



Effects of finfish farms in eastern Canada (Nova Scotia) on American lobster and rock crab movements

Marie-France Lavoie¹, Ryan A. Horricks², Nathaniel Feindel³, Shawn M. C. Robinson⁴,
Christopher W. McKindsey^{1,*}

¹Fisheries and Oceans Canada, Maurice Lamontagne Institute, 850 Route de la mer, Mont-Joli, Québec G5H 3Z4, Canada

²Centre for Marine Applied Research, 27 Parker Street, Dartmouth, Nova Scotia B2Y 4T5, Canada

³Nova Scotia Department of Fisheries and Aquaculture, 1575 Lake Road, Shelburne, Nova Scotia B0T 1W0, Canada

⁴Longline Environment, 63 St Mary Axe, London, EC3A 8AA, UK

ABSTRACT: While aquaculture is increasing worldwide, there are concerns on the east coast of Canada about the influence of finfish aquaculture sites on crustacean distribution patterns. This study evaluated the abundance and movement of American lobsters *Homarus americanus* and rock crabs *Cancer irroratus* in the vicinity of 2 salmonid aquaculture leases in Liverpool Bay and Port Mouton, Nova Scotia. The study was done over a full 3 yr production cycle in Liverpool Bay. In Port Mouton, the study was done over 4 mo in 2019, 4 yr after salmonid production had ceased. Each year, around 50 lobsters and 50 crabs were tagged with acoustic transmitters and released at an existing fish farm or at 1 of 2 reference sites. Tagged lobsters travelled throughout Liverpool Bay and showed little affinity to the farm, as most lobsters caught and released adjacent to or below the farm did not stay in the area over time, and their home ranges did not exhibit much overlap with the farm. Very similar patterns were observed for lobsters released in the reference areas and in Port Mouton sites. In contrast, rock crabs moved more slowly than lobsters and seemed to be associated with the farm in Liverpool Bay, as their home ranges had a high overlap with the farm for crabs tagged directly under it. Overall, both rock crab and lobster associated with the Liverpool Bay aquaculture site, although the degree of association varied by species with rock crabs being much more attracted to the area under the farm.

KEY WORDS: American lobster · Rock crab · Acoustic telemetry · Movement · Salmonid farm · Aquaculture

1. INTRODUCTION

Finfish aquaculture is increasing worldwide and also in Canada (FAO Fisheries and Aquaculture Department 2022, Fisheries and Oceans Canada 2022a). Finfish farms are known to attract wild animals, and interactions between fish farms and wild fishes have been well documented (Callier et al. 2018, Barrett et al. 2019). Many mechanisms have been identified that attract and repel wild fish to and from fish farms: waste feed, farms acting as fish

aggregation devices (FADs) or artificial reefs (ARs), biofouling communities on the nets, secondary attraction of predators, benthic changes, and husbandry practices (Callier et al. 2018, Barrett et al. 2019). While the bulk of prior research has focused on fish, birds, and marine mammals (Barrett et al. 2019), other taxonomic groups have also been the focus of studies, including some benthic invertebrates (Callier et al. 2018), but less is known about how fish farms attract or repel invertebrates, despite the importance of several commercial invertebrate

*Corresponding author: chris.mckindsey@dfo-mpo.gc.ca

species, including the American lobster *Homarus americanus* (Florko et al. 2021).

Some studies have shown that decapods use and assimilate waste from marine finfish farms. For example, northern shrimp *Pandalus borealis* fatty acid signatures in tissues were altered close to Atlantic salmon *Salmo salar* fish farms in comparison to those caught distant from farms (Olsen et al. 2012). Likewise, caramote prawn *Melicertus kerathurus* show isotopic evidence that animals close to the fish farms (gilthead sea-bream *Sparus aurata* and sea-brass *Dicentrarchus labrax*) had been feeding on farm waste (Izquierdo-Gomez et al. 2015). The brown crab *Cancer pagurus* displayed fatty acid and stable isotope evidence of being affected by the salmonid farm at distances up to 1 km from the farm (Woodcock et al. 2018). A study in the Bay of Fundy on American lobster and rock crabs *Cancer irroratus* found that both species near Atlantic salmon farms had modified fatty acid profiles, indicating, by comparing the results from animals in similar nearby locations without fish farms, that they had been feeding on feed waste or faeces (Sardenne et al. 2020). Likewise, Baltadakis et al. (2020) showed that juvenile European lobster *Homarus gammarus* at a control site differed from those deployed adjacent to an Atlantic salmon farm in terms of fatty acid signatures due to organic loading from the farm.

The American lobster fishery is the most valuable in all of Canada (ca. \$CAN 1.78 billion in 2022; Fisheries and Oceans Canada 2022b). There are increasing concerns from fishery representatives and local communities about the potential influence of finfish aquaculture sites on lobster distribution patterns and potential changes in food sources that may impact their condition, biology, and catchability (reviewed in Horricks et al. 2022). There are concerns that fish farms may negatively impact lobster abundance, as fewer lobsters were caught near farms using commercial lobster traps during a multi-year study (Loucks et al. 2014, Milewski et al. 2018), and that the health of the lobsters might be compromised if chemical therapeutics are used at the farms to control sea lice (Wiber et al. 2012). However, other empirical studies, using diver surveys, on the relationship between lobster abundance and salmon aquaculture found no effect of the fish farms (Grant et al. 2016). In addition, the rock crab is also fished commercially in eastern Canada, and although the landings of this species are dwarfed by the landed value of lobster, it is of importance in several areas (Fisheries and Oceans Canada 2022c). The preferred prey of lobster is rock crab (Gendron et al. 2001, Hanson 2009), and unpublished work from south-

west New Brunswick suggests that there are clear differences in associations of rock crab and lobster to salmon farm sites, as rock crabs were more attracted by the fish farms, making a comparison between the 2 species of interest (C. McKindsey pers. comm.).

Loucks et al. (2014) suggested that fish farm activities may impact crustaceans close to salmonid farms by altering their movement and behaviour. Work on lobster movement around mussel farms in Iles-de-la-Madeleine and Prince Edward Island (Lavoie et al. 2022, Lees et al. 2023) showed that lobsters had little affinity to blue mussel *Mytilus edulis* farms, neither setting up territories within farm limits nor remaining in them for extended periods. Work in Prince Edward Island showed that lobsters may use mussel farms for foraging and shelter and that they entered and exited farms frequently, sometimes multiple times a day (Lees et al. 2023). In contrast, rock crabs mostly remained within mussel farm lease boundaries, typically moving more slowly and staying directly below culture structures (Lees et al. 2023).

This study evaluated the abundance and movement of decapods in the near vicinity of 2 salmonid aquaculture leases in Port Mouton and Liverpool Bay, Nova Scotia, Canada, using direct diver-based observation of animals and acoustic telemetry. The study was done over a full 3 yr production cycle in Liverpool Bay, starting with a fallow year in 2019 (no fish on site) and subsequently evaluating decapod interactions with a farm site at different production stages (fallow, 1 yr old fish, and 2 yr old fish prior to harvesting, 2020–2021). Previous work done around the Port Mouton Atlantic salmon/rainbow trout farm suggested it impacted the distribution of berried lobster (Loucks et al. 2014, Milewski et al. 2018), making it of interest in the present study. The goal of this study was to inform managers on the spatial interactions between 2 economically important activities in eastern Canada: marine farming of salmonids and lobster/crab fisheries.

2. MATERIALS AND METHODS

2.1. Study areas

The study was done in Port Mouton Bay (43° 54' 15" N, 64° 47' 31" N) and Liverpool Bay (44° 01' 59" N, 64° 39' 31" W), Nova Scotia (NS), Canada, from 2019 to 2021 (Fig. 1). Port Mouton Bay is partially sheltered, covering an area of 55.6 km² with depths varying from 8 to 18 m (Milewski et al. 2018). The substrate is characterized by a mix of sand, gravelly sand, and mud (Piper et al. 1986). Liverpool Bay has an area of 11.7 km²

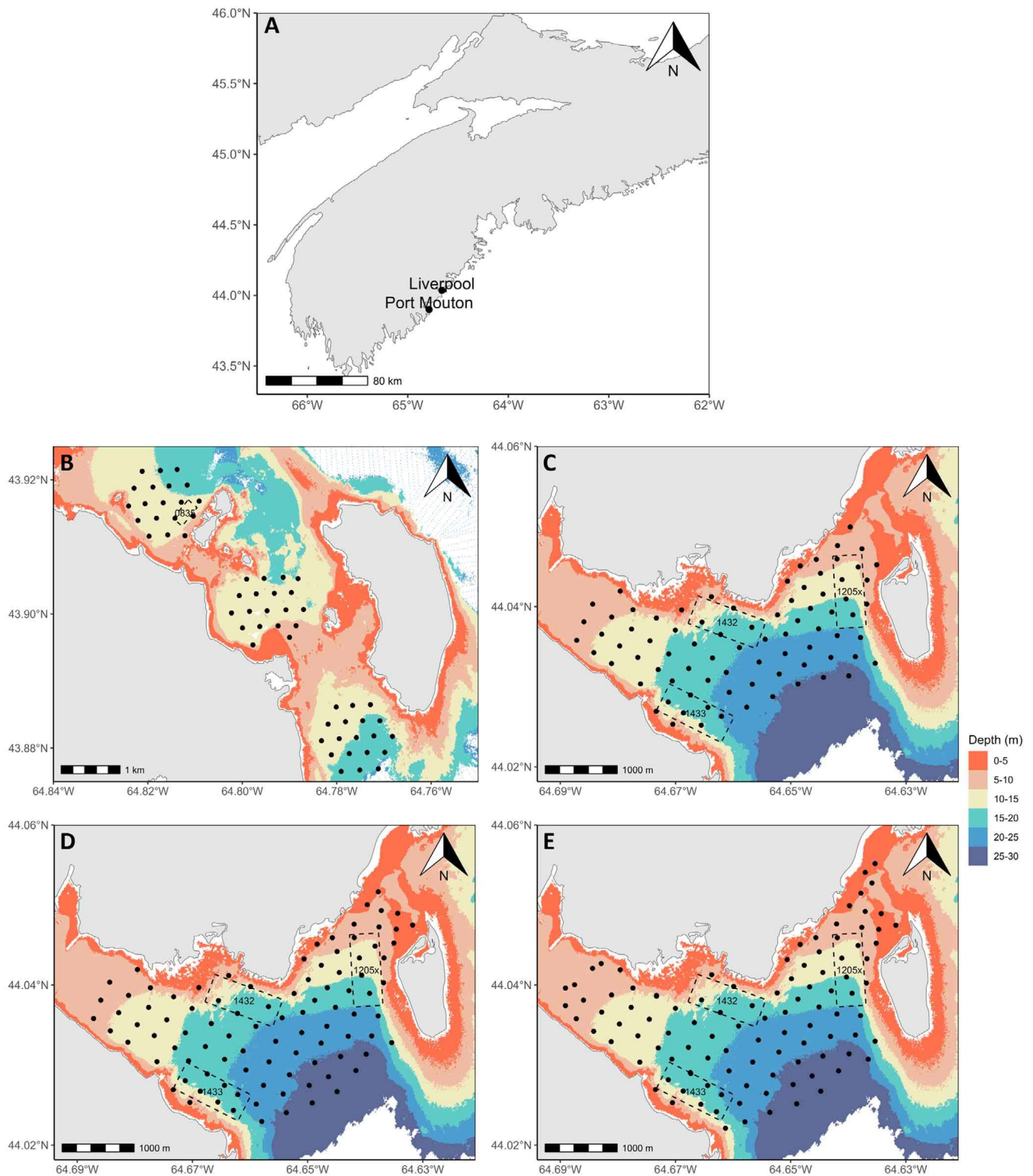


Fig. 1. (A) Location of the 2 study sites (black dots) in southern Nova Scotia, Canada. (B) Location of the Port Mouton receivers in 2019 where the dashed outline represents the previously farmed site (AQ#0835), and in Liverpool Bay in (C) 2019, (D) 2020, and (E) 2021. Black dots represent the acoustic receivers in the study sites. For (C–E), the 1205x polygons represent the finfish lease, and the 1432 and 1433 polygons represent the proposed culture sites (1432: Fralick Cove; 1433: Mersey Point). Colors represent the bathymetry in m

and is open to the ocean. Coffin Island protects the northeast entrance to the bay and provides shelter for the current Atlantic salmon net pen aquaculture site. Benthic substrate in Liverpool is principally characterized by sand in the middle of the bay and by rock and gravel in the north and south sections of the bay (McKee et al. 2021). North and south sections are represented in the study by 2 sampling sites: Fralick Cove (north) and Mersey Point (south). The substrate in Fralick Cove is more characterized by rock and Mersey Point by gravel and rock (McKee et al. 2021). Rock substrate is also found in shallow subtidal areas near Coffin Island (McKee et al. 2021). Neither aquaculture site was in use in 2019, and salmonid production (rainbow trout *Oncorhynchus mykiss*) had ceased in 2015 in Port Mouton. Since no immediate salmonid aquaculture was planned for the Port Mouton site following 2019 (Nova Scotia Department of Fisheries and Aquaculture pers. comm.), the acoustic telemetry study was not continued at this location. As of the writing of this manuscript, there is a proposal to expand finfish aquaculture in Liverpool with an additional 2 Atlantic salmon leases and an expansion of the current finfish site (by adding 6 cages at the AQ#1205x lease) (Fig. 1). During the 2019 field season, the physical structure of the cages (i.e. the floating circular high-density polyethylene cages, HDPE) were present at the Liverpool site (7 × 2 cages, near Coffin Island, NS), and only some buoys and ropes were visible in the north site (northwest of the Spectacle Islands) in Port Mouton, although no fish were in cages at either site. In 2020, fish were added to the cages in Liverpool, and in 2021 the cages contained 2 yr old Atlantic salmon.

2.2. Observational sampling

From 18 to 20 July 2019, a total of 21 transects (50 m long × 2 m wide) were swum by SCUBA divers in 3 distinct areas (7 per site: farm site, Fralick Cove, and Mersey Point) in Liverpool Bay. Divers collected all decapods (3 species: American lobster, rock crab, and Jonah crab *Cancer borealis*) on encounter and brought them to the surface where they were sexed, measured, and counted. In Port Mouton, SCUBA divers collected and measured decapods they encountered along 30 transects (50 m long × 2 m wide) in 3 distinct areas (fallowed farm site, and 2 reference sites to the southeast of the first site). No transects were done at any location in 2020 due to travel restrictions caused by the COVID-19 pandemic, which made such voyages impossible. From 15 to 17 July 2021, 30

transects were sampled in Liverpool Bay (10 per site: farm site, Fralick Cove, and Mersey Point) using the same methodology as in 2019.

2.3. Acoustic telemetry design and tag deployments

2.3.1. Acoustic telemetry

Three receiver models were deployed during the study: VR2W, VR2Tx, and VR2AR (69 kHz, Innovasea). Receivers were deployed in a grid that satisfied the criteria for the VEMCO positioning system (VPS) fine-scale movement analysis (Espinoza et al. 2011, Orrell & Hussey 2022). At the beginning of the study, a range test was done prior to the deployment of the acoustic receiver grid to determine optimal receiver spacing (each receiver was separated by 250 to 375 m from its neighbour). A synchronisation tag (model V13, 36 mm long and 13 mm diameter, transmission delay between 500 and 700 s, Innovasea) was deployed 1 m above each VR2W receiver; VR2Tx and VR2AR receivers contain synchronisation tags (transmission delay between 540 and 660 s, Innovasea) within the units, and no additional tags were required. At each site, 2 or 3 reference tags (V9, Innovasea) were used and placed where most receivers could record the signal to increase the precision of spatial data.

2.3.2. Deployment in 2019

Fig. 1B,C shows the design for each location and the position of acoustic receivers. A substantial portion of Liverpool Bay was covered with receivers. Three areas were studied in Port Mouton (North, where the salmonid farm was located; Center; and South). This was a substantial sampling campaign with a total of 138 receivers deployed (Liverpool = 81 and Port Mouton = 57) in 2019. Receivers were deployed between July 16 and 23 and recovered between November 19 and 22, 2019.

A total of 47 rock crabs (34 male [M] and 13 female [F]) and 50 lobsters (29 M and 21 F) were captured and tagged in Liverpool, and 51 rock crabs (22 M and 29 F) and 50 lobsters (29 M and 21 F) were captured and tagged in Port Mouton (Table 1). All animals were measured (width for crabs and cephalothorax length [CL] for lobsters) before being released at the same site as the one where they were caught (farm site, Fralick Cove, and Mersey Point for Liverpool; and North, Center, and South sites for Port Mouton Bay). Animals were caught

Table 1. Number and sex of American lobster *Homarus americanus* and rock crab *Cancer irroratus* tagged each year and at each site in Nova Scotia, Canada. M: male; F: female

Year	Species	Sex	Liverpool Bay			Port Mouton		
			Farm	Fralick Cove	Mersey Point	North	Center	South
2019	Lobster	M	13	5	11	10	7	12
		F	12	0	9	10	8	3
	Rock crab	M	9	0	25	12	2	8
		F	11	0	2	9	13	7
2020	Lobster	M	18	5	7	—	—	—
		F	11	2	7	—	—	—
	Rock crab	M	36	4	2	—	—	—
		F	8	0	0	—	—	—
2021	Lobster	M	10	7	10	—	—	—
		F	10	8	5	—	—	—
	Rock crab	M	8	14	4	—	—	—
		F	12	1	11	—	—	—

using commercial lobster traps or by SCUBA divers on encounter and fitted on a boat with acoustic transmitters (Innovasea V9, 26 mm long and 9 mm diameter, transmission delay between 180 and 300 s). Transmitters were attached to carapaces cleaned with sandpaper (180 grit) followed by ethanol swabs using ethyl 2-cyanoacrylate glue (LePage® Ultra Gel Control® Super Glue) and released back into the study arrays. Transmitter attachment required approximately 3 min for each of the animals, which were then released within about 10 min of being brought to the surface.

2.3.3. Deployment in 2020

A total of 106 receivers were deployed in Liverpool Bay on June 29 to July 13 (Fig. 1D) and recovered November 3 to 4, 2020. Ten of these receivers were installed outside the bay to the northeast and deployed in 2 lines. One hundred animals were captured using commercial lobster traps, sexed, measured, and tagged (Table 1): 50 lobsters (30 M and 20 F) and 50 rock crabs (42 M and 8 F). Animals were also released at the same site they were caught.

2.3.4. Deployment in 2021

Following the same methods used in 2019 and 2020, 104 receivers were deployed in Liverpool Bay on July 12 to 15 and recovered November 9 to 10, 2021 (Fig. 1E). A total of 50 lobsters (27 M, 23 F) and 50 crabs (26 M, 24 F) were captured using commercial lobster traps and on encounter by SCUBA divers (Table 1).

2.4. Data analysis

2.4.1. R analysis

Data were analyzed using the open-source statistical software R version 4.3.2 (R Core Team 2023) and PRIMER-e (v. 7.0.21).

2.4.2. Animal abundance — direct observations

Variations in animal abundance observed within transects in Liverpool Bay were examined using permutational multivariate analysis of variance (PERMANOVA) (with 9999 permutations) with the fixed factors 'Year' (2 levels: 2019 and 2021), 'Site' (3 levels: farm site, Fralick Cove, and Mersey Point), 'Species' (3 levels: lobster, rock crab, and Jonah crab), and 'Sex' (2 levels: M and F) since data transformations were unable to constrain the data to meet the assumptions of ANOVA (Anderson 2001). The similarity matrix used was constructed based on Euclidean distances. The homogeneity of multivariate dispersion was evaluated using PERMDISP and data transformed ($\log + 1$). Differences among treatments were determined using *a posteriori* pairwise comparisons, also using PERMANOVA. The same analyses were done for Port Mouton, except with 3 fixed factors as 'Site' (3 levels: North, Center, and South), 'Species' (2 levels: lobster and rock crab), and 'Sex' (2 levels: M and F).

2.4.3. Acoustic telemetry data pre-processing

Prior to analysis, data were filtered using a linear regression to remove observations with high posi-

tioning error (HPE) (Skerritt et al. 2015, Lees et al. 2020, Lavoie et al. 2022). A regression was done for each site based on the synchronisation tags deployed at each site within each year. HPE filtration was done independently for each year of the study in Liverpool Bay. In Liverpool Bay in 2019, less than 20% of the synchronization tag data were lost by filtering by $HPE \leq 35$ ($r^2 = 0.99$). The animal detections from 2019 were filtered with an $HPE \leq 35$ and a mean (\pm SE) position error for individuals of 4.9 ± 0.01 m. For 2020, less than 1% of the synchronization tag data were lost by filtering by $HPE \leq 25$ ($r^2 = 0.99$). Animal detections from 2020 were filtered with an $HPE \leq 25$, giving a mean position error (\pm SE) of 12.4 ± 0.02 m. For the last year of the study in Liverpool Bay, less than 5% of the sync tag data were lost by filtering by $HPE \leq 30$ ($r^2 = 0.88$). The 2021 animal detections were filtered with an $HPE \leq 30$, giving a mean position error (\pm SE) of 12.09 ± 0.01 m. Synchronization tag data from Port Mouton were filtered by $HPE \leq 30$ ($r^2 = 0.98$) with a loss of less than 5% of the data. The mean position error (\pm SE) for Port Mouton animal detections with $HPE \leq 30$ was 4.07 ± 0.008 m. The first 24 h of all tracking data were excluded at all sites to minimize the impact of tagging on behavior (Lavoie et al. 2022).

Only animals with more than 200 detections over the entire deployment at each year were used in the analyses. A final filtration was used to remove data with individual walking speeds $>10 \text{ km d}^{-1}$, as these speeds are abnormal for lobster and rock crabs.

2.4.4. Movement parameters analyses

Animal track analyses were done using the 'adehabitatLT' package (Calenge 2006). When animals leave and then reenter the acoustic telemetry array, some gaps in the data may occur. To avoid such gaps in residence time estimates and walking speed trajectories were split into separate bursts if the time between detections was >12 h and if the distance was >200 m (Lavoie et al. 2022, Lees et al. 2023). Residence time corresponds to the cumulative time spent by each animal within the acoustic array. Walking speed was estimated by dividing the distance interval from each step by the time interval from the same step. Variations in residence time for Liverpool Bay was examined using a 4-way ANOVA with the fixed factors 'Year' (3 levels: 2019, 2020, and 2021), tagging 'Site' (3 levels: farm site,

Fralick Cove, and Mersey Point), 'Species' (2 levels: lobster and crab), and 'Sex' (2 levels: M and F). Assumptions of homoscedasticity were evaluated for ANOVA analyses using the Shapiro-Wilk test, as outlined in Quinn & Keough (2002). Data were transformed, when necessary, to satisfy the assumptions of ANOVA. Variation in walking speed for Liverpool Bay was evaluated using PERMANOVA (with 9999 permutations), as data transformations were unable to constrain the data to meet the assumptions of ANOVA (Anderson 2001). The homogeneity of multivariate dispersion was evaluated using PERMDISP and data transformed (square root). PERMANOVA analyses included the same 4 factors as the ANOVA analyses.

Variation in movement parameters for Port Mouton individuals were evaluated using 3-way ANOVAs with 3 fixed factors ('Site,' 'Species,' and 'Sex'). Assumptions of homoscedasticity were evaluated for each ANOVA analysis using the Shapiro-Wilk test. Data were transformed to satisfy assumptions of ANOVA (square root for the residence time and log-transformation for walking speed). Differences among treatment means of factors that were deemed significant in the ANOVAs were evaluated using *a posteriori* Tukey multiple comparison tests.

2.4.5. Home range analyses

The 95% confidence home range estimates for the 2 species were calculated using kernel density estimations with the 'amt' package (Signer et al. 2019) in Liverpool Bay. An overlap with the farm site and a 250 m buffer around fish farm were quantified and used to determine the utilization percentage of the farm area for each individual. To compare the home range and the overlap results, PERMANOVA (based on 9999 permutations) analyses were used to identify variation between 4 fixed factors ('Year,' 'Site,' 'Species,' and 'Sex'). Euclidian distances were used to construct the similarity matrix, and data were transformed as necessary (square root transformation). Differences among treatments were determined using *a posteriori* pairwise comparisons, also using PERMANOVA. For Port Mouton, home range data were analyzed with a 3-way ANOVA with 3 fixed factors ('Site,' 'Species,' and 'Sex') and with a fourth root transformation to satisfy assumptions. Differences among treatment means of factors deemed significant in the ANOVA were evaluated using *a posteriori* Tukey multiple comparison tests.

3. RESULTS

3.1. Animal abundance – direct observations

3.1.1. Liverpool Bay

Three decapod species were observed in the transects at all sites in Liverpool Bay: American lobster, rock crab, and Jonah crab (Fig. 2A; Table S1 in the Supplement at www.int-res.com/articles/suppl/aei00515_supp.pdf). Abundance of Jonah crab was noted; however, Jonah crab was not tagged with acoustic transmitters. Abundance was predicted by significant 'Site × Sex' and 'Year × Site × Sex' interactions (Table 2). According a post-hoc test, the number of lobsters observed under the farm was significantly different ($p < 0.001$) from 2019 (fallow year) relative to 2021 (production year II) with fewer individuals in 2021. A mean (\pm SE) density of lobsters of $6.29 \text{ ind./}100 \text{ m}^2 \pm 1.90$ was observed in 2019 under the farm compared to $0.30 \text{ ind./}100 \text{ m}^2 \pm 0.21$ in 2021. On the other hand, differences between the 2 yr under the farm was not observed for rock ($p = 0.51$) or Jonah ($p = 0.413$) crabs. There were no significant differences in decapod abundance at Mersey Point from

2019 to 2021 (lobster, $p = 0.086$; rock crab, $p = 0.947$; Jonah crab, $p = 0.518$). The same results were observed in Fralick Cove, with no significant difference in lobster ($p = 0.158$), rock crab ($p = 0.443$), or Jonah crabs ($p = 0.638$) abundance between 2019 and 2021. For both year, significant differences were observed for lobster abundance between the farm site and Mersey Point (2019, $p = 0.012$; 2021, $p < 0.001$) and between the farm and Fralick Cove (2019, $p = 0.045$; 2021, $p < 0.001$). For rock crab abundance, the same pattern was observed with significant differences between the farm site and Mersey Point (2019, $p = 0.01$; 2021, $p < 0.001$) and the farm and Fralick Cove (2019, $p = 0.017$; 2021, $p < 0.001$) for the 2 yr of the abundance survey. No significant difference for lobster (2019, $p = 0.477$; 2021, $p = 0.665$) and rock crab (2019, $p = 0.546$; 2021, $p = 0.168$) abundance was observed between Mersey Point and Fralick Cove sites.

3.1.2. Port Mouton

Only 2 species were observed in transects at Port Mouton: American lobster and rock crab (Fig. 2B,

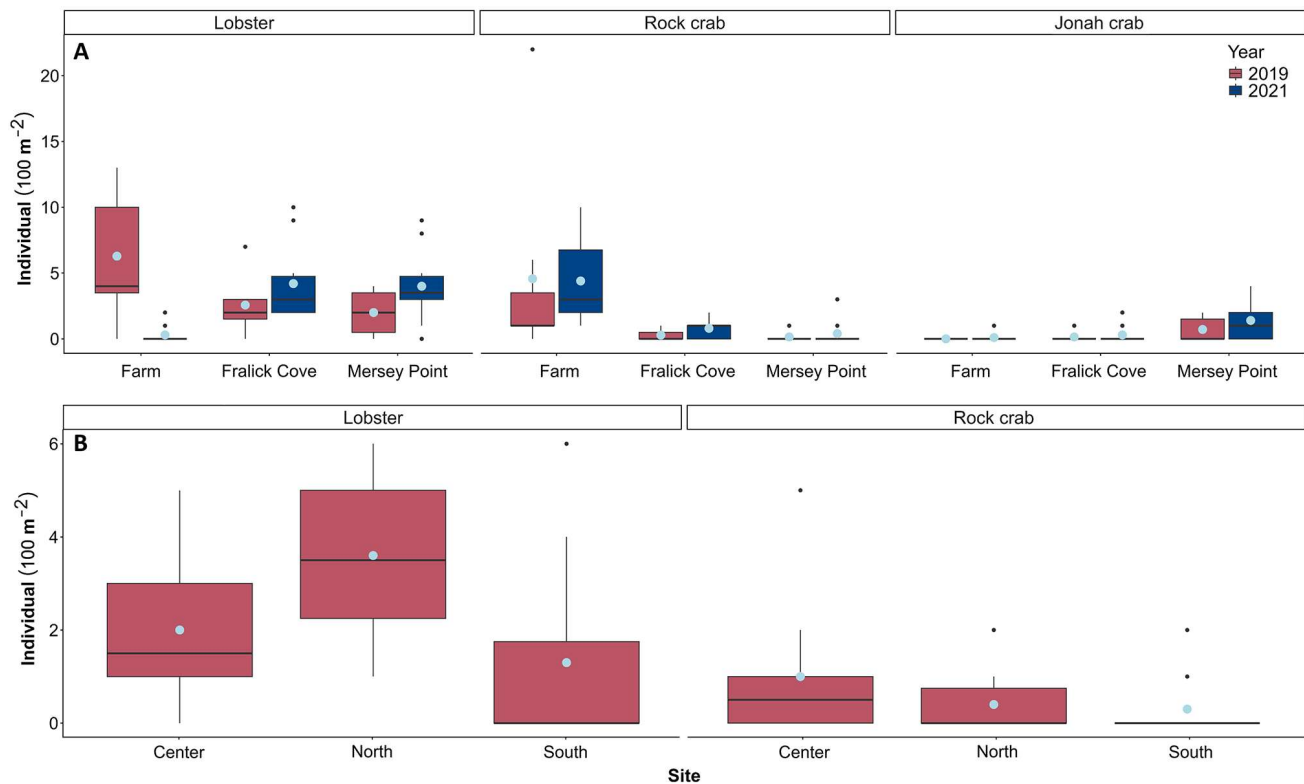


Fig. 2. Abundance of American lobster, rock crab, and Jonah crab in (A) Liverpool Bay in 2019 and 2021, and (B) Port Mouton in 2019. Light blue dots in the boxplot represent the means. Whiskers represent minimum and maximum values; black points represent outliers. Flattened box is represented by a black bar and means that 75% of the data has the same value

Table S1). There was a significant interaction of crustacean abundance with the 'Site × Species' interaction (Table 3). Lobster abundance was only significantly different from rock crab in the North site ($p < 0.001$). Lobster abundance differed significantly between the North and the Center sites ($p = 0.021$) and North and South sites ($p < 0.001$). Rock crab abundance did not differ between the 3 sites (p -values > 0.05).

3.2. Animal movement – acoustic telemetry

3.2.1. Detected animals

The number of tagged animals detected after filtering and mean animal size for each year are shown in Table 4. In 2020, 21 animals tagged from the previous year in Liverpool Bay were also detected (3 M lobsters; 3 F and 15 M crabs). In 2021, 10 animals tagged in 2020 were also detected (1 F and 1 M lobsters; 2 F and 6 M crabs). All animals tagged previously were included in the analyses for the given year they were detected. All animal trajectories are included in the Supplement (Figs. S1–S8). In 2020, 2 berried lobsters were retained after post-data filtration (ID 54214 and 54297) but were kept with the other females for the analyses.

3.2.2. Liverpool Bay

Residence time only varied by 'Species' (Table 5). Residence time for crabs in the acoustic array was sig-

Table 2. PERMANOVAs for the animal abundance by year, site, species, and sex in Liverpool Bay. Significant effects at $p < 0.05$ highlighted in **bold**

Source	Abundance			
	df	MS	F	p
Year	1	0.0071	0.0354	0.849
Site	2	0.7548	3.7413	0.024
Species	2	8.6763	43.004	< 0.001
Sex	1	0.0044	0.0217	0.878
Year×Site	2	1.6892	8.3723	< 0.001
Year×Species	2	0.4966	2.4613	0.088
Year×Sex	1	0.0179	0.0885	0.764
Site×Species	4	2.8408	14.08	< 0.001
Site×Sex	2	1.0294	5.1022	0.006
Species×Sex	2	0.2085	1.0335	0.362
Year×Site×Species	4	2.1026	10.421	< 0.001
Year×Site×Sex	2	0.0785	0.3891	0.676
Year×Species×Sex	2	0.1651	0.8183	0.441
Site×Species×Sex	4	0.3474	1.7219	0.141
Year×Site×Species×Sex	4	0.0595	0.2948	0.882
Error	270	0.2018		

Table 3. PERMANOVAs for the animal abundance by site, species, and sex in Port Mouton. Significant effects at $p < 0.05$ highlighted in **bold**

Source	Abundance			
	df	MS	F	p
Site	2	0.8937	4.6947	0.011
Species	1	5.1626	27.119	< 0.001
Sex	1	0.2201	1.1564	0.283
Site×Species	2	1.146	6.0198	0.004
Site×Sex	2	0.2731	1.4344	0.233
Species×Sex	1	0.0080	0.0421	0.836
Site×Species×Sex	2	0.0964	0.5062	0.604
Error	108	0.1904		

Table 4. Total detections and mean size of American lobster and rock crab each year and by tagging site after filtering for Liverpool Bay and Port Mouton. M: male; F: female

	Species	Sex	No. of individuals	No. of detections	Size (mm) ± SE
Port Mouton 2019	Lobster	M	19	39 000	86.24 ± 0.001
		F	10	23 682	83.32 ± 0.0004
	Rock crab	M	19	113 720	77.12 ± 0.003
		F	27	212 603	76.97 ± 0.008
Liverpool 2019	Lobster	M	24	99 990	88.03 ± 0.001
		F	19	78 448	88.86 ± 0.003
	Rock crab	M	33	269 358	109.49 ± 0.003
		F	12	118 642	86.99 ± 0.003
Liverpool 2020	Lobster	M	27	92 036	89.13 ± 0.002
		F	18	79 626	87.56 ± 0.008
	Rock crab	M	55	528 323	110.89 ± 0.002
		F	10	111 214	90.43 ± 0.002
Liverpool 2021	Lobster	M	21	80 611	89.60 ± 0.002
		F	21	76 597	86.98 ± 0.001
	Rock crab	M	27	260 245	94.37 ± 0.003
		F	24	184 193	88.10 ± 0.002

Table 5. Movement parameter results with the 4-way ANOVAs and PERMANOVA analyses for Liverpool Bay. Significant effects at $p < 0.05$ highlighted in **bold**

Source	ANOVA, Residence time				PERMANOVA, Walking speed			
	df	MS	F	p	df	MS	F	p
Year	2	1592	2.322	0.100	2	0.0377	0.9863	0.375
Site	2	62	0.091	0.913	2	0.0813	2.1272	0.121
Species	1	49 664	72.430	< 0.001	1	1.0065	26.322	< 0.001
Sex	1	312	0.455	0.501	1	0.0051	0.1342	0.719
Year×Site	4	564	0.822	0.512	4	0.0055	0.1428	0.966
Year×Species	2	470	0.686	0.505	2	0.0011	0.0298	0.971
Year×Sex	2	732	1.067	0.346	2	0.0070	0.1818	0.830
Site×Species	2	907	1.323	0.268	2	0.0054	0.1408	0.862
Site×Sex	2	627	0.915	0.402	2	0.0130	0.3402	0.715
Species×Sex	1	179	0.260	0.610	1	0.0079	0.2069	0.651
Year×Site×Species	3	1096	1.598	0.190	3	0.0179	0.4682	0.700
Year×Site×Sex	3	213	0.311	0.818	3	0.0320	0.8374	0.484
Year×Species×Sex	2	1256	1.831	0.162	2	0.0264	0.6913	0.502
Site×Species×Sex	2	2025	2.953	0.054	2	0.0123	0.3223	0.721
Year×Site×Species×Sex	1	78	0.114	0.736	1	0.0292	0.7623	0.383
Error	260	686			260	0.0382		

nificantly higher ($p < 0.0001$) with a mean (\pm SE) of $57.83 \text{ d} \pm 2.41$ compared to $31.80 \text{ d} \pm 1.75$ for lobsters over the 3 yr study (Fig. 3A). For all years combined, a female crab tagged under the farm site in 2019 (100.81 mm CL) stayed the longest time within the array (121.32 d). A male lobster tagged at Mersey Point in 2019 (86.4 mm width) remained the shortest time (1.14 d). Variation in walking speed was only significantly affected by the factor 'Species' (Table 5, Fig. 3B). Lobsters had a mean (\pm SE) walking speed of $1.75 \text{ km d}^{-1} \pm 0.06$ compared to crabs with a mean walking speed of $1.22 \text{ km d}^{-1} \pm 0.03$.

3.2.3. Port Mouton

Movement parameters for the animals tagged in Port Mouton Bay varied as a function of the factor 'Site' and 'Species' (Table 6, Fig. 4A,B). A male lobster (86.40 mm CL) spent the longest time in the array (113.38 d) while another male lobster (93.70 mm CL) stayed only for 1.10 d in the array. According to the pairwise test, residence time within the arrays for all the animals tagged in the North site differed significantly from that in the Center ($p = 0.004$) and South ($p = 0.006$), and the time passed in the study area differed between lobsters and crabs ($p < 0.001$), who spent $15.19 \text{ d} \pm 2.86$ and $39.04 \text{ d} \pm 4.30$ in the array, respectively (Fig. 4). Walking speed differed significantly between South and Center sites ($p = 0.003$), and South and North sites ($p < 0.001$). Mean walking speed for lobsters and crabs was significantly different ($p < 0.001$), as lobsters moved more quickly

with a mean of $1.93 \pm 0.18 \text{ km d}^{-1}$ compared to $0.86 \pm 0.04 \text{ km d}^{-1}$ for the crabs.

3.3. Farm attraction

3.3.1. Liverpool Bay

Variation between individual home ranges differed significantly as a function of the 'Site × Species' interaction (Table 7), and the pairwise test showed that there was a significant difference in the home range estimates of lobsters and crabs tagged under the farm ($p < 0.001$). Mean (\pm SE) home range for all the lobsters tagged under the farm was $2.83 \text{ km}^2 \pm 0.34$ compared to $0.61 \text{ km}^2 \pm 0.08$ for all rock crabs. Estimated lobster home ranges did not vary significantly by site (farm = $2.83 \text{ km}^2 \pm 0.34$, Mersey Point = $1.87 \text{ km}^2 \pm 0.29$, and Fralick Cove = $2.00 \text{ km}^2 \pm 0.37$). Crab home range differed significantly for individuals tagged under the farm compared the 2 control sites, Mersey Point ($p = 0.048$) and Fralick Cove ($p = 0.047$). Mean (\pm SE) estimated home range for the crabs tagged in Mersey Point ($1.57 \text{ km}^2 \pm 0.22$) and Fralick Cove ($1.11 \text{ km}^2 \pm 0.30$) was larger than for individuals tagged under the farm ($0.61 \text{ km}^2 \pm 0.08$).

The factor 'Sex' and the interaction 'Site × Species' were significant for the percent home range overlap with the farm area (Table 7). The percent overlap of lobster home range estimates with the farm for the individuals tagged under it ($12.54\% \pm 2.58$) differed significantly from lobsters originating from Fralick Cove ($p = 0.024$; mean \pm SE = $1.24\% \pm 0.60$) and Mer-

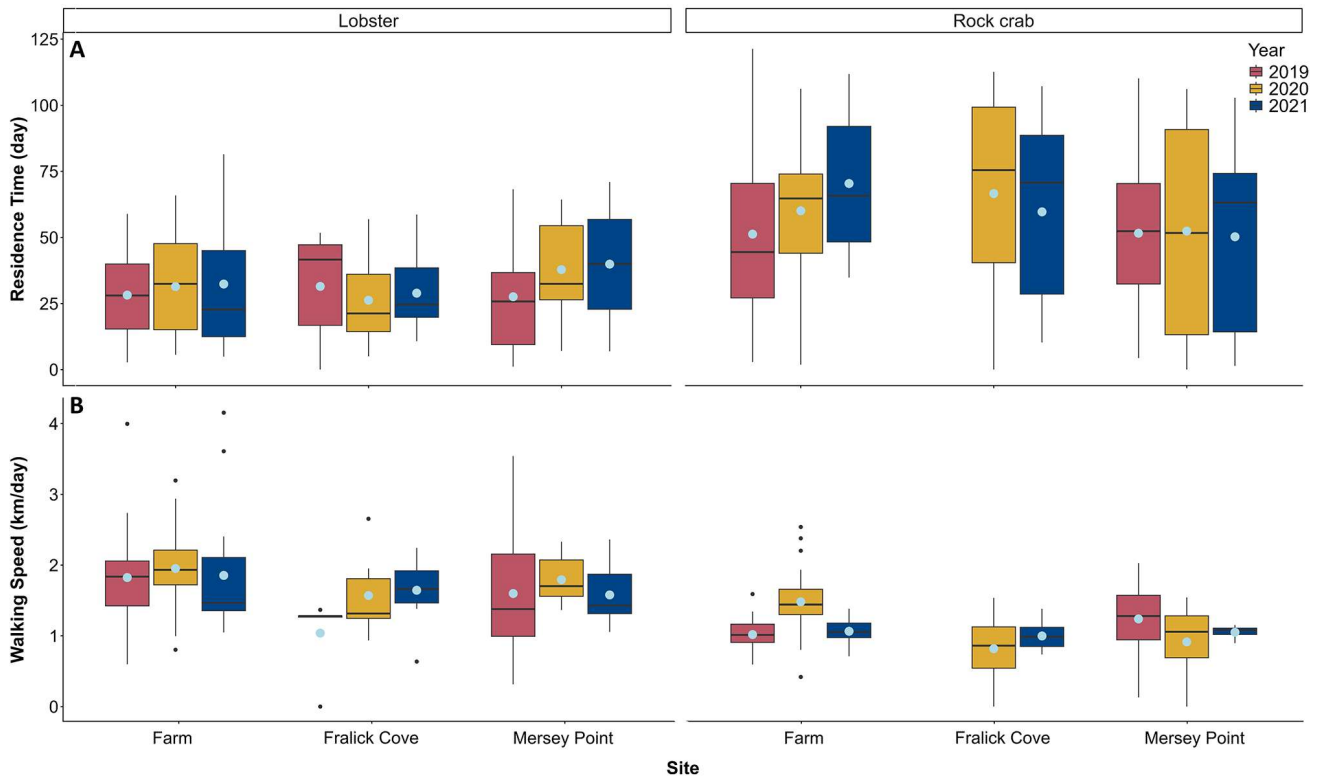


Fig. 3. Distribution of (A) residence time and (B) walking speed by year for American lobster and rock crab and tagging site in Liverpool Bay. Light dots in the boxplot represent the means. Whiskers represent minimum and maximum values; black points represent outliers. Flattened box is represented by a black bar and means that 75% of the data has the same value

sey Point ($p < 0.001$; mean \pm SE = $0.58\% \pm 0.22$). For crabs, the only significant difference ($p < 0.001$) was between the overlap for the individuals tagged under the farm ($36.31\% \pm 3.63$) and in Mersey Point ($4.35\% \pm 1.46$). The home range overlap between the crabs tagged under the farm and those in Fralick Cove is not significant ($p = 0.079$) but may be attributed to the low number of crabs tagged in Fralick Cove and because the pairwise test was not powerful enough to detect differences. The percent overlap with the farm differed significantly ($p = 0.032$) for females ($36.17\% \pm 4.96$) compared to males ($15.53\% \pm 2.53$) for both

species combined. Home ranges within the 250 m farm buffer differed significantly as a function of 'Site' and 'Species' (Table 7). The 250 m overlap around the salmon farm differed ($p < 0.001$) from individuals tagged under the farm ($21.72\% \pm 1.86$) compared to those tagged at Mersey Point ($4.08\% \pm 0.85$). Crabs had greater overlap ($p = 0.024$; $15.98\% \pm 1.67$) with the 250 m buffer than did lobsters ($9.63\% \pm 1.52$). Home range estimates and overlap with the farm and the 250 m buffer are shown in Fig. 5 for each year and tagging site. Home range and tracks for individuals are provided in the Supplement (Figs. S1–S6).

Table 6. Movement parameter results for the 3-way ANOVAs for Port Mouton. Significant effects at $p < 0.05$ highlighted in **bold**

Source	Residence time				Walking speed			
	df	MS	F	p	df	MS	F	p
Site	2	29.81	7.245	0.002	2	1.386	11.008	< 0.001
Species	1	111.51	27.102	< 0.001	1	9.162	72.750	< 0.001
Sex	1	5.37	1.305	0.258	1	0.035	0.281	0.598
Site×Species	2	1.23	0.299	0.743	2	0.143	1.136	0.328
Site×Sex	2	8.86	2.154	0.124	2	0.104	0.823	0.444
Species×Sex	1	1.73	0.420	0.519	1	0.049	0.387	0.536
Site×Species×Sex	2	9.46	2.299	0.109	2	0.148	1.174	0.316
Error	63	4.11			63	0.126		

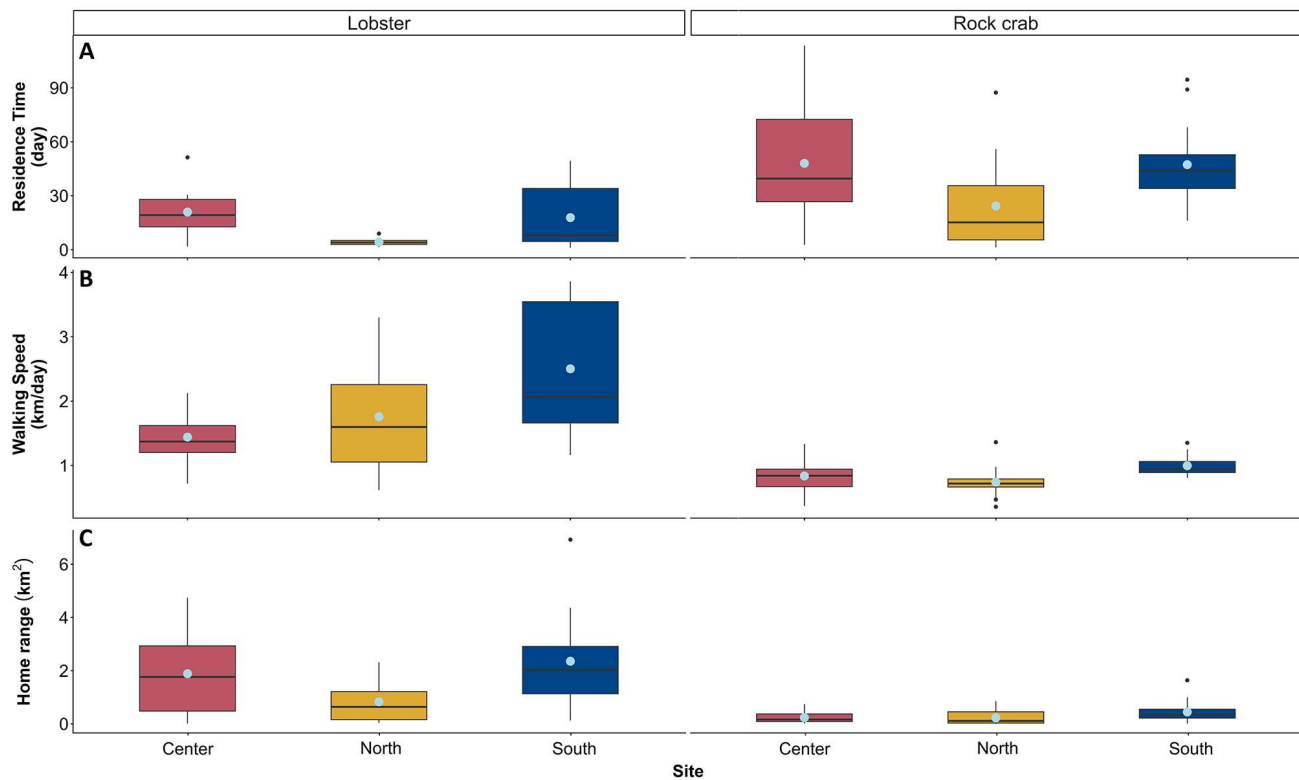


Fig. 4. Distribution for (A) residence time, (B) walking speed, and (C) home range by tagging site for American lobster and rock crab in Port Mouton. Light dots in the boxplot represent the means. Whiskers represent minimum and maximum values; black points represent outliers

Overall, 71.21% of lobsters tagged under the farm for the 3 yr had a portion of their estimated home ranges that overlapped with the salmon farm. Ten lobsters had greater than 25% of their home range that overlapped with the farm, and 2 lobsters had 100%

overlap. These 2 individuals undertook only small movements under the farm and stayed within the farm boundaries (see Fig. S1 — 15080 and Fig. S3 — 54246). More than 75% of lobsters (77.27%) had a home range that included the 250 m buffer around the fish farm,

Table 7. PERMANOVAs for home range and the area that overlaps with the fish farm in Liverpool Bay. Significant effects at $p < 0.05$ highlighted in **bold**

Source	Home range				Overlap with fish farm				Overlap 250 m around fish farm			
	df	MS	F	p	df	MS	F	p	df	MS	F	p
Year	2	0.2037	0.4311	0.651	2	2.343	0.4705	0.623	2	6.841	1.357	0.255
Site	2	0.0464	0.0981	0.910	2	182.36	36.618	< 0.001	2	99.963	19.829	< 0.001
Species	1	1.8079	3.826	0.053	1	59.649	11.977	< 0.001	1	26.68	5.2923	0.025
Sex	1	0.0701	0.1484	0.693	1	23.005	4.6193	0.034	1	12.277	2.4353	0.114
Year×Site	4	0.1381	0.2922	0.879	4	7.9429	1.5949	0.168	4	4.1229	0.81781	0.513
Year×Species	2	0.0607	0.1284	0.880	2	3.458	0.6944	0.498	2	6.7866	1.3462	0.257
Year×Sex	2	0.0494	0.1044	0.906	2	0.52915	0.1063	0.897	2	0.36541	0.072305	0.931
Site×Species	2	1.8829	3.9848	0.021	2	22.634	4.5449	0.012	2	2.9454	0.58425	0.556
Site×Sex	2	0.0690	0.1461	0.866	2	6.721	1.3495	0.265	2	3.8119	0.75614	0.473
Species×Sex	1	0.5502	1.1644	0.28	1	16.212	3.2553	0.076	1	9.3199	1.8487	0.177
Year×Site×Species	3	0.7779	1.6462	0.185	3	12.864	2.583	0.054	3	2.4947	0.49486	0.691
Year×Site×Sex	3	0.3236	0.6848	0.564	3	2.2675	0.4553	0.713	3	3.4568	0.6857	0.559
Year×Species×Sex	2	0.0199	0.0422	0.959	2	2.4276	0.4875	0.627	2	1.4136	0.2804	0.756
Site×Species×Sex	2	0.6468	1.3688	0.256	2	4.1265	0.8286	0.436	2	9.9724	1.9781	0.148
Year×Site×Species×Sex	1	0.4836	1.0233	0.306	1	2.274×10 ⁻⁵	4.566×10 ⁻⁶	0.999	1	1.0799	0.2142	0.645
Error	260	0.4725			260	4.9802			260	5.0413		

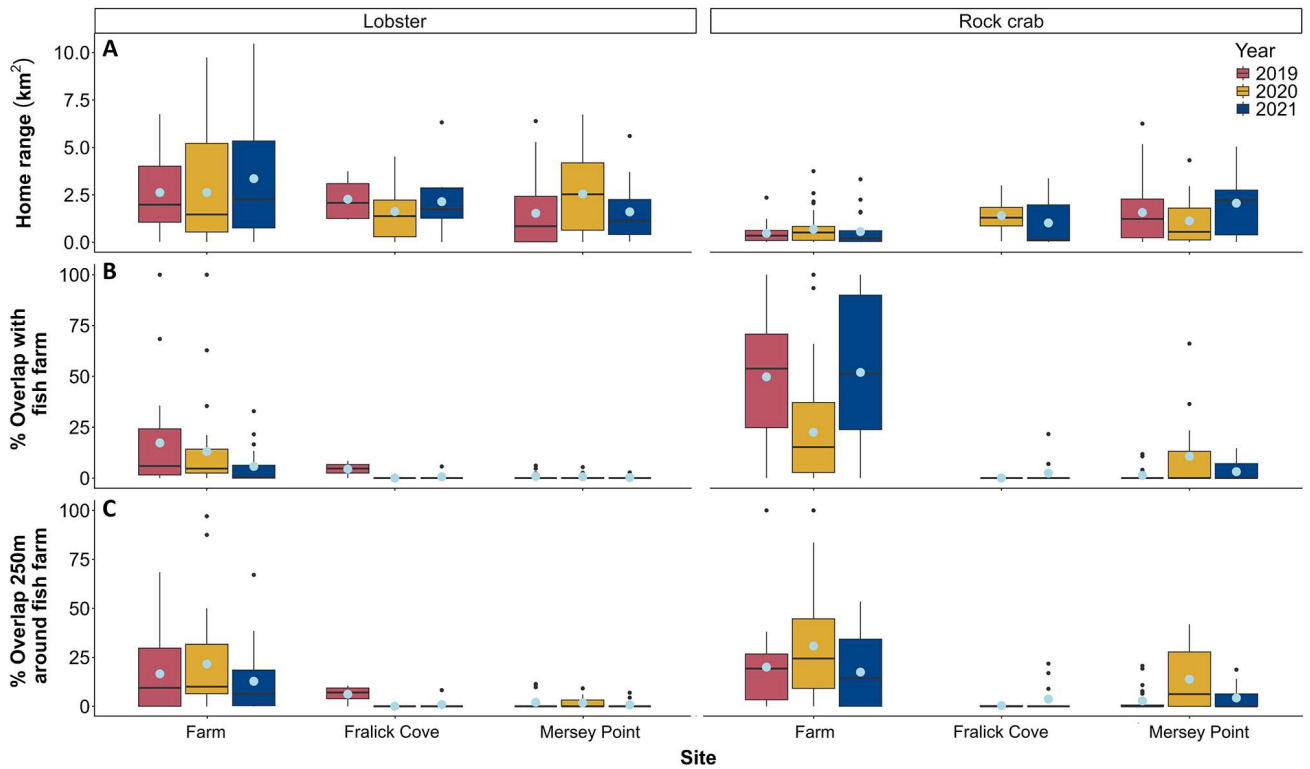


Fig. 5. Distribution of the (A) home range, (B) area overlap (%) with the salmon farm, and (C) movement (%) in 250 m buffer around fish farm by tagging site for American lobster and rock crab in Liverpool Bay. Light dots in the boxplot represent the means. Whiskers represent minimum and maximum values; black points represent outliers. Flattened box is represented by a black bar and means that 75% of the data has the same value

and 18 individuals had >25% overlap with this area. For the crabs tagged under the farm over the 3 yr, 85.39% of the 89 detected individuals had a home range that overlapped with the farm and 9 had 100% home range overlap, staying within the boundary of the farm for the duration of the study. A total of 80.90% of the detected crabs had a portion of their home range that overlapped with the 250 m buffer around the fish farm and 36 individuals had >25% overlap.

3.3.2. Port Mouton

Home range estimates for Port Mouton individuals varied significantly as a function of 'Site' and 'Species' (Table 8). The pairwise test showed a significant difference ($p < 0.001$) between lobster (mean \pm SE = 1.77 km² \pm 0.31) and rock crab home ranges (mean \pm SE = 0.30 km² \pm 0.05). The home range estimates of individuals tagged in North (0.42 km² \pm 0.12) and South (1.25 km² \pm 0.31) sites differed significantly ($p = 0.004$). Distribution of the home ranges for each species and tagging site are shown in Fig. 4C.

4. DISCUSSION AND CONCLUSIONS

This study demonstrated the efficacy of using high temporal frequency acoustic tagging to evaluate the behavior of 2 important commercial crustacean species in relation to salmon aquaculture farming activities in coastal Nova Scotia. A temporal resolution of approximately 3 min was used to simultaneously track 50 American lobsters and 50 rock crabs each year for approximately 125 d (4 mo) from July to

Table 8. Home range results for the 3-way ANOVAs for Port Mouton. Significant effects at $p < 0.05$ highlighted in **bold**

Source	df	Home range		
		MS	F	p
Site	2	388.7	5.658	0.006
Species	1	2319.4	33.762	< 0.001
Sex	1	48.5	0.706	0.404
Site×Species	2	70.2	1.022	0.366
Site×Sex	2	8.7	0.126	0.882
Species×Sex	1	9.3	0.135	0.715
Site×Species×Sex	2	70.1	1.020	0.366
Error	63	68.7		

November over the course of 3 yr during the most productive period for growth for both the crustaceans and the salmon. It was found there were distinct behaviors exhibited by both species but that they differed in their ecological strategies that were consistent with previously known biological characteristics.

For lobster, the 2 diver-based surveys showed that they did not appear to be attracted to the fish farm and may have been repulsed, as there were significantly more individuals (abundance) under the farm boundaries in the fallow year (2019) compared to the second year of production when the fish were 2 yr old (2021). This trend was not observed in the 2 reference areas (Fralick Cove and Mersey Point). It was unfortunate that no other dive surveys could have been undertaken in the first year of fish production (2020), but travel restrictions due to the COVID-19 pandemic prevented diving. The direct observational data from the 2 dive surveys were also in contradiction to the additional data from the lobster traps deployed from 2019 to 2021 and the remote operated vehicle (ROV) observations done in September 2021. Observational data from lobster traps deployed during this project around the edge of the farm showed that around 40–50 lobsters could be captured in less than 24 h per trap (N. Feindel pers. comm.). In addition, footages from an ROV deployed under the cage in September 2021 continually showed several lobsters in the field of view either moving around or sitting in shallow depressions on the sand bottom (Fig. S9; S. Robinson pers. comm.). The most likely explanation for these diverging views relates to the time periods in which the observations were generated. The second dive survey was done between July 15–17, 2021. This was 5 d after the tropical storm Elsa hit the southern Nova Scotia coastline with winds of over 80 km h⁻¹ with heavy rains and a strong storm surge. Since the farm is in relatively shallow water with a rippled sand bottom and no rock shelters, the lobsters may have moved to deeper water and were in the process of returning. There have been several studies that have shown American lobsters tend to move to deeper waters with the onset of storms and then return when the turbulence dies down, depending on the time of year (Cooper et al. 1975, Ennis 1984, Jury et al. 1995, Goldstein & Watson 2015). This behaviour of moving to deeper water in relation to storms has also been shown for spiny lobsters (Kanciruk & Herrnkind 1978) and for demersal oceanic fish species (Bacheler et al. 2019). There are too few observations from both the dive survey and the observational data from the ROV and trapping to be sure what the true temporal trends are with abundance of the lobster populations in the

area surrounding the fish farm. It is likely that both observations are correct for the time period in which they were collected and suggest a non-uniform distribution of lobsters over time.

These types of periodic, quantitative, observational data highlight the difficulties involved with trying to interpret patterns and infer the processes that are happening within populations. The question on potential impacts was important in the study because there exists a lot of concern within the public, resource management and industry over potential negative interactions that may be happening between the salmon aquaculture industry and the lobster and crab fishery. In the vicinity of a Grand Manan (New Brunswick, Canada) salmon farm, lobsters were less abundant during a period when farms were operational, particularly for egg-bearing (berried) lobster, than in periods when salmon were not in fish cages, and historical patterns of site occupation returned when the farm was removed (Lawton 2002). Conversely, Grant et al. (2019) did not observe any differences in lobster abundance between farm and reference sites over 8 yr of dive surveys on Grand Manan Island. Lobsters are known to be attracted by food resources (Grant et al. 2019), and rock crabs are one of their preferred prey (Gendron et al. 2001, Hanson 2009), so changes in crab densities or distribution might be important. Some studies have suggested that lobster movements and behaviour may be influenced by olfaction and that lobsters leave an area for a more preferred habitat if they detected an environmental stressor (e.g. Milewski et al. 2021) thereby affecting catch rates by the fishers. While organic enrichment from fish farms may impact and reduce benthic oxygen with the production of free sulfides, lobsters may also just avoid these conditions (Horricks et al. 2022).

The telemetry data provided a much broader and nuanced perspective on the behavior of the lobsters. Lobsters were apparently not deterred by the farm, as greater than 70% of detected lobsters had a portion of their home range under or around the fish farm over the 3 yr. The tagging results showed that different years of salmon production in Liverpool Bay did not affect home range estimates and the overlap with the farm for lobsters that were caught and remained in the vicinity. The same pattern was seen at the 2 reference sites. This is reflected by the small home range overlap of lobsters tagged under the salmon farm and by their movements throughout the bay (Figs. S1, S3, & S5). Results also showed that the home range for lobsters tagged at the 2 reference sites beyond the farm had a very low or no overlap with the salmon farm, suggesting that most lobsters are not attracted from

remote locations to the farm and the refugia or food that they could find under it. Lobsters tagged under the farm in the present study had a mean home range overlap of 34.26% under and around (250 m buffer) the farm, indicating that most of their estimated home range was outside the farm. Lobsters made use of most of the area within the acoustic array, and no clear homing activities were observed (Scopel et al. 2009, Scopel & Watson 2021). The home range mean was similar over the 3 tagging sites for the lobsters, suggesting that most of them moved away naturally and did not stay near their release area. This has been observed previously for lobsters within mussel leases in Prince Edward Island and Îles-de-la-Madeleine (Lavoie et al. 2022, Lees et al. 2023). This continual ranging movement is consistent with the patterns found in other lobster populations in the Gulf of Maine and the Gulf of St. Lawrence (reviewed in Lawton & Lavalli 1995, Bowlby et al. 2007). Lobsters can be classified into resident versus dispersers related to their mobile behaviour (Bowlby et al. 2007) and to food acquisition and seasonal movements for reproduction. The movement of lobster populations into deeper water in the late fall in Nova Scotia has been shown in studies that have used both traditional and electronic tags (Hanley 2018, Turner 2024) and is consistent with the non-sheltering movement patterns observed in Liverpool Bay. Local lobster harvesters deployed many of their traps near the fish farm adjacent to Coffin Island due to the high catch success they experienced in the area (see McKee et al. 2021). With a high implied lobster population, there may have been strong competition for food resources and/or refuges, leading to highly mobile lobster around the Liverpool Bay. Substrates within the bay may have also influenced lobster distribution and mobility, as lobsters are more associated with hard rock bottom (Lawton & Lavalli 1995, Tanaka & Chen 2015), and the bottom underneath the farm was rippled sand (McKee et al. 2021).

In Port Mouton, lobsters were more abundant in the North site, where the fish farm had been operating several years prior to this study. Some structures (buoys and ropes) were still visible on the site, and some of these may have been used by lobsters as a refuge, as observed with physical structure associated with suspended mussel aquaculture (McKindsey et al. 2011). With these observations, no major effects on lobster behaviour were seen between the 3 sites in Port-Mouton.

This study did not focus on berried female lobsters, as only 2 berried individuals were retained in the analyses for Liverpool Bay. Fig. S3 showed the movement across the Liverpool bay for these 2 individuals

(ID 54214 and 54297), and their behaviour seemed to reflect the other individuals in the area in 2020. As this reproductive state may cause different site selection and behaviour (Goldstein & Watson 2015), further work should be done on berried lobsters. Temperature and depth are also known to be drivers that may influence the behaviour of lobsters (Comeau & Savoie 2002, Goldstein & Watson 2015, Koepper et al. 2021). Further work on temperature, storms, and depth associations with lobster movements should be very interesting to do.

In contrast to lobster, rock crabs were definitely associated with the salmon farms, particularly the crabs that were tagged in close proximity to the farm (Figs. S2, S4, & S6). They would often remain underneath the farm or in close proximity. Crabs tagged in the reference areas were less likely to make it to the farms, suggesting that they are perhaps less attracted to the farms due to the dilution of potential food odors coming from the salmon feeding activities or perhaps were less mobile because of predation. The crabs were much less mobile than the lobsters in walking speed (43% slower) and remained in the receiver array for almost twice as long as the lobsters (57 d or 46% of the time). Crabs had smaller home ranges around the farm and high overlap with the farm lease for animals tagged under the farm, potentially indicating that crabs stayed under the farm. This may be due to a fall-off of fouling organisms (mussels *Mytilus edulis*) on the structures in the fallow year (C. McKindsey pers. comm.) and the consumption of salmon feed and/or other organisms that consume it during production years (Sardenne et al. 2020). The effect of mussel fall-off on rock crab distributions was previously noted in Prince Edward Island by Lees et al. (2023), and rock crabs are known to consume salmon feed from laboratory studies (Drolet et al. 2022). Female crabs overlapped the farm with home ranges more than males by a factor of 2. Females extrude their eggs in late October (Fisheries and Oceans Canada 2000), so perhaps they are maximizing energy intake for reproduction during the summer months. Differential behaviors of crustaceans by sex have also been documented in Sweden with regard to movement patterns in the edible brown crab that are related to reproduction (Ungfors et al. 2007). The aggregating behaviour of the crabs is normal and would suggest that they are responding to a valuable food resource, since shelter was limited. Increasing levels of food near aquaculture operations that attract crustaceans has been documented in several studies (D'Amours et al. 2008, Sean et al. 2022). The prey of rock crabs is typically comprised of polychaetes (>60%), molluscs, amphipods

pods and other organisms (Stehlik 1993), but they can also be opportunistic when opportunities arise (Hudon & Lamarche 1989). The crabs primarily search for prey with olfaction and are attracted to food odor plumes in the water column carried by currents (Rebach 1996, Zhou & Rebach 1999). Interestingly, crabs may become conditioned to familiar foods after being fed for longer periods of time (Ristvey & Rebach 1999), so perhaps the farm operations and the organic waste are conditioning crab behaviour. Crabs and lobsters tend to exist together in the same ecosystem as niche segregation occurs and where different prey items are consumed (Hudon & Lamarche 1989). Lobster biomass often increases concurrently with rock crab biomass (Hudon & Lamarche 1989).

The conclusions from this study are that salmonid aquaculture in Liverpool Bay has behavioural effects on rock crabs, but very little on lobsters in the surrounding area. Both American lobster and rock crab have been shown to uptake nutrients from aquaculture activities (Sardenne et al. 2020). It has also been demonstrated, in a worst-case scenario lab experiment, that a diet of only salmon feed may have negative impacts on rock crab condition (Drolet et al. 2022). This study demonstrated that lobsters in Liverpool and Port Mouton Bays were very mobile, and there was no indication that movement of lobsters in areas adjacent to the farm significantly changed compared to reference areas, refuting the previous assertions that salmon farms drive lobsters away. Lobsters were present and abundant near and under the farm, although we did not collect enough data to ascertain what the temporal patterns in abundance might be. Crabs were more attracted to the farm and tended to remain in relatively close proximity, as their spatial overlaps with the farm increased over time, although the movement of animals adjacent to the farm remained similar over the 3 yr of the study. As for Bay of Fundy salmon aquaculture sites (Walters 2007), salmonid aquaculture will continue to interact with decapods throughout eastern Canada. More studies need to be done to improve our knowledge regarding crab and lobster-farm interactions and to investigate the cause–effect relationship of these decapods that use food resources and live under local environmental conditions generated by the fish farm, on both a behavioral and physiological basis. It is hoped that results from this study will foster the development of a sustainable salmonid aquaculture industry while allowing the continued use of fisheries resources by fishers by providing an evidence-based understanding of the links between these 2 activities.

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