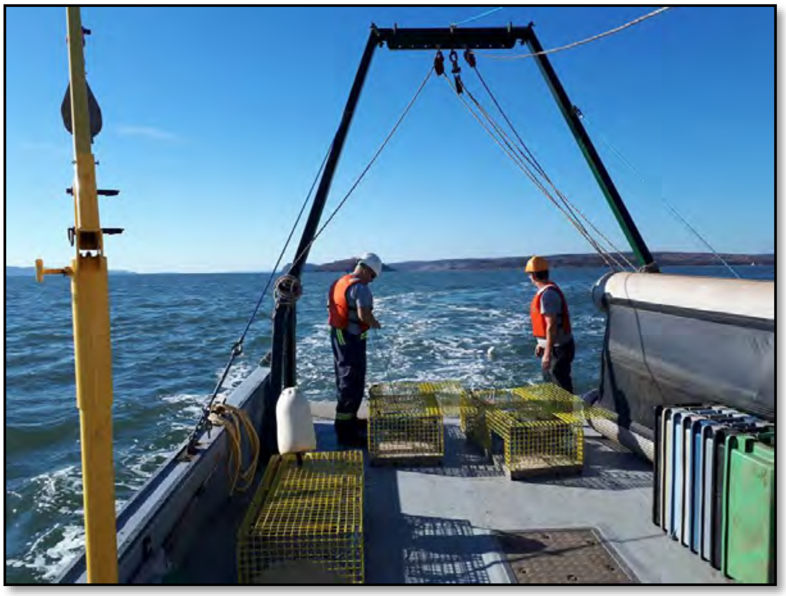

LOBSTER CATCHABILITY STUDY REPORT

PREPARED FOR: FORCE

NEXUS Coastal Resource Management Ltd. | December 2017

NEXUS COASTAL

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SECTION I: OBJECTIVES SUMMARY

The purpose of this study is to monitor lobster catchability within the FORCE Crown Lease Area (CLA; Figure 1). Lobster catchability is represented as catch per unit effort (CPUE), or catch per trap, which functions as a proxy measure for population density. Surveying prior to TISEC turbine deployment establishes initial data for future comparison. Comparing data collected during TISEC turbine deployment against the initial data assesses the level of impact the technology may have on lobster catchability. This research will also test the assumptions of the initial environmental assessment (EA). The AECOM (2009) report assumes minimal TISEC turbine impacts on lobster populations within the CLA, based on the following prescriptive characteristics:

- Species diversity and population density is low;
- The substrate is scoured bedrock;
- The TISEC turbine and equipment has a small footprint in the area;
- With minimal impact, populations will recover to baseline levels in the short-term (AECOM, 2009).

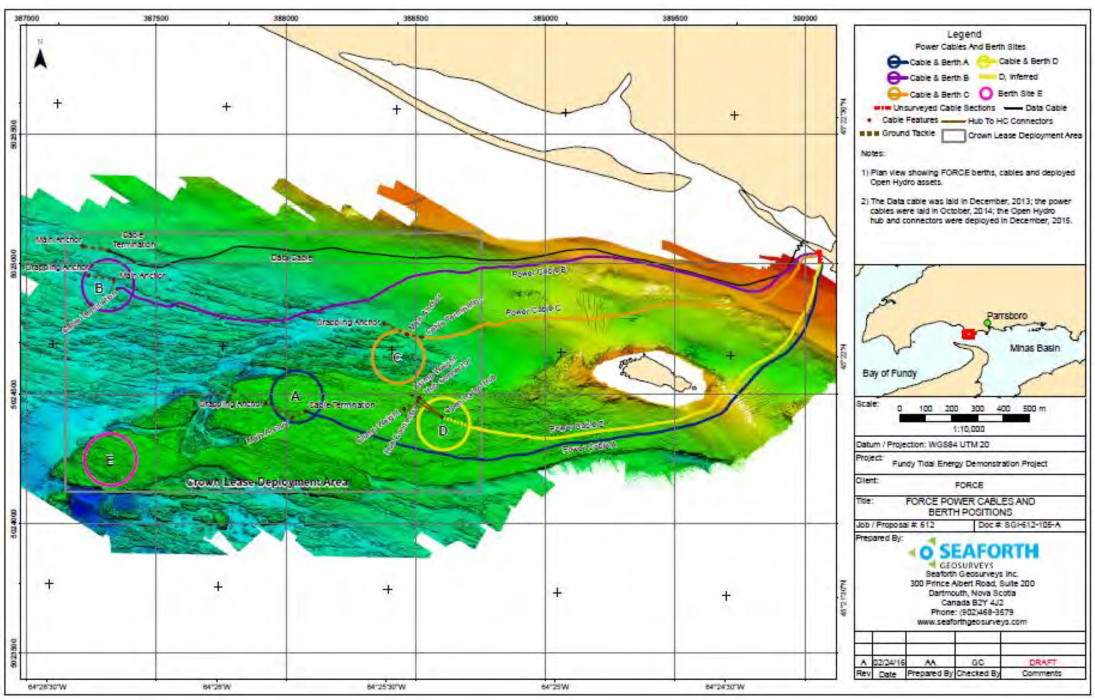


Figure 1. Map of Proposed TISEC device deployment berths (FORCE, 2016).

This study provided opportunity to test sampling methodologies and provided a reference point for comparison of the catchability statistics recorded within the CLA against the general fishery in the Minas Passage, as determined by Fisheries and Oceans Canada (DFO

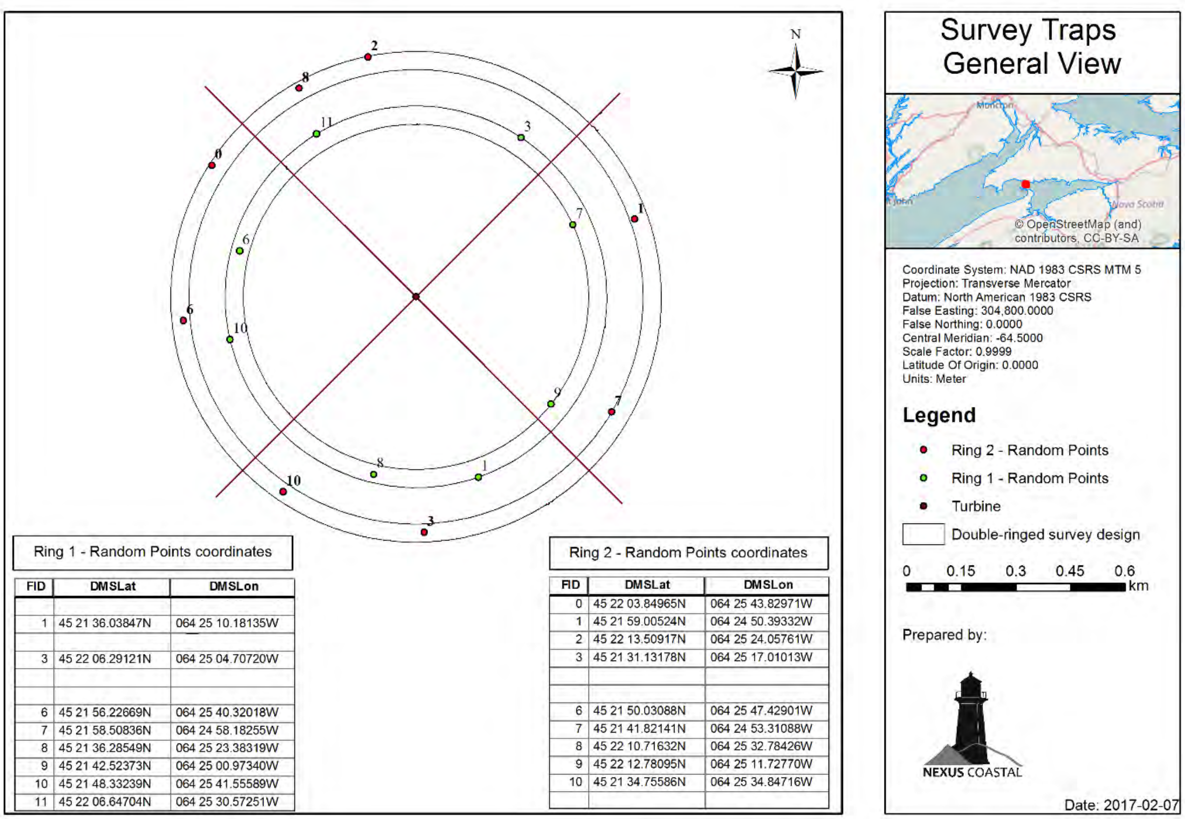
2014). According to the DFO 2014 report, lobster population density in the broader Minas Passage (outside the CLA) as high, using the following catchability gradients:

- 0 - 0.7 kg CPUE (low)
- 0.8 - 1.1 kg CPUE (moderately low)
- 1.2 - 1.7 kg CPUE (moderate)
- 1.8 – 2.3 kg CPUE (moderately high)
- 2.4 – 10.7 kg CPUE (high) (p. 22, Serdynska & Coffen-Smout, 2017)

SECTION II: OVERVIEW OF METHODS

FALL, IN-SEASON SURVEY

The survey plot (Figure 2) is a design modification proposed by Bayley (CEF, 2011). The plot consists of two interval rings centered around the turbine. The inner 'treatment' ring is 50m wide, positioned 475m-525m from the turbine. The 475m exclusion zone over compensates for trap drift due to currents and allows a broad buffer to protect against trap interference with the turbine. The outer 'control' ring is also 50m wide, positioned 575m-625m away from the turbine. In the Bayley design, each ring is comprised of 12 randomized, fixed stations – 24 stations in the entire survey plot. Bayley also recommended sampling stations 3 times for one complete survey (to correct against gear foul or loss), ensuring useable data is collected for each station. Bayley also proposed a soak time parameter of no longer than 24 hours after trap deployment. The survey plot is divided into North, East, South, and West quadrants.



Ring 1 - Random Points coordinates

FID	DMSLat	DMSLon
1	45 21 36.03847N	064 25 10.18135W
3	45 22 06.29121N	064 25 04.70720W
6	45 21 56.22669N	064 25 40.32018W
7	45 21 58.50836N	064 24 58.18255W
8	45 21 36.28549N	064 25 23.38319W
9	45 21 42.52373N	064 25 00.97340W
10	45 21 48.33239N	064 25 41.55589W
11	45 22 06.64704N	064 25 30.57251W

Ring 2 - Random Points coordinates

FID	DMSLat	DMSLon
0	45 22 03.84965N	064 25 43.82971W
1	45 21 59.00524N	064 24 50.39332W
2	45 22 13.50917N	064 25 24.05761W
3	45 21 31.13178N	064 25 17.01013W
6	45 21 50.03088N	064 25 47.42901W
7	45 21 41.82141N	064 24 53.31088W
8	45 22 10.71632N	064 25 32.78426W
9	45 22 12.78095N	064 25 11.72770W
10	45 21 34.75586N	064 25 34.84716W

Figure 2. Adapted double-ringed survey plot.

Local fishing industry representatives advised that it would be difficult to sample more than 12 stations per day, based on tidal cycle and currents. Thus, the survey plot designed was adapted - comprising 16 randomized fixed stations, 8 traps per ring (Table 1).

Table 1. Corresponding coordinates for the 16 randomly selected fixed survey stations. Fixed identification (FID) numbers are also included.

Ring 1 – Coordinates			**Ring 2 - Coordinates**		
FID	DMSLat	DMSLon	FID	DMSLat	DMSLon
1-1	45 21 36.03847N	064 25 10.18135W	0	45 22 03.84965N	064 25 43.82971W
3-1	45 22 06.29121N	064 25 04.70720W	1-2	45 21 59.00524N	064 24 50.39332W
6-1	45 21 56.22669N	064 25 40.32018W	2	45 22 13.50917N	064 25 24.05761W
7-1	45 21 58.50836N	064 24 58.18255W	3-2	45 21 31.13178N	064 25 17.01013W
8-1	45 21 36.28549N	064 25 23.38319W	6-2	45 21 50.03088N	064 25 47.42901W
9	45 21 42.52373N	064 25 00.97340W	7-2	45 21 41.82141N	064 24 53.31088W
10-1	45 21 48.33239N	064 25 41.55589W	8-2	45 22 10.71632N	064 25 32.78426W
11	45 22 06.64704N	064 25 30.57251W	10-2	45 21 34.75586N	064 24 55.42939W

The team used modified commercial American lobster traps made with 2.5 cm wire mesh and measuring 1.21 m (48”) x 0.38 m (15”) x 0.61 m (24”), with two 12.7 cm rings, and one blocked biodegradable escape vent (Figure 3). The traps were weighted with a 150kg concrete slab to minimize movement from the strong tides of the Bay of Fundy. Each trap was connected to a 75m buoy line and corresponding marked buoy (with vessel name and licence number). Each trap was freshly baited with 1.5 kg of redfish during each deployment to align with standard fishing industry practice in the area and affixed with DFO-approved identification tags (Table 2).

Figure 3. Study trap configuration.

Table 2. Documented DFO Science ID tag numbers for each survey trap placed by NEXUS Coastal, which correspond to each survey station. Nexus mooring codes and survey traps are regulated by the provisions of DFO science license #347451.

NEXUS mooring codes	
R1-00-A-3018300	**R2-00-A-3018324**
R1-01-A-3018301	**R2-01-A-3018325**
R1-02-A-3018302	**R2-02-A-3018326**
R1-03-A-3018303	**R2-03-A-3018327**
R1-04-A-3018304	**R2-04-A-3018328**
R1-05-A-3018305	**R2-05-A-3018329**
R1-06-A-3018306	**R2-06-A-3018330**
R1-07-A-3018307	**R2-07-A-3018331**
R1-08-A-3018308	**R2-08-A-3018332**
R1-09-A-3018309	**R2-09-A-3018333**
R1-10-A-3018310	**R2-10-A-3018334**
R1-11-A-3018311	**R2-11-A-3018335**
R1-00-B-3018312	**R2-00-B-3018336**
R1-01-B-3018313	**R2-01-B-3018337**
R1-02-B-3018314	**R2-02-B-3018338**
R1-03-B-3018315	**R2-03-B-3018339**
R1-04-B-3018316	**R2-04-B-3018340**
R1-05-B-3018317	**R2-05-B-3018341**
R1-06-B-3018318	**R2-06-B-3018342**

NEXUS mooring codes	
R1-07-B-3018319	**R2-07-B-3018343**
R1-08-B-3018320	**R2-08-B-3018344**
R1-09-B-3018321	**R2-09-B-3018345**
R1-10-B-3018322	**R2-10-B-3018346**
R1-11-B-3018323	**R2-11-B-3018347**

The field team conducted a Fall, in-season survey from October 24th to November 15th, 2017. Logistically, only 8 stations could be deployed and retrieved in one day. Marine operations in the CLA are greatly impacted by tidal speed, tidal range, and depth; therefore, stations were deployed and retrieved in the most efficient manner possible depending on these factors.

Station positions were entered into the vessel's (*Nova Endeavor*) Nobeltec® GPS plotter to ensure all traps were deployed appropriately. During trap deployment, date, time, station FID, latitude, longitude, ID tag number, and surface temperature were recorded in a logbook. During trap retrieval, ID tag numbers were used to verify station FID, and all other fields were recorded in the logbook. For each station retrieved, the following data was recorded on data sheets (Figure 4):

- Station FID
- Position
- Depth
- Time retrieved
- Species name
- Sex codes (e.g. male – 1; female – 2; and berried female – 3)
- Carapace length for relevant Crustacea– using standard issue calipers
- Total length for relevant fin fish – using a 1 cm offset measuring board
- By-catch total number of individual – for all other species

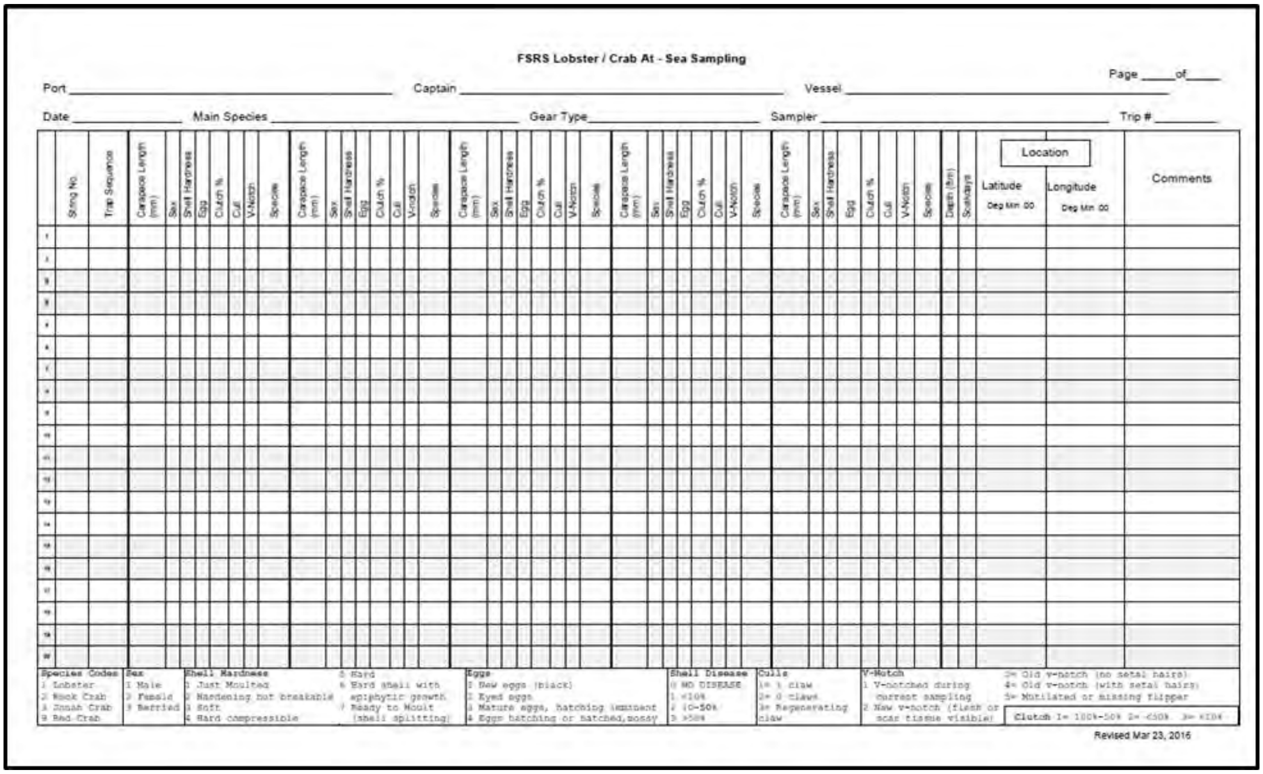


Figure 4. Lobster/Crab At-Sea Sampling data sheet.

Data was entered into the DFO Crustacean Research Information System (CRIS) and an output excel created. The analysis examines catch (kg) per trap by date, station FID, quadrant, and ring (i.e. inner vs. outer).

SECTION III: PRELIMINARY RESULTS

FALL, IN-SEASON SURVEY

Eight survey stations were successfully deployed on seven days between October 24th and November 15th, 2017. During this period three survey plot replications were completed with a retrieval success rate of 97.9% (47 of 48 traps). All stations were successfully retrieved within a soak period of 24 hours except for one station on October 24th. Due to weather conditions all stations set on October 25th were left for a longer soak period. Stations retrieved beyond the 24-hour soak period have been omitted from further analysis.

Within the survey period, daily catchability for survey stations within the CLA plot are categorized as high (>2.7 kg/trap), with one exception. On November 13th, 2017 the field team recorded 1.00kg of lobster caught at station 7-1 – which is moderately low on the DFO catchability scale. Although mean station catchability was high throughout the period, there appears to be a declining trend over time (Figure 5). Catch variability between stations appears to have lowered in the later period. Although we may glean a semblance of trends from these results, currently, the limited time scale prevents broader trend analysis.

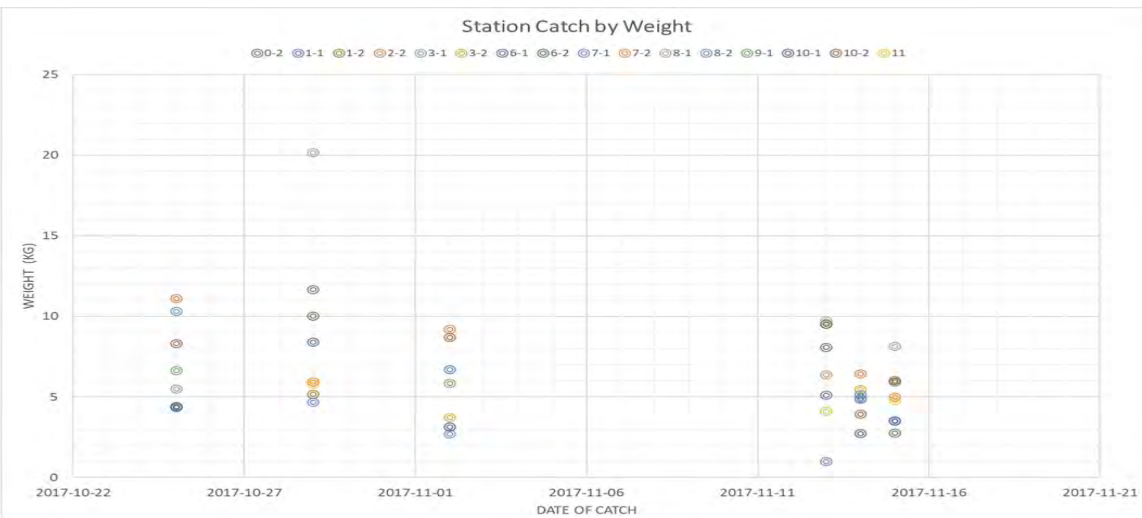


Figure 5. Daily station catchability.

In Figure 6, maximum tidal ranged between 10.5m to 12.3m, throughout the study. The figure depicts a strong negative relationship ($R^2 = 0.75$) between the two variables – as tidal height increases, catches decrease. Our team infers that lobsters limit their movements during periods of high tidal velocity. There was also increased rock debris and trap damage during high tidal velocity – which provides supporting evidence that it may be difficult for lobsters to move during these periods. In contrast, the team found no relationship ($R^2 = 0.0845$) between catch and depth (at mean tide) (Figure 7).

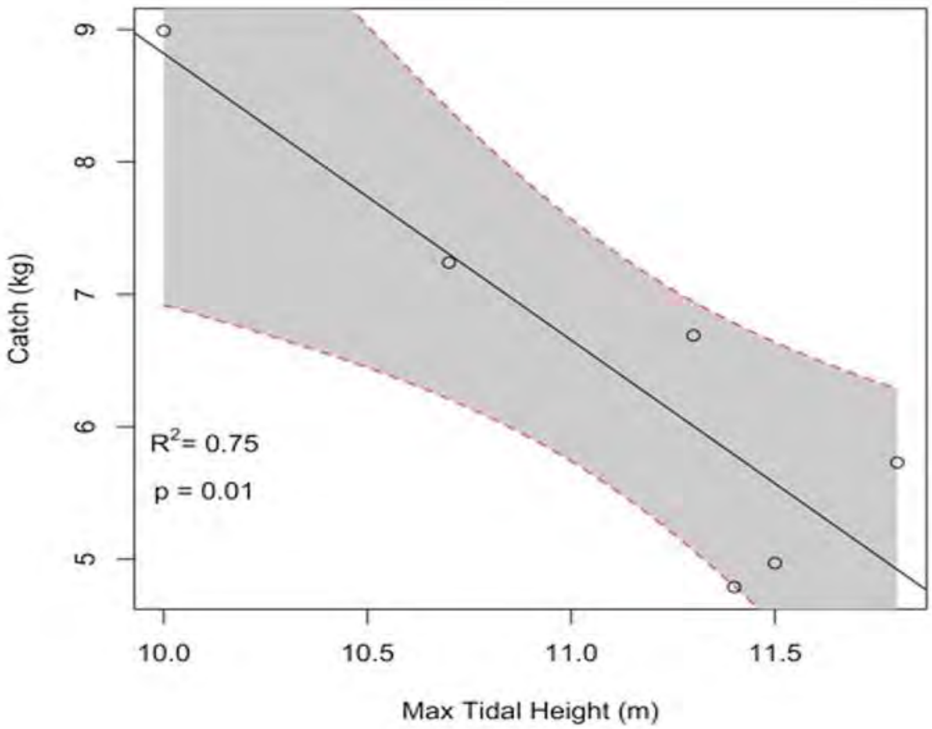


Figure 6. Mean daily station catchability relative to maximum daily tidal height.

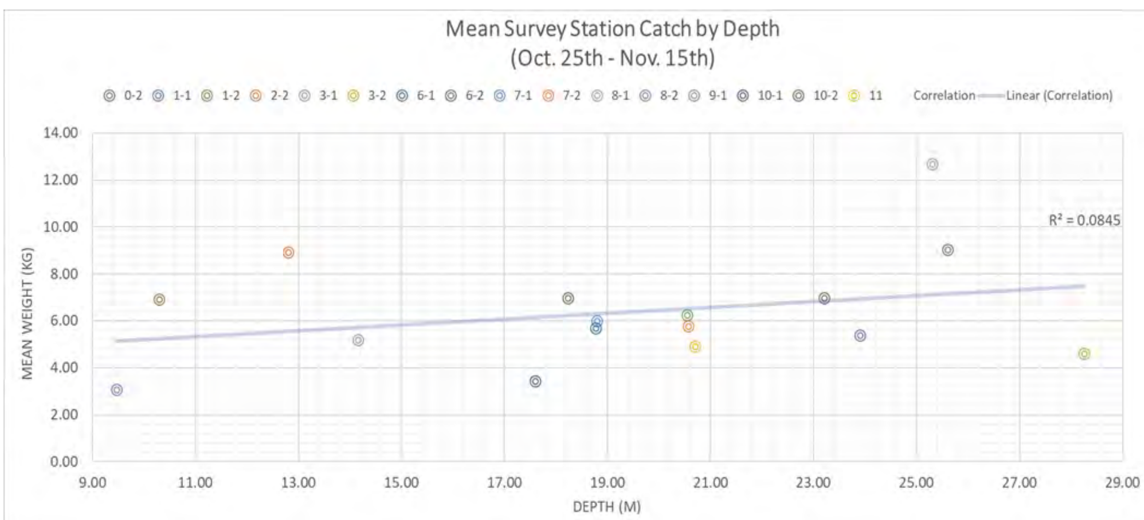


Figure 7. Mean station catchability relative to depth throughout the survey period.

Daily mean catchability for ring 1 was also high (> 2.7kg/trap) throughout the survey period (Figure 8). Ring 1 catch rates diminished slightly over time, and variability fluctuated with no clear trend. In figure 9, ring 2 daily catchability was also greater than 2.7kg/trap for the period. In contrast to ring 1, ring 2 mean catch rates reduced by a larger degree and variability also diminished. On November 2nd, 2017, ring 2 variability was almost negligible (0.13) and cannot be depicted on the chart.

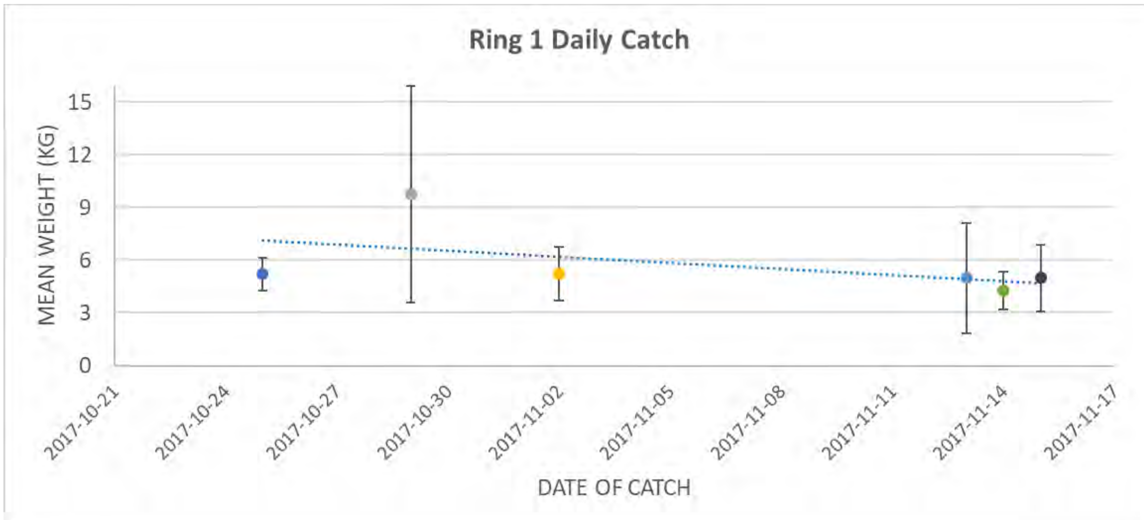


Figure 8. Mean daily ring 1 catchability and associated daily catch variability.

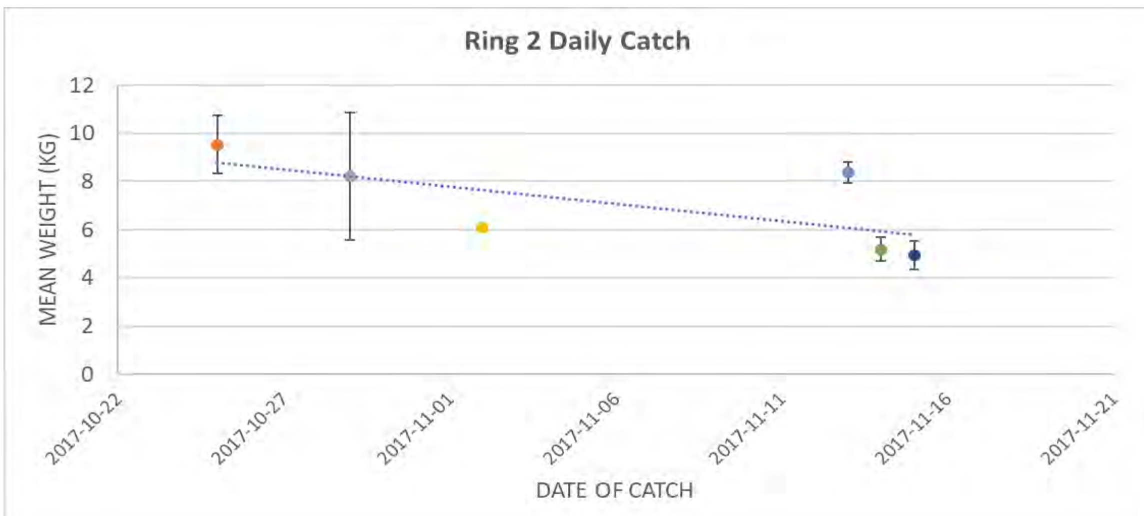


Figure 9. Mean daily ring 2 catchability and associated daily catch variability.

Mean ring 1 catchability for remained above 2.7kg/trap, for each quadrant throughout the period (Figure 10). Variability was high for the South quadrant (5.29) and moderate to low for the other quadrants. All quadrants in ring 2 also displayed high catchability throughout the period and variability was moderate. Catchability and variability trends are not depicted since these datasets are averaged across the survey period.

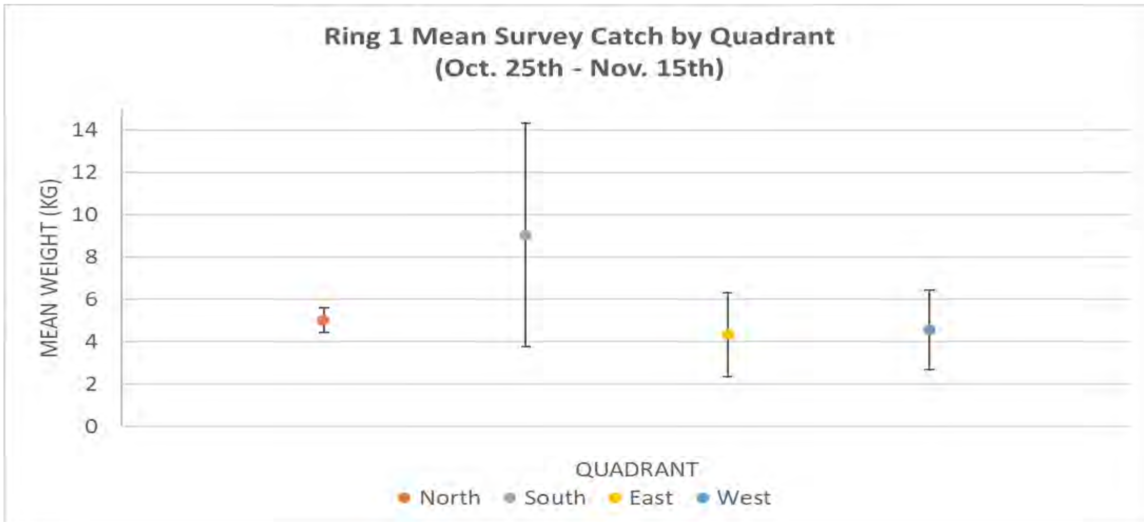


Figure 10. Mean ring 1 catchability and catch variability by corresponding quadrant.

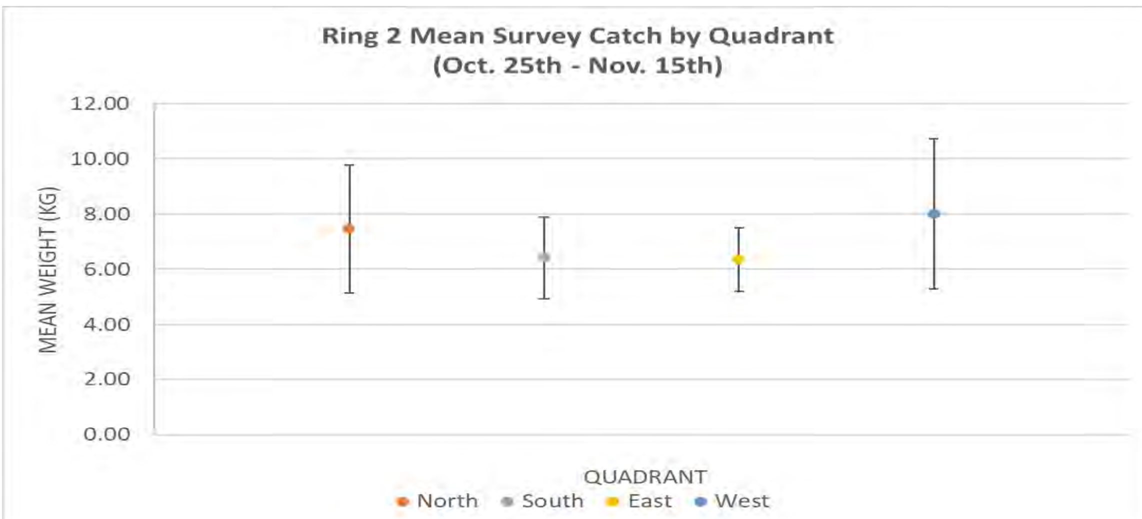


Figure 11. Mean ring 2 catchability and catch variability by corresponding quadrant.

SECTION IV: DISCUSSION OVERVIEW

FALL, IN-SEASON SURVEY

There is high catchability within the CLA, which indicates high lobster population density. Although catchability recorded by DFO is 2014 (above) is based on traps fished with open escape panels, the mean catchability for the CLA Fall survey trended within the baseline range of the broader Minas Passage fishery (DFO, 2017).

The following factors contribute to lobster population dynamics:

- Depth
- Temperature
- Currents (e.g. velocity and direction)
- Season
- Lobster mobility
- Lobster molt cycle
- Reproductive cycles (i.e. mating)
- Salinity
- Dissolved oxygen
- Photoperiod
- Natural mortality
- Fishing mortality (Factor, 1995)

Since mean tidal height trended within a narrow range of 0.10m, it is assumed that this tidal height will be a more significant factor to determine effect on catchability and will be used as a co-variant in the analysis of subsequent surveys. The potential effect of tidal height on future catchability studies can be mitigated by surveying within the same tidal period (neap tides; least variability between tides).

If we assume that the level of fishing efforts remains constant throughout the season (where all harvesters fish 300 traps per licence), then it may reasonable to assume this factor will not affect catchability if the survey is conducted during same period (commencing near the start of the fall lobster fishing season - October 15th). This will also enable inter-annual catch comparisons.

Sampling the same random fixed stations during each survey mitigates any effects of changing trap depth on catchability. Surface temperature data was collected for each station; however, the temperature-catchability relationship was deemed outside of the scope of this initial study and not analyzed. Subsequent studies will include covariant analysis of catch with temperature, as well as salinity, data collected at the site by FORCE

The following factors constrained the operational execution of the survey: high current velocity affecting vessel mobility, buoy resurfacing (which is dependent on depth and buoy length,) and short tidal window (approximately 1 hour straddling low slack tide). Buoy resurfacing time can be reduced by increasing the length of buoy line from 75m to 100m –

thus, increasing length of time buoys remain on the surface, which should improve operational efficiency. Unfortunately, due to the area's oceanography, and the constraints on the vessel to dock and depart straddling high tides, the other factors affecting operations cannot be mitigated.

Geological features of the CLA also had an impact on operations. The vessel experienced difficulties maneuvering to survey stations near Black Rock during high current velocities. The field team mitigated this by ensuring traps at these survey stations were deployed and retrieved during low velocity (during slack tide; 15-minute window). Station 9 was fixed near Black Rock and there was a risk to trap retrieval. Additionally, the bathymetry of the Minas Passage Plateau constrains the spatial bounds of the survey plot. Station 3-2 was fixed along the plateau's edge, which presented a risk to trap retrieval. Subsequent studies (after deployment of the Turbine) will focus sampling along the flow axis, by increasing the number of stations in instream quadrants and reducing the number of stations in lateral quadrants.

SECTION V: RECOMMENDATIONS

The 2017 Fall survey provided information on the nature and abundance of lobster in the immediate area around the FORCE site that will be essential for systematic evaluation on lobster catchability effects after future deployment of turbines at the site. The survey also provided an opportunity to test the methodology and survey design. Therefore, based on the findings from the survey the following recommendation are offered:

1. ***Modify survey design to ensure continued statistical validity of the study.***
2. ***Collect additional environmental information, specifically, temperature, salinity, turbidity.***
3. ***Adapt overall program design to consider cumulative effects of multiple pilot tidal energy projects.***

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