | Lot | $36,123.00 | 15 |
| Scallop grader (includes shipping, converter, battery, fabrication, and installation) | Lot | $13,643.85 | 15 |
| Sorting racks | Pair | $75.00 | 7 |
| Business computer | Single | $800.00 | 7 |
| Spat line (11/32”) | Foot | $0.07 | 10 |
| Spat anchors | Each | $5.00 | 10 |
| Spat bag floats | Each | $20.00 | 10 |

Table S8. Longline components

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Item* | *Unit* | *Unit Cost* | *Lifespan* | *Quantity per line* | *Total cost per line* |
| Anchor (2-ton granite blocks, includes ring and bridles) | Each | $199.00 | 8 | 2 | $398.00 |
| Longline (1.25", 8 strand woven nylon) | Foot | $0.91 | 8 | 800 | $728.00 |
| Mooring line (1.25", 8 strand woven nylon) | Foot | $0.91 | 8 | 360 | $327.60 |
| Corner tension floats (75 lb., 16" diameter) | Each | $14.99 | 8 | 15 | $224.85 |
| Compensation floats (75 lb., 16" diameter) | Each | $14.99 | 8 | 70 | $1,049.30 |
| Negative buoyancy weights (cement buckets) | Each | $4.00 | 8 | 94 | $376.00 |
| Compensation float and weight dropper lines (11/32") | Foot | $0.07 | 8 | 1074 | $75.18 |

Table S9. Operating expenses

|  |  |  |
| --- | --- | --- |
| *Item* | *Unit* | *Unit Cost* |
| Boat Maintenance | Monthly lot | $100.00 |
| Truck Maintenance | Monthly lot | $75.00 |
| Misc. Equipment Maintenance (Pumps, grader, washer, hydraulics) | Monthly lot | $50.00 |
| Misc. Expendable Supplies (Fish totes, coolers, zip ties, tools, power washer, etc.): 1 lot per lantern net | USD / net | $0.10 |
| Boat Fuel | USD / gallon | $2.11 |
| Truck Fuel | USD / gallon | $2.85 |
| Harvesting and packaging supplies | USD / 200 harvested individuals | $0.12 |
| PPE replacement | Lot | $15.00 |
| Spat bags (annual cost) | USD / bag | $2.00 |
| Spat bag filling (annual cost) | USD / sq foot | $0.10 |

Table S10. Fixed costs

|  |  |  |
| --- | --- | --- |
| *Item* | *Annual Cost* | *Notes* |
| Boat insurance | $9,000.00 | 6% of the vessel value |
| Truck insurance | $300.00 |  |
| Mooring and Dockage | $2,000.00 |  |
| Biotoxin testing\* | $7,200.00 | Avg. 2 tests / month (4 tests/month in summer, 1 test/month in winter) |
| Business liability insurance | $500.00 |  |
| Accounting fees | $400.00 |  |
| Lease rent fees | $100.00 | $ / acre |

Table S11. Labor tasks and associated rates

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Item* | *Unit* | *Time* | *Individuals* | *Full time equivalent* |
| August spat line/bag assembly | Hours per line | 1 | 2 | 2 |
| Fall spat bag deployment | Hours per line | 2 | 2 | 4 |
| Winter spat line maintenance | Hours per line | 1 | 2 | 2 |
| Spring spat bag collection | Hours per line | 2 | 2 | 4 |
| Spring seed sorting | Minutes per spat bag | 20 | 2 | 40 |
| Spring seed stocking: 6mm lantern nets | Minutes per net | 5 | 2 | 10 |
| Fall juvenile thinning/net swap: 12mm lantern nets | Minutes per net | 13 | 2 | 26 |
| Spring adult grading/cleaning/net swap: 12mm nets | Minutes per net | 20 | 2 | 40 |
| Fall adult thinning\* | Minutes per net | 20 | 2 | 40 |
| Year round harvest | Minutes per 250 individuals | 2 | 2 | 4 |
| Spring line installation | Hours per line | 6 | 2 | 12 |