

Town of Orleans

Lonnie's Pond Aquaculture and Nitrogen Management Plan



**A Partnership with
Coastal Systems Program
School for Marine Science and Technology
University of Massachusetts Dartmouth**

Lonnie's Pond Aquaculture/TMDL Annual Report (Part One)

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Town of Orleans

1.0 Background

The Town of Orleans is working on options to reduce nitrogen loads to its estuaries through a variety of strategies, including improved wastewater treatment, but also through lower-cost, non-traditional approaches. These efforts reflect the community's desire for clean water and an understanding of the linkage of the local economy to healthy ecosystems, but also recognition of the need to attain nitrogen reductions required by the Massachusetts Department of Environmental Protection (MassDEP) through their adoption of Total Maximum Daily Loads (TMDLs) for impaired waters under the federal Clean Waters Act.

In 2007, MassDEP finalized TMDLs for Pleasant Bay that identified portions of the estuary, including Lonnie's Pond, as having excessive nitrogen with resulting impaired water and habitat quality.¹ The Massachusetts Estuaries Project report for Pleasant Bay², which is the technical basis for the TMDLs, suggested that the nitrogen load to Lonnie's Pond would need to be lowered by 300 kg N/yr to mitigate the impairments.

In 2016, the Town began a demonstration project in Lonnie's Pond to evaluate a non-traditional, nitrogen reduction approach using oyster aquaculture. The Lonnie's Pond Demonstration Project was planned as a three-year effort to evaluate likely water quality improvements and determine any implementation issues associated with enhanced aquaculture for nitrogen reduction as part of achievement of the TMDL without sewerage within the Pond watershed. Monitoring during the demonstration project found significant removal of nitrogen and some water quality improvements due to shellfish growth and bio-deposition.³

In 2018, the Town approved the Lonnie's Pond Aquaculture and Nitrogen Management Plan⁴ to transition from an oyster aquaculture demonstration project to a sustainable long-term oyster aquaculture system for nitrogen removal toward achieving compliance with the TMDL. The Management Plan detailed the logistical, regulatory, monitoring, and public coordination components needed for long-term use of aquaculture as part of the Town's nitrogen management program for its estuaries, including two regular reports on Plan implementation to be prepared by the Monitoring Contractor [Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth (CSP-SMAST)]: a Semi-Annual Status Update and Annual Report. A Quality Assurance Project Plan (QAPP) was submitted and approved by MassDEP in May 2019 to ensure regulatory acceptance of collected data for TMDL compliance. As specified in the Management Plan, the Annual Report summarizes aquaculture

¹ MassDEP. 2007. FINAL Pleasant Bay System Total Maximum Daily Loads For Total Nitrogen (Report # 96-TMDL-12, Control #244.0). 53 pp.

² Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2006). Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA. 245 pp.

³ Coastal Systems Program, School of Marine Science and Technology (CSP/SMAST), University of Massachusetts-Dartmouth, Lonnie's Pond Shellfish Demonstration Project: Year 2 Monitoring Summer/Fall 2017 Oyster Deployment. September 2018. 75 pp.

⁴ Howes, B. and E. Eichner. 2018. Town of Orleans Lonnie's Pond Aquaculture and Nitrogen Management Plan. Coastal Systems Program, School of Marine Science and Technology (CSP/SMAST), University of Massachusetts-Dartmouth. New Bedford, MA. 128 pp.

activities, shellfish N removal, progress toward meeting the TMDL, and considerations for refinement of Plan activities and follows the 1st Semi-Annual Status Update, submitted July 31, 2019. This current document is part one of the 1st Annual Report relating directly to TMDL compliance monitoring, focusing primarily on the aquaculture N removal relative to the TMDL N target. Part two will focus on water quality impacts and ecosystem monitoring and their relationship to TMDL goals.

In 2019, Ward AquaFarms deployed year 1 (seed) and year 2 oysters in mid-July. Approximately, 1.5 million oysters, weighing 1,359 kg live wet weight, with 4.2 kg of N contained within their tissue and shell. Oysters remained in Lonnie's Pond until mid-December for an average deployment of 144 days. Upon harvest in December 2019 there were 708,423 live year 1 and 69,427 live year 2 oysters containing a total N mass of 63.2 kg N in their tissue and shell. Accounting for the N content in the YR1 and YR2 oysters at the times of their deployment and harvest yields a net removal of 59 kg of nitrogen by the implementation of the aquaculture plan. This removal was 79% of the plan goal (75 kg N) and 20% of the overall Lonnie's Pond TMDL nitrogen removal target. An additional 1.9 kg N was removed (1.9 kg N) by YR3 and YR4 oysters that remained from the demonstration project, which makes the total N removed by oysters in 2019 ~61.9 kg N or 82.5%.

The 2019 harvest results were comparable to those achieved in 2018, the final year of the demonstration project, but were achieved in only 62 days due to the later initial deployment. Therefore, it is likely that additional nitrogen would be removed with a longer oyster deployment (e.g. earlier deployment).

2.0 Water Quality Monitoring

Using procedures approved in the Lonnie's Pond QAPP, CSP/SMASST staff began coordinating and conducting biweekly water quality monitoring in Lonnie's Pond starting on April 24, 2019. To date there have been ten sampling events from 4-24-19 through 10-23-2019 (Table 1). Samples were collected at nine locations in Lonnie's Pond (Figure 1). The deployment of a continuous monitoring device was delayed to match the later oyster deployment. Deployment of two moorings occurred on 08-06-2019 at LP6 and LP 10 and recorded until retrieval on 12-4-2019.

All water quality samples were transported back to the CSP Analytical Facility to be processed for dissolved nutrients, particulate organic C and N, total nitrogen, total chlorophyll a pigments, and salinity. In addition to the pond sampling, water samples and stream flow measurements were made biweekly at the two streams discharging into Lonnie's Pond: 1) the herring run from Pilgrim Lake and 2) the cranberry bog outlet downstream of Crystal Lake. A continuous stage meter is deployed in the stream from Pilgrim Lake to provide daily freshwater discharge volume. Flow from the cranberry bogs is minimal and intermittent and is only monitored at the time of the biweekly stream sampling. Flows in 2019 from the cranberry bog were very low and there were no flows from September through October. These results are reviewed in part 2 of this report.

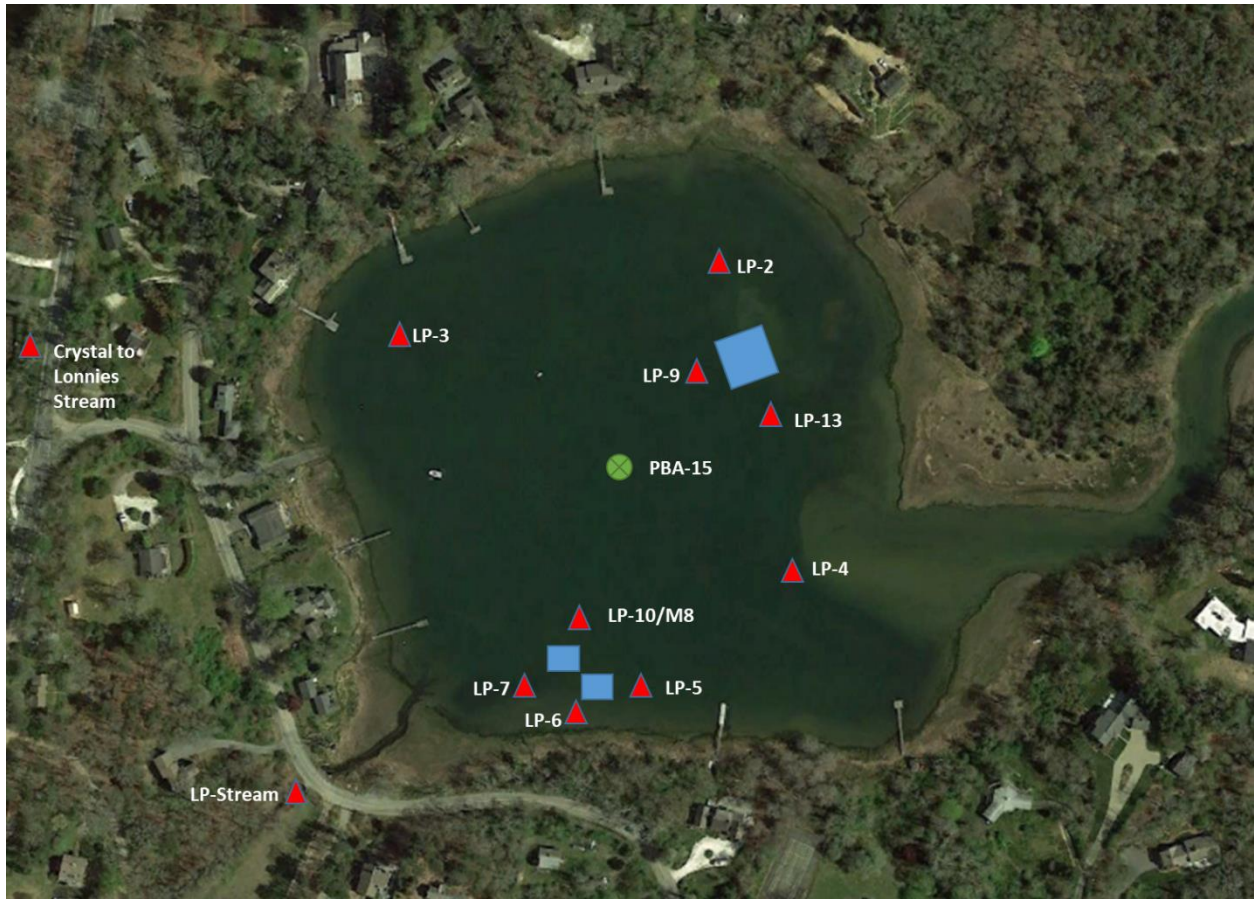


Figure 1. Station map of Lonnie's Pond 2019 water quality sampling locations. The red triangles are sampled biweekly by CSP staff April 24, 2019 through November 2019, green circle is sampled biweekly by volunteers from July 15 to September 15, and blue squares represent the oyster deployment areas.

Table 1. Sampling dates for water quality and laboratory assays performed on samples.

Sample Date	# of samples	Assays							
		NH4	PO4	NO3/NO2	TDN	POCN	TSS	CHLA	Salinity
4/25/2019	20	X	X	X	X	X	X	X	X
5/13/2019	21	X	X	X	X	X	X	X	X
5/28/2019	21	X	X	X	X	X	X	X	X
6/12/2019	21	X	X	X	X	X	X	X	X
7/11/2019	21	X	X	X	X	X	X	X	X
7/25/2019	21	X	X	X	X	X	X	X	X
8/8/2019	22	X	X	X	X	X	X	X	X
9/5/2019	21	X	X	X	X	X	X	X	X
9/23/2019	23	X	X	X	X	X	X	X	X
10/23/2019	23	X	X	X	X	X	X	X	X
Total	214								

3.0 Oyster Aquaculture Deployment

The Aquaculture Contractor (Ward Aquafarms, LLC) began the installation of oysters in Lonnie's Pond on July 9. This installation was later than the July 1 date specified in the QAPP and Management Plan, but was required to ensure that the oyster seed was large enough (10 mm) to remain in the floating bags used for grow-out. Ward Aquafarms speculated that the 2019 seed grew slower than usual in the pre-deployment upwellers due to the cooler weather conditions in the spring and early summer. Whatever the precise cause, an additional week of seed growth was required before deployment. Oysters were deployed on Tuesdays and Thursdays beginning July 9 over 3-weeks, totaling six deployment days; full deployment was completed on July 25.

Ward Aquafarms and CSP/SMASST staff coordinated weighing and counting of oysters on each deployment day. Staffs worked with each other to cross-check count estimates by bag and subsample weights and volumes, as well as documenting values for each of the various oyster strains. Comparison of methods generally showed differences in individual counts of less than 5%, typically <2.5%. Over the six deployment days, a total of 1.55 million oysters were deployed. The total deployed oysters was comprised of approximately 1.47 million year 1 (YR1) oyster seed comprised of Maine, Connecticut, Mixed, and Triploid strains and 77,000 year 2 (YR2) oysters relayed from Falmouth (Table 2).

For all oyster strains deployed in 2019, subsamples of oysters at the time of deployment were collected for weighing and determination of N content. As specified in the QAPP, % N content was determined for tissues and shells. These were used to determine the total N mass in the initial deployment and the same procedures were utilized at the harvest.

The nitrogen content of the oysters deployed in July totaled 4.2 kg N (see Table 2). While oysters were in the pond, Ward Aquafarms staff maintained the bags by flipping them regularly and rotating them around Lonnie's Pond for optimal growth based on insights developed during the Lonnie's Pond Demonstration Project 2016-2018. CSP staff noted very little algae on floating bags with the overall result being a relatively low mortality for all strains, less than 9%.

Table 2. Total weight and counts of the initial oyster deployment. Oyster subsamples collected for each strain for percent nitrogen determination (Revised from Semi-Annual Report 2019).

Oyster Deployment Data							
ID	Date	Oyster Strain	Total		Dry Weight (kg)	%N Content (DW)	Total N inputs (kg)
			Wet Weight (kg)	Total # of live oysters			
Day1	7/9/2019	YR1 CT	31.1	166,619	20.69	0.86	0.178
Day1	7/9/2019	YR1 MK	34.6	140,665	22.70	0.83	0.188
Day2	7/11/2019	YR1 CT	45.3	349,250	28.07	0.83	0.234
Day2	7/11/2019	YR1 MK	33.9	183,375	21.79	0.97	0.212
Day3	7/16/2019	YR1 Mixed	42.7	321,561	27.66	0.74	0.204
Day4	7/18/2019	YR1 Mixed 4mm	7.9	110,880	4.86	0.63	0.031
Day4	7/18/2019	YR1 Mixed 2mm	2.7	90,818	2.40	0.66	0.016
Day4	7/18/2019	YR1 Trips 2mm	1.7	57,551	1.15	0.83	0.010
Day5	7/23/2019	YR2 Fal	438.9	38,581	310.22	0.40	1.233
Day5	7/23/2019	YR2 Fal (Shells)	31.7	-	28.55	0.15	0.043
Day6	7/25/2019	YR2 Fal	641.8	38,477	447.37	0.40	1.775
Day6	7/25/2019	YR2 Fal (Shells)	43.5	-	39.13	0.14	0.056
Day6	7/25/2019	YR1 Trips 8mm	3.4	48,171	2.24	0.83	0.019
Total YR1			203.2	1,468,889	131.6	-	1.09
Total YR2			1155.9	77,058	786.1	-	3.11
Total			1359.2	1,545,947	956.8	-	4.20

In December, oysters were relayed from the pond by Ward Aquafarm on five dates over a period of 16 days. CSP staff worked with the Town of Orleans and Ward Aquafarm staff to collect oyster weights, counts, and subsamples. Large trucks were used to transport oysters from the Pond. At the start of the each relay day, empty trucks were weighed at the Orleans Transfer Station and then weighed again after loading the oysters to determine the total mass of oysters removed from Lonnie's Pond. CSP staff collected whole bag weights on a minimum of 25 bags for each of the variety of oyster strains: YR2, YR1 CT, YR1 MK, YR1 Triploid, YR1, Mixed. In addition, 5 to 10 bags (per strain) were further assessed to determine: empty bag weight, live oyster count and weight, and dead oyster count and weight. Data was collected on the Lonnie's Pond boat ramp and occasionally the next day at the Ward Aquafarms storage facility when necessary. CSP weight data and Orleans Transfer Station Scale weights were within 3% of each other each day and within 0.5% for all days totaled (Table 3), indicating that the truck scale is an accurate way to determine total mass of oysters removed, as long as pre-loading truck weight is determined each day and there is an appropriate correction for the empty grow-out bags.

Table 3. Oyster weights determined by CSP staff compared to Orleans Transfer Station truck scale weights. This exercise was conducted as an independent verification of the harvested oyster weights by strain and showed excellent agreement between the methods.

Date	# of Bags		Strain	Average	Total Wet	Net Wet	Percent Difference
	Relayed	Tag Color		Oyster Wet Weight with Bag (kg)	Weight with Bag By Strain (kg)	Weight from Truck Scale (kg)	
12/2/2019	50	Purple	YR2 Fal Megansett	7.50	375		
12/2/2019	44	Barcode	Eric's Studs	12.30	541		
12/2/2019	44	No tag	Dan YR2 - x2 stock	9.82	432		
12/2/2019					1348	1313	2.7%
12/4/2019	179	Purple	YR2 Fal. Megansett	8.55	1531		
12/4/2019	25	No tag	Dan YR2 - x2 stock	9.53	238		
12/4/2019					1769	1752	1.00%
12/9/2019	272	Purple	YR2 Fal. Megansett	8.21	2234		
12/9/2019					2234	2232	0.11%
12/16/2019	427	Blue	YR1 Mixed	6.21	2650		
12/16/2019	168	Red	YR1 Triploid	7.36	1237		
12/16/2019	102	Green	YR1 Maine	11.22	1145		
12/16/2019					5032	5126	1.84%
12/18/2019	241	Green	YR1 Maine	13.58	3272		
12/18/2019	463	Yellow	YR1 Conneticut	9.67	4477		
12/18/2019	8	Blue	YR1 Mixed	4.17	33		
12/18/2019					7782	7829	0.60%
Total -All Relay Days					18166	18250	0.46%

Over the five days of harvesting, over 20 tons of oysters and bags were relayed from Lonnie's Pond comprised of approximately 708,000 YR1 oysters at ~40 mm shell length and 70,000 YR2 oysters at ~55 mm shell length (Table 4). Using deployment counts, relay counts, and mortality of YR1 oysters, it is estimated that approximately 650,000 oysters were lost by falling through the mesh in the grow-out bags when deployed into 8 mm mesh bags before reaching a minimum size of 10 mm (see Table 4). YR1 Maine (MK) oysters were deployed at ~11.5 mm size, resulting in a loss of only 54,000 oysters. Whereas, the strain, YR1 Mixed, were deployed at a size of ~7.9 mm size, resulting in a loss of 341,000 oysters.

Due to poor growing conditions the oyster seed was still small in July when the oysters were deployed to Lonnie's Pond. The "lost" oysters represent a significant amount of nitrogen removal potential that could have been realized if the oysters had survived and grown throughout the

season. Based on the average weight and % N content of the harvested oysters, it is estimated that the “lost” oysters represent up to 38 kg of potential nitrogen removal, if the oyster seed was all a minimum 10 mm size.

Table 4. Total counts, sizes, and mortality of each oyster strain. ”lost”* oysters are oysters that fell through the 8mm mesh bags upon deployment due to their small size. “% mortality**” is based on # of dead oysters (open shells) compared to total individuals in a bag, which does not include “lost” oysters.

Strain	# of Oysters Deployed	# of Live Oysters Relayed	# of Oysters "lost"*	avg. size at	avg. size at	%
				deployment (mm)	relay (mm)	Mortality **
YR1 Connecticut (CT)	515,869	234,741	236,297	10.09	40.4	9%
YR1 Maine (MK)	324,040	242,937	54,136	11.58	40.2	8%
YR1 Mixed	523,258	149,635	341,023	9.46	40.2	6%
YR1 Triploids	105,722	81,110	19,183	7.90	39.0	5.1%
YR2 Fal	77,058	69,427	NA	40.6	55.2	9%
Total	1,545,947	777,850	650,639	-	-	-

Weights and count data documented that a total of 781,392 live oysters totaling 17,441 kg were harvested from Lonnie’s Pond in December 2019 (Table 5). Oysters from all five strains, plus the YR3 and YR4 oysters from the 2016-2018 demonstration project were subsampled for dry tissue weight, shell weight, and their respective %N content.; these were combined to determine the total nitrogen in the oysters harvested from Lonnie’s Pond. Generally, %N content (dry weight) of oysters was not significantly different for year 1 (0.66 to 0.75 %N) and year 2 (0.46 to 0.83 %N) oysters (see Table 5) and were also similar to the YR3 & YR4 oysters (0.68 %N). Collectively, the oysters in Lonnie’s Pond incorporated a total of 61 kg of nitrogen in their tissues and shells during growth from their initial deployment.

If the only the YR1 and YR2 oysters are considered, they incorporated a total of 59 kg N during the 2019 growing season in Lonnie’s Pond. It should also be noted that significant additional removal of nitrogen through sediment processes (8 to 10 kg N in 2016-2018) is not included in these removal numbers, which reflect only the actual net removal in harvested tissue and shell. The sediment removals and water quality information are detailed in Part 2 of this report.

Table 5. Total weight and counts of the oyster relay. Oyster subsamples collected for each strain for percent nitrogen determination.

Oyster Relay Data							
ID	Date	Oyster Strain	Total Wet Weight (kg)	Total # of live oysters	Dry Weight (kg)	%N Content (DW)	Total N removed (kg)
Day1	12/2/2019	YR2 Fal	2649	5,500	1,689	0.46	7.820
Day1	12/2/2019	YR2 Fal (Shells)	53	-	48	0.19	0.092
Day1	12/2/2019	YR2 Fal x2stocked	342	6,516	211	0.51	1.070
Day1	12/2/2019	YR2 Fal x2stocked (Shells)	63	-	52	0.14	0.074
Day1	12/2/2019	YR3 & YR4 Studs	461	3,542	284	0.68	1.931
Day1	12/2/2019	YR3 & YR4 Studs (Shells)	61	-	50	0.42	0.214
Day2	12/4/2019	YR2 Fal	1124	19,213	702	0.60	4.236
Day2	12/4/2019	YR2 Fal (Shells)	171	-	189	0.16	0.307
Day2	12/4/2019	YR2 Fal x2stocked	186	3,400	114	0.60	0.690
Day2	12/4/2019	YR2 Fal x2stocked (Shells)	25	-	28	0.16	0.045
Day3	12/9/2019	YR2 Fal	1711	34,798	1,047	0.83	8.653
Day3	12/9/2019	YR2 Fal (Shells)	249	-	216	0.32	0.682
Day4	12/16/2019	YR1 Triploids	1038	81,110	472	0.75	3.533
Day4	12/16/2019	YR1 Triploids (Shells)	105	-	84	0.28	0.233
Day4	12/16/2019	YR1 Mixed	2019	147,884	1,015	0.75	7.583
Day4	12/16/2019	YR1 Mixed (Shells)	40	-	32	0.22	0.070
Day4	12/16/2019	YR1 MK	994	71,369	528	0.66	3.472
Day4	12/16/2019	YR1 MK (Shells)	59	-	51	0.20	0.102
Day5	12/18/2019	YR1 MK	2485	171,568	1,320	0.66	8.681
Day5	12/18/2019	YR1 MK (Shells)	210	-	182	0.20	0.362
Day5	12/18/2019	YR1 CT	3400	234,741	1,880	0.76	14.375
Day5	12/18/2019	YR1 CT (Shells)	344	-	280	0.27	0.751
Day5	12/18/2019	YR1 Mixed	26	1,750	15	0.78	0.114
Day5	12/18/2019	YR1 Mixed (Shells)	1	-	1	0.26	0.002
Total YR1			10719	708,423	5858	-	39.3
Total YR2			6261	69,427	4027	-	22.9
Total YR3&YR4			461	3,542	284	-	1.9
Total			17441	781,392	10169	-	65.09
Total Harvested N from Lonnie's Pond: 65.09 kg - 4.20 kg =							60.89

4.0 Considerations for Future

Overall, the 2019 oyster deployment achieved the general goals outlined in the Lonnie's Pond Aquaculture and Nitrogen Management Plan. CSP staff working with Ward Aquafarm and Town staff were able to document ~60 kg N net removal in the oyster harvest. We also documented ways to make the future deployment and monitoring more efficient. Considerations for future deployments include:

- 1) Try to identify the best 2 or 3 oyster strains. Multiple strains of oysters increase the time and effort for documenting nitrogen removals, since each strain must have a complete tracking, evaluation, subsampling, analysis, etc.
- 2) Use of the Orleans Transfer Station Scale "truck scale" for harvest weight determinations appears to be adequate on its own for determining oyster mass harvested, although individual strains must be accommodated.
- 3) The Town should explore the possibility of installing a spring upweller in Lonnie's to increase the nitrogen removal in May/June. Oysters in upwellers are efficient at taking up nitrogen as the seed grow to the size needed for deployment in floating bags. The siting and logistics would need to be worked out, but portable upwellers are in regular use on Cape Cod. This type of installation would address the uncertainties of attaining sufficiently sized seed in years like 2019, including the loss of seed.
- 4) Continue examination of new approaches to streamline deployment and harvest and to optimize monitoring.
- 5) Continue to specify coordination between the Town, aquaculture contractor and monitoring contractor. The procedures developed during 2019 worked very well and need to be codified and followed in future years. A meeting in February among the parties should be held each year for this purpose.