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POPULATION CHARACTERISTICS AND MOVEMENTS OF AMERICAN LOBSTERS (*HOMARUS AMERICANUS* H. MILNE-EDWARDS, 1837) CAPTURED IN THE MINAS REGION OF THE INNER BAY OF FUNDY, NOVA SCOTIA

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ABSTRACT

Tidal power potential is being explored for Minas Passage, the body of water that connects Minas Basin to the Bay of Fundy (BoF). The Minas Channel−Minas Basin area of the BoF supports an American lobster fishery of ~200*t* worth $2.0-3.0 million/year. Three studies in the region were conducted during 2008-2018 to evaluate population characteristics and movement of lobsters for future assessment of impacts from tidal power development. A total of 12,327 lobsters captured in commercial and experimental lobster traps were examined for carapace length (CL), sex, and reproductive condition. Of these, 5614 marked with exterior streamer tags during 2008 and 2017 were released for recapture information from fishers. During 2011-2013 and 2017-2018, 125 and 50 lobsters, respectfully, were marked with acoustic tags and monitored in Minas Passage and Minas Basin with acoustic receivers deployed by Acadia University, the Mi'kmaq Conservation Group, the Ocean Tracking Network, and Fundy Ocean Research Center for Energy. Carapace length of males and females ranged from 41-200 mm and 51-216 mm and mean CL varied from 87.1-121.0 mm and 88.3-115.7 mm, respectively. Male: female ratios ranged from 1.0:0.6-1.0:1.2. Mean daily movement varied from 0.33 km/d to 1.21 km/d. Females released larvae during July, egg extrusion began in October, and proportion of berried females peaked in December at 50.4%. Experimental trap catches, streamer tag returns, and acoustic detections indicated that lobsters were spread evenly over the

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sampled area in summer but movement into Minas Passage occurred during autumn where the lobsters remained for winter. Movement of berried females into Minas Passage is possibly a local life history strategy that enhances development rate of attached eggs in the relatively warmer water of this region during winter (+1.0°C). Lobsters marked with streamer tags migrated throughout the BoF and were reported from traps off Advocate and as far as Grand Manan and SW Nova Scotia (200+ km).

INTRODUCTION

The fishery for American lobster (*Homarus americanus* H. Milne-Edwards, 1837) is the largest by value in Atlantic Canada. Between 2015-2024, Canadian lobster landings varied from 90,000 to 106,000*t* (Goldstein *et al*. 2026) and the annual value to the Canadian economy was approximately $3 billion with large exports to the United States, the United Kingdom and China. Landings from Lobster Fishing Areas (LFA) 33-35 (Fig 1; Halifax-Inner Bay of Fundy) in 2018 were 31,863*t* with a landed value of $502 million (DFO 2021). The Minas Channel to Minas Basin lobster fishery has annual landings of approximately 200*t* and during 2018 with a dockside price of $6.50/lb was worth $2.86 million. A total of 29 fishers, operating out of Parrsboro on the north side of Minas Basin, Delhaven on the south side of the Basin and Halls Harbour in Minas Channel share the fishery (Morrison 2014). This well-defined fishery operates in Minas Channel to Minas Basin (Fig 1, LFA 35) during May 1-July 31 and October 15-late December. Although the fishery in this region is open during winter; fishing is not possible because of drifting ice. Fishing is also difficult because the large tides (range 11-16 m) and strong currents (3-6 m/s) cause lobster buoys to submerge except around high water and low water slacks; periods of about 2-4 hours in each case. Trap hauls average about 100/day/fisher but daily yields are high both in the spring-summer and autumn (average 400-500 kg; Dadswell *et al.* 2009). In LFA 35 the minimum allowable retention size was 82.5 mm carapace length (CL) during our 2008 study but was raised to 88.5 mm CL before the 2017-2018 study. Lobsters sampled from fisher's traps ranged from 41-216 mm CL and the proportion of shorts (lobster <88.5 mm CL) to markets was about 1: 2 during both 2008 and 2017. The sex ratio in the catch is approximately 1:1 and there is a high proportion of berried females (DFO 2021).

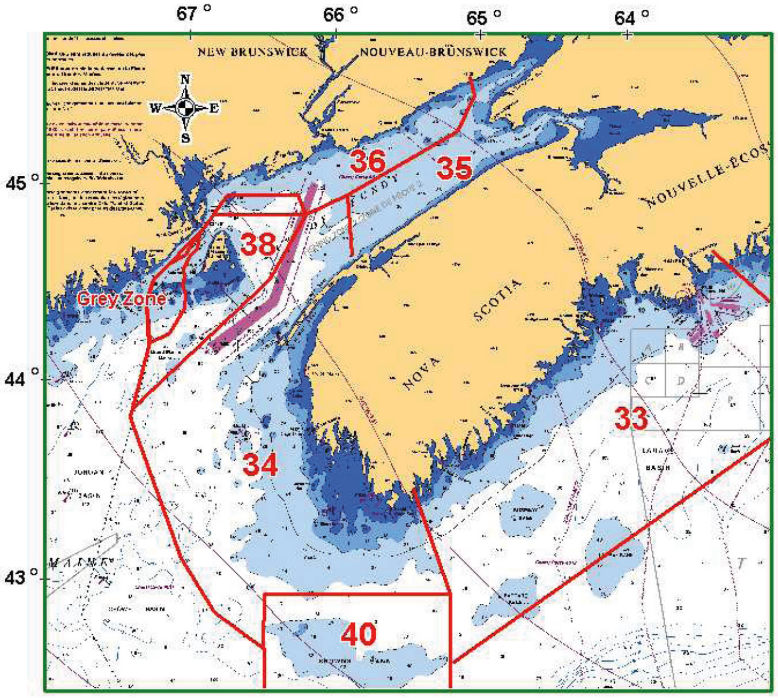


Fig 1 **Lobster fishing areas in western Nova Scotia and the Bay of Fundy. The Minas Channel–Minas Basin fishery is in LFA 35 (after DFO 2021).**

Brief Synopsis of American Lobster Biology

The American lobster is a member of the Crustacean clawed lobster family, Nephropidae (Goldstein *et al*. 2026). The basic body plan consists of two parts: the cephalothorax which represents the fusion of head and thorax; and the abdomen (Cobb 1976). The cephalothorax is covered by a heavy, fused shell or carapace, but the abdomen is flexible because each segment has its own shell. It has two, large forward projecting claws which it uses for defense, prey capture and to process its food and habitat. There are four sets of walking legs in the rear section of the cephalothorax and a large tail fan consisting of flattened appendages called the uropods and the telson. With these appendages lobsters can move rapidly, walking over the bottom or swimming to avoid predators, capture prey or move long distances to remain in preferred temperatures and salinity for growth, reproduction, and survival (Campbell 1986). They feed on most any kind of benthic organism including but not restricted to marine worms (Polychaeta), isopods and decapods,

particularly crabs, bivalve and gastropod mollusks, echinoderms including sea urchins, fish, and plant matter (Goldstein *et al.* 2026). They are also scavengers and can be cannibalistic.

The American lobster is distributed from Labrador to North Carolina and found from low tide to depths of 400 m (Cobb 1976, Wahle and Steneck 1991). At the northern extent of its range, the lobster occurs inshore at relatively shallow depths (0-100 m) but in the middle and southern portions of its range inhabit deeper water and offshore to marine canyons (100-400 m). Lobsters occur on most any substrate from clay to cobble but generally select habitat with rocks where they can hide in crevices or burrow under them to hide from predators. With their large claws numerous feet and powerful tails lobster dig away the substrate to make tunnels (Cobb 1976, Berrill and Stewart 1973). The tunnels are used to hide from predators such as wolf fish, cod, flounder, crabs or other lobsters and for protection when molting during reproduction.

Lobsters grow by molting their external shell (ecdysis; Cobb 1976). Molting can occur two or three times annually in young lobsters but for adult lobster takes place once annually usually during the warmest period of the summer (June-August, Goldstein *et al*. 2026). After molting their shell is soft and the lobster is especially vulnerable to predation. Growth of lobsters in the Bay of Fundy (BoF) is relatively slow compared to growth in other Atlantic coast regions because of the lower annual accumulation of degree days in the cooler Fundy waters. Lobsters in the BoF take about six years to reach 81 mm CL and another 2-3 years to attain commercial size (88.5 mm CL) and sexual maturity (90-100 mm CL; Campbell 1983).

Most mature lobster females reproduce only once every other year, so the maximum portion of egg-bearing females found in a local population seldom exceeds 50% annually (Cobb 1976, Campbell 1983, Waddy and Aiken 1986). Mating only takes place when the female is in the soft-shell condition immediately after molting. She enters a males' burrow, molts, is mounted by the male and sperm transfer occurs. The female then stores the sperm in seminal vesicles. The male continues to defend the burrow and protect the female until her shell hardens at which time she departs. About 2-3 mouths later the female makes her own burrow or finds a place to hide and at night turns on her back and releases her eggs which pass through the seminal vesicle, are fertilized, and as they are released through the oviduct, the

female 'glues' them to the swimmeret appendages on the underside of her abdomen. Individual females release between 5,000-40,000 eggs depending on size (Koopman *et al.* 2015). The female is now in the 'berried' condition and she carries the developing eggs on her abdomen for nine to ten months until the larvae are ready to hatch during June-August (Perkins 1971). About a quarter of her eggs hatch with the larvae released each night (Pandian 1970).

American Lobster Movements

During the first years of their life, American lobster juveniles remain hidden in or near their shelter to avoid predation (Wahle and Steneck 1991). When larger, lobster migrate to shallow depths in summer and deeper depths in winter and in numerous studies approximately 75% moved <15 km (Campbell 1986, Robichaud and Lawton 1997). Similar research done in the southern Gulf of St. Lawrence concluded that of 42,445 lobsters that had been tagged and released with 8503 recoveries, most had moved only 2-19 km from their release points (Comeau and Savoie 2002). In BoF, the Gulf of Maine, the offshore regions of the Scotian Shelf and off New England, however, some lobsters undertake long distance migrations of 100 km or more (Campbell 1986, Campbell and Stasko 1986, Robichaud and Lawton 1997). The record distance for travel to date was 798 km by a lobster tagged off Alma in the inner BoF and recovered on the southern side of Georges Bank.

The Environment of the Minas Region

Minas Basin (45°19'N, 64° 00'W) is a mega-tidal, cul-de sac marine embayment on the eastern side of the inner BoF and is semi-enclosed by the Province of Nova Scotia. The triangular basin is 80 km long and 29 km wide at the base and ~2000 km^2 in area. It consists of the central Minas Basin proper, Cobequid Bay the eastern extremity inside Economy Point, and the Southern Bight (Fig 2). Maximum depth in the Basin is 17 m at low tide. Minas Basin has the largest recorded tides in the world (mean 11 m, maximum 17 m; Garrett 1972) and at low tide about one third of the Basin area (670 km^2) is exposed as tide flat (Bousfield and Liem 1959). The tidal regime is semi-diurnal and an estimated 3 x 10^9 m^3 of water flows in and out of the Basin with each tide (Karsten *et al.* 2008). Because of the extreme tides the water column is homogeneous for temperature and salinity. Sea surface temperature (SST) ranges from a peak of 16-22°C in summer (August-September; Bousfield and Liem 1959) to -1.5-0.0°C in winter (February; Sanderson

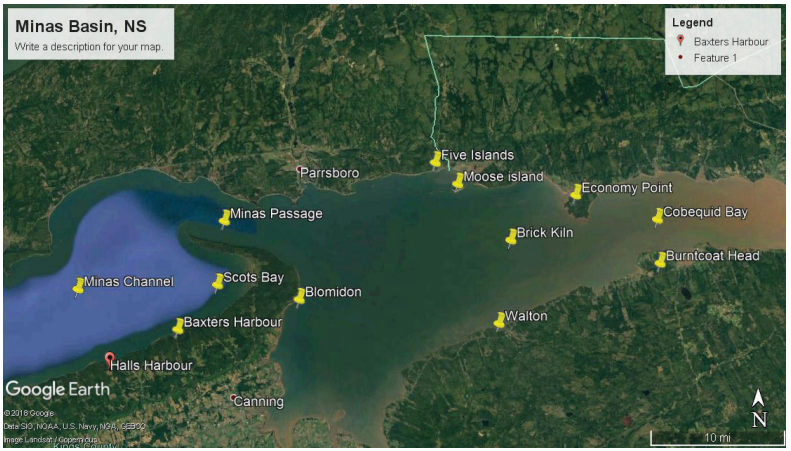


Fig 2 **Minas Channel, Minas Passage, and Minas Basin at the eastern extent of the inner Bay of Fundy. Locations highlighted with yellow markers are referred to in the text.**

and Redden 2015). Winter is characterized by drifting ice pans up to 5 m thick which in some years cover most of the Basin from January to March and severely scour the substrate of the intertidal zone (Desplanque and Mossman 1998).

Minas Passage (45°20'N, 65°40'W) connects Minas Channel of the inner BoF with Minas Basin (Fig 2). It is 15 km long and ~5 km wide with low tide depths of 35-115 m. Tidal velocities from 3-6 m/s occur in Minas Passage during falling and rising tides and large gyres have been identified around Cape Split and Cape Blomidon (Greenberg 1984). The strong tidal velocities have scoured most of the substrate of Minas Passage to bedrock (AECOM 2009).

Minas Passage has SSTs of 14-16°C from June to October (Bousfield and Liem 1959) and because of extensive upwelling the water column is isothermal from bottom to surface (AECOM 2009). The upwelling also causes Minas Passage to be warmer in winter than Minas Basin or Minas Channel. Winter temperatures range from 6.0°C in December to 1.0°C in March (Keyser *et al.* 2016).

Minas Channel (45°10'N, 65°50'W) connects the inner BoF to Minas Passage (Fig 2). It is 40 km long and 15-30 km wide with low tide depths of 10-60 m. Tidal velocities are similar to Minas Passage. SSTs in the Channel are the same as Minas Passage in summer but colder during winter.

Development of Tidal Power in Minas Passage

The Fundy Ocean Research Center for Energy (FORCE) has developed a reserve for energy and environmental research in Minas Passage where companies can test tidal power hydro-kinetic devices and study their effects on the environment (Fig 3, FORCE 2017, Bangley *et al*. 2022). FORCE has an array of five acoustic receivers on their research site and the Ocean Tracking Network (OTN) has an array of 12 receivers across Minas Passage between Cape Sharp and the Cape Split headland (Fig 3).

The development of tidal power in Minas Passage has been a concern for regional fishers because of the unknown and potentially deleterious effects caused by the devices. Because of this concern lobster fishers, Big Moon Power Canada, the Marine Institute of Natural and Academic Sciences, the Mi'kmaw Conservation Group, FORCE, and Acadia University partnered to study the biology and movements

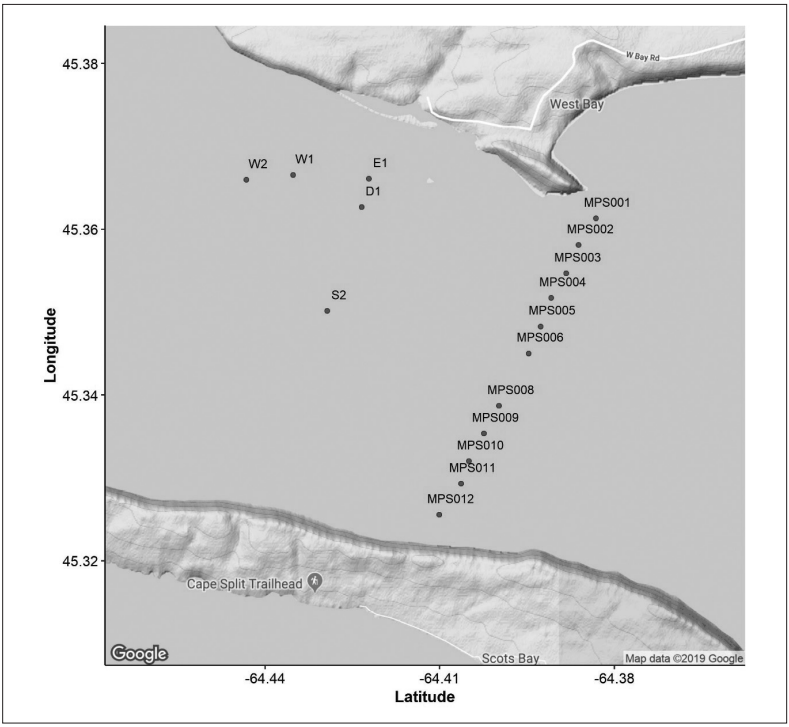


Fig 3 Positions of VEMCO VR2W receivers deployed by the Ocean Tracking Network (MPS001-MPS012) and by FORCE at their tidal power research site (D1-W2) in Minas Passage during 2008–2018.

of American lobster in Minas Basin, Minas Passage, and Minas Channel to establish a baseline of knowledge. The information gained will be used for comparison to the Minas region lobster population in the future to determine if any significant effects from tidal power development may have occurred.

METHODS

This study involved five stages. Sampling of fisher's lobster traps in Minas Passage and Minas Channel for catch data and lobster biological characteristics was conducted during May-October 2008 and short lobsters (<82.5 mm) and berried females were tagged with streamer tags (Dadswell *et al.* 2009). During 2011-2013 lobsters were obtained from fisher's traps in Minas Basin, tagged with acoustic tags, and monitored with acoustic receivers deployed in Minas Passage by Acadia University, and the FORCE and OTN arrays (Morrison *et al.* 2014). During November-December 2017 catches from commercial traps set in Minas Channel, Minas Passage and Minas Basin were sampled and lobsters examined to determine biological characteristics. Lobsters supplied by fishers from their traps were tagged with streamer and acoustic tags. Then, in 2018 experimental lobster traps (Fig 4) and acoustic receivers (Fig 5) were deployed in Minas Basin and Minas Passage and captured lobsters were examined for biological characteristics. Finally, movement data collected from lobster sampling, tag returns, and acoustic detections from all acoustic receivers in the study area during 2008-2018 were analyzed for distance moved, time at large, and direction of movement.

Lobster Tags

Streamer tags used were FLOY yellow plastic tags with a printed ID number and return address on each tag. Tags were inserted into the flesh on the underside of the abdomen between the second and third segments. Approximately 10 cm of tag was obvious to view on each side of the abdomen (Fig 6). Plastic streamer tags have excellent retention (~98%), do not affect the lobster physically, and are usually not lost during molting and other activities (Scarratt 1970, Comeau and Mallet 2003).

Acoustic tags used were VEMCO V-13 tags during 2011-2013 and VEMCO V9-2H tags during 2017-2018 (VEMCO 2019). VEMCO V-13 tags are 45 mm long. At a signal phase of 60-120 seconds, they

have a life span of 286 days. VEMCO V9-2H tags are 9 mm in diameter, 24 mm in length and weigh 2.9 gm in water (VEMCO 2019). At a signal phase of 180 seconds, they have a life span of 324 days. Underwater reception range of acoustic pings was 0-400 m depending on current speeds (Morrison 2014).

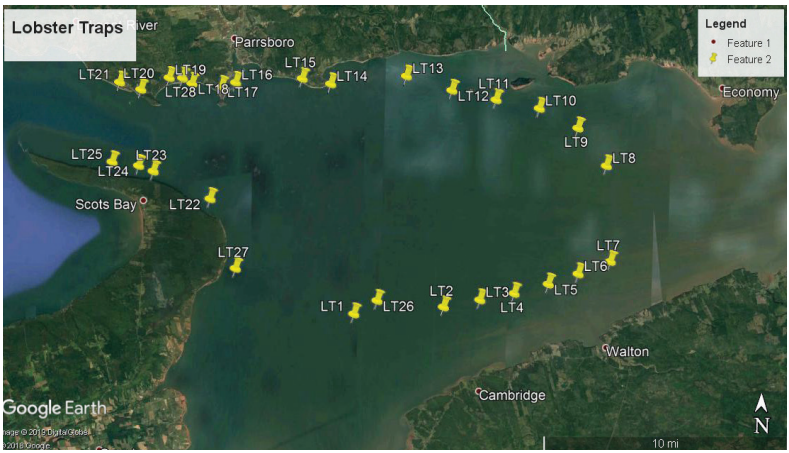


Fig 4 Distribution of experimental lobster traps in Minas Passage and Minas Basin during August 6-October 14, 2018.

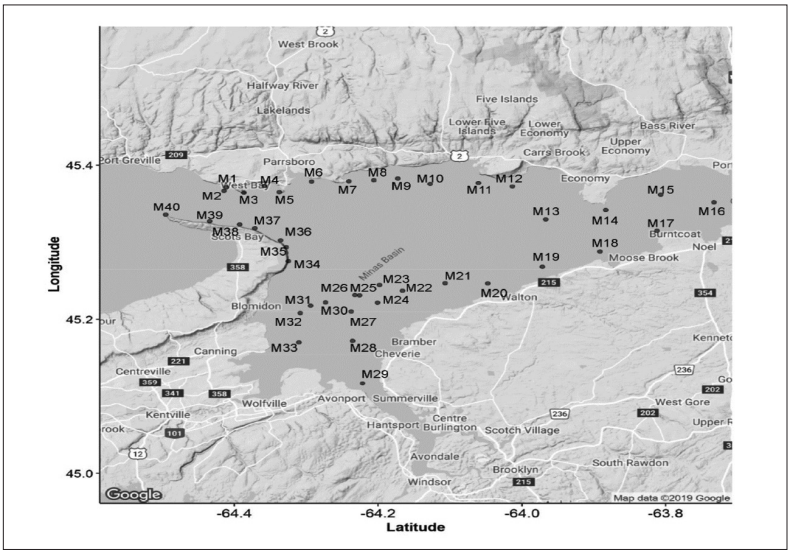


Fig 5 Positions of VEMCO VR2W receivers (M1-M40) in Minas Passage and Minas Basin deployed during April-December 2018.



Fig 6 **Lobster tagged with a yellow FLOY streamer tag through the underside of the abdomen. This lobster was MCG0473. It was a hard-shelled, 70 mm CL male captured off Halls Harbour in Minas Channel on November 3, 2017. To date it has not been recaptured.**

The tag was attached to the dorsal surface of the lobster carapace with 5-minute epoxy resin adhesive (Fig 7). First the lobster was placed on a level, damp surface (wet paper towel) to reduce desiccation. Then the dorsal surface of the carapace was washed with isopropyl alcohol and allowed to dry for five minutes. The epoxy resin was mixed and applied to the carapace surface and the tag pressed into the epoxy. The epoxy was allowed to air-dry for one-half hour at which time the lobster was released back into the sea. Release sites were fixed for latitude and longitude using a handheld GPS meter (Garmin Etrex HTC; accuracy±3 m).

Lobster Sampling and Tagging 2008-2018

During 2008 lobster traps set by fishers were allowed to soak for time periods between 1-3 days. For at-sea sampling personnel went aboard fishing vessels when pre-set lobster traps were hauled. Captured lobsters were counted, measured for CL, examined for sex and whether females were berried and assessed for molt stage (soft/hard). Sampling was conducted during June 1-July 31 and October 1-2 in Minas Channel and Minas Passage (Fig 2). Short lobsters (<82.5 mm CL) and berried females were tagged with FLOY streamer tags (2633).

During November 2011 and December 2012 traps set by fishers in Minas Basin were used to obtain lobsters for tagging with VEMCO



Fig 7 **An acoustic tag (VEMCO V9-2H) attached to the dorsal portion of a lobster carapace using epoxy adhesive. This was acoustic lobster 986 which was a berried female of 145 mm CL. She was released on the north side of Minas Passage on November 1, 2017, and was detected at the OTN line from November 6-22, 2017, then at the FORCE site on December 1, 2017. During 2018 she was detected numerous times at the middle to northern end of the OTN line before returning to the FORCE site in late July then back to the OTN line in August. During a period of 293 days, she moved a minimum distance of 8.8 km.**

V-13 acoustic tags. A total of 125 lobsters were released with acoustic tags attached, 85 in 2011 and 40 during 2012. An additional 29 VEMCO VR2W acoustic receivers were deployed in Minas Passage by Acadia University on the westward side of the FORCE site (Morrison 2014). Detections were obtained from the ACADIA, FORCE, and OTN receivers which facilitated range testing data with reference to current speed. Receiver spacing allowed for maximum coverage and optimization of receptions (Clements *et al.* 2005).

During November-December 2017 lobster traps pre-set by fishers in Minas Basin, Minas Passage and Minas Channel were again sampled. Protocol and data taken on lobsters was the same as in the 2008 study. Lobsters were tagged with FLOY streamer tags (2981) and VEMCO V9-2H acoustic tags (50). Acoustic tags were released during November 1-26, 2017.

During August 6-October 13, 2018, 28 experimental lobster traps were deployed in Minas Passage and Minas Basin (Fig 4). Traps used were the standard, commercial type like those used by fishers during the 2008 and 2017 surveys. Lobster catches were analyzed for CL of males and females, sex ratio, proportion of berried females and molt stage. Population characteristics found during 2017 and 2018 were compared using Student's t-test ($p<0.05$; Zar 2010).

Deployment of Acoustic Receivers 2011-2018

A total of 11 VEMCO VR2W acoustic receivers were deployed by OTN at their Minas Passage array from Cape Sharp on the north side of Minas Passage to the Cape Split headland on the south side. Data was available from November 1, 2011, to November 20, 2018. Downloads occurred approximately every four months. Receivers were titled MPS001-MPS012 (Fig 3). MPS007 was lost after June 2018. Range testing of these receivers indicated that acoustic tag receptions were lost when current speeds exceeded 1.5 m/s or for about 80% of each tidal cycle (Morrison *et al*. 2014). On the other hand, when current speeds were low (twice every 6 h) receptions were obtained from distances of 200-400 m.

Five (5) VEMCO VR2W acoustic receivers were deployed by FORCE at their tidal, hydroelectric test site in Minas Passage. The receivers were deployed and data was available from November 1, 2011, to August 23, 2018. Receivers are W1, W2, E1, D1 and S2 (Fig 3). An additional array of 29 VEMCO VR2W acoustic receivers were deployed by Acadia University between Minas Channel and Minas Passage during 2011-2013 (Morrison 2014).

Forty VEMCO VR2W acoustic receivers were deployed on moorings in Minas Basin and Minas Passage during April 4-December 16, 2018 (Fig 5). Receiver latitude and longitude at deployment were determined with a handheld Garmin meter. Receivers were visited once a month and downloaded to guard against loss of data.

Analysis of Lobster Movements in Minas Basin, Minas Passage and the Bay of Fundy

Catch/trap was determined from data collected between June 1-October 2, 2008, and August 8-October 14, 2018. The 2018 catches were further analyzed for season and % females. Movement of lobsters marked with streamer and acoustic tags were analyzed for direction, time at large, and distance of movement. Acoustic receptions in Minas Passage and Minas Basin were analyzed with the R-statistics package (R Core Team 2013) for number of detections, acoustic tag identification, duration and time of presence near each receiver.

Tag returns from commercial fishers and study sampling were mapped using Google Earth and analyzed for start and end point of movement, movement direction, and distance traveled. Streamer tag returns from the 2008 study (Dadswell *et al*. 2009) were incorporated with 2017-2018

tag returns to provide further information on long-distance movements in the Bay of Fundy.

RESULTS

Lobster Population Characteristics

A total of 971 fisher trap hauls were monitored during June 1-October 2, 2008, in Minas Passage and Minas Channel. The mean lobster catch was 4.73/trap. In 2018 the 28 experimental traps in Minas Basin and Minas Passage were monitored every two to three days during August 8-October 14. Mean lobster catch was 9.75/trap in Minas Basin and 17.36/trap in Minas Passage.

In 2008 a total of 2633 lobsters were examined for CL, sex, reproductive stage and molt stage, 1196 between June 9-July 30 and 1142 on October 5-6 (Table 1). Carapace length ranged from 55-143 mm for sampled male lobsters and 57-136 mm for sampled females. Mean CL of males during June-July was 87.1 mm compared to 91.1 mm in October. Mean CL of females was 88.3 mm during June-July and 96.4 mm in October. Mean CL of berried females was 100.7 mm during June-July and 101.9 mm in October.

During 2017-2018 a total of 9,694 lobsters were examined for CL, sex, reproductive stage and molt stage; 2413 during November 2-December 22 and 7281 during August 8-October 14 (Table 1). Carapace length of sampled male lobsters in 2017 ranged from 41-165 mm; sampled females, 63-216 mm (Fig 8). Carapace length of males in the 2018 sample ranged from 60-200 mm; females, 67-178 mm.

Table 1 Comparison of sample size (N), mean and range of carapace length of all males (M), all females (F), and berried female (BF) lobsters and the sex ratio (M: F) during 2008 and 2017-2018. Minimum carapace length for commercial take in 2008 was 82.5 mm but was increased to 88.5 mm before 2017-2018.

Sample Month/Year	Catch N	Mean Carapace Length M mm	F mm	BF mm	Range M mm	F mm	Sex Ratio M:F
06-07/2008	1196	87.1	88.3	100.7	54-133	57-136	1.0:0.9
10/2008	1142	91.1	96.4	101.9	55-133	51-124	1.0:0.6
11-12/2017	2413	101.7	102.5	124.1	41-165	63-216	1.0:1.2
08-10/2018	7281	121.7	115.7	125.7	60-200	67-178	1.0:0.6

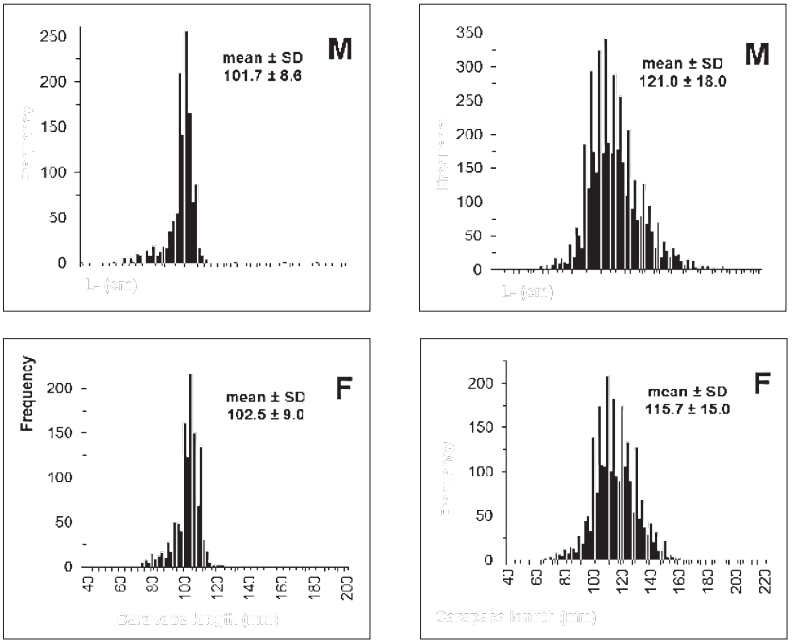


Fig 8 **Carapace length (mm) frequency of American lobster tagged in Minas Channel to Minas Basin from November–December 2017 and Minas Passage to Minas Basin during August-October 2018. Top (M=males 2017, n=1,221; 2018, n=4,708); bottom (F=females 2017, n=1192; 2018, n=2,573). Lengths grouped in 2 mm bins.**

Mean CL of males and females were 101.7±8.6 mm and 102.5± 9.0 mm in 2017 and 121.0±18.0 mm and 115.7±15.0 mm in the 2018 sample, respectively (Fig 8). Mean CL of males sampled during August-October 2018 was significantly larger than mean CL for males sampled during November-December 2017 as were females (t-test, $p<0.01$). Mean CL of berried females during November-December 2017 was 125.1 mm and was significantly greater than the mean CL of non-berried females from the same sample (Fig 9; t-test, $p<0.01$). There were too few berried females in the 2018 sample for comparison to non-berried females. The proportion of females in the November-December 2017 sample was greater (M: F=1.0: 1.2) than the proportion of females in the August-October sample (M: F=1.0: 0.6, Table 1).

Statistical comparison of lobster population characteristics between 2008 and 2017-2018 was not possible because the minimum commercial CL during 2008 was 82.5 mm (shorts) but was raised to 88.5 mm by 2017-2018. Also, because the minimum CL was raised, lobster fishers had

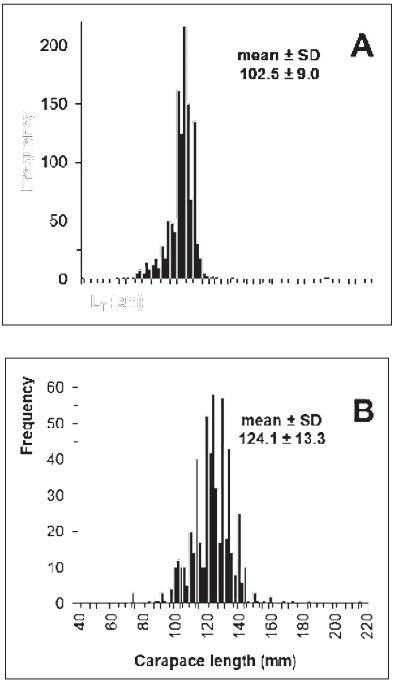


Fig 9 **Carapace length (mm) frequency of female non-berried (A, n=1,192) and berried (B, n =557) American lobster tagged in Minas Passage and Minas Channel from November to December 2017. Carapace lengths are grouped in 2 mm bins.**

to increase the size of the escape vents on their traps, which probably released more small lobsters during 2017-2018 before trap catches were examined. The mean CL of all 2008 lobster groups (males, females, berried females) were all lower than those observed in 2017-2018 although the CL range remained somewhat similar (Table 1).

Among samples taken during two-week periods from June-July 2008, August-October 2018 and November-December 2017, berried females represented 35.2% of females in June, declined to 5% of females in July, was <2.0% females during August-September, then steadily increased to 50.4% of females by December (Table 2). The proportion of soft-shell lobsters in the population also exhibited a seasonal cycle. Soft-shell lobsters were not observed during June but increased to 42.9% during late July and then decreased rapidly to 0.1-4.0% during August to December (Table 2).

Table 2 **American lobster sampled in Minas Channel to Minas Basin in biweekly periods during June to December, 2008-2018: total sample size, number of females and percent of total; number of berried females, percent of females and percent softshell.**

Period	Total Sampled	Females	% total	Berried	% Females	Softshell %
Jun 1-15	532	316	59.4	115	36.3	0.0
Jun 16-30	296	184	62.1	63	34.2	0.0
Jul 16-30	368	144	39.1	8	5.5	42.9
Aug 8-15	1306	578	44.2	1	0.1	0.4
Aug 16-31	2071	911	43.9	5	0.2	0.4
Sep 1-15	1609	592	36.8	7	0.4	0.3
Sep 16-30	1335	376	35.8	17	1.3	2.7
Oct 1-15	1051	344	32.7	24	6.9	3.9
Nov 1-15	994	534	53.7	191	35.7	0.1
Nov 16-30	995	436	43.8	200	45.9	0.1
Dec 1-15	220	141	64.1	54	38.3	0.1
Dec 15-22	772	460	59.5	232	50.4	0.2

Lobster Tagging

During June-October 2008 a total of 2633 Floy streamer tags were deployed in Minas Channel and Minas Passage in lobsters ranging from 45-130 CL mm. Of streamer tags deployed during 2008, 455 (17%) were returned from commercial fishers. None of the 2008 FLOY tagged lobsters were recovered during our 2011-2013 and 2017-2018 studies.

A total of 2981 Floy streamer tags were deployed on lobsters ranging from 41-185 CL mm from November 1-December 22, 2017, in Minas Channel, Minas Passage and Minas Basin. Streamer tag numbers were from 1-3000. Nineteen tags (0.06%) were either defective or missing. Of streamer tags deployed during 2017, 59 (2%) were returned by commercial fishers during 2017, five were returned during 2018 and one was recaptured during our study trap survey.

During the 2011-2013 study 125 acoustic tags were deployed on lobsters in Minas Basin during November 2011 and December 2012. Tags were deployed on 61 male (Range 90-144 mm CL), 43 females (Range 90-123 mm CL), and 21 berried females (Range 90-123 mm CL). Mean CL of berried females was 95.5 mm. Of the 125 acoustic tags deployed in Minas Basin a total of 40 (32%) were detected in Minas Passage during 2011-2013. Mean distance moved after release for all lobsters detected during 2011 was 0.33±0.34 km/day and for 2012 was 1.21±1.21 km/day. Female lobsters detected after release during 2012 moved 1.42±1.68 km/day.

A total of 50 acoustic tags were deployed in Minas Channel, Minas Passage and Minas Basin during November 1-26, 2017 (Table 2). Acoustic tags were deployed on six males (Range 86-105 mm CL), 5 non-berried females (Range 82-107 mm CL) and 39 (78.0%) berried females (Range 98-152 mm CL). Mean CL of berried females tagged was 131.3 mm. Of the 37 acoustic tags deployed in Minas Passage and Basin, a total of 23 (62.2%) were detected during 2017 or 2018 in Minas Passage. Of the 13 acoustic tags deployed in Minas Channel none were detected by Minas Passage receivers.

Detections on Acoustic Receivers During 2011-2013, 2017-2018

A total of 100,744 acoustic pings were recorded from 40 lobsters tagged in Minas Basin by receivers in Minas Passage at the ACADIA and OTN lines and at the FORCE site during 2011 to 2013. There were a total of 2335 acoustic pings at the northern portion of the OTN line, 1990 at the central portion, and 2980 at the southern end of the line. Since the acoustic data collected during 2011-2013 would have added little to the overall conclusions of our studies we chose to use only the 2017-2018 acoustic data for the detailed examination of lobster movement in the Minas region.

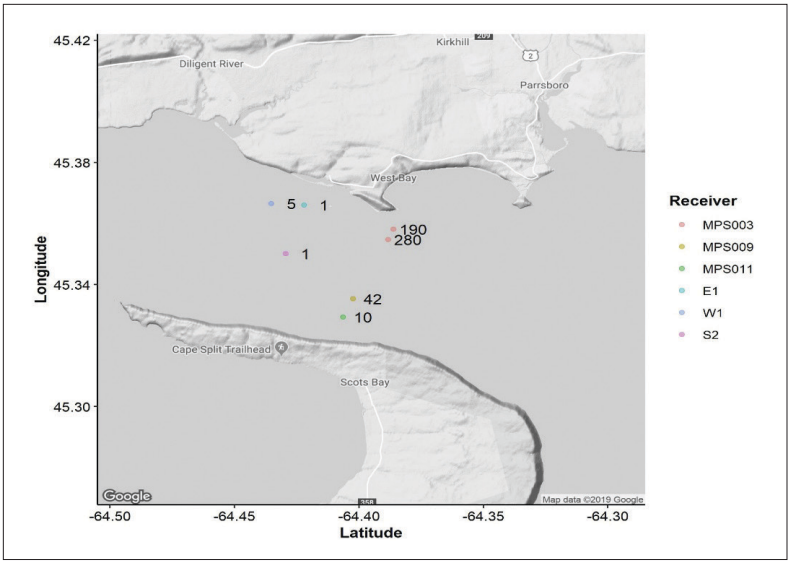


Fig 10 Total number of receptions of acoustic tagged lobsters at OTN line and FORCE site during 2017.

During November-December 2017 a total of 522 acoustic pings were recorded from tagged lobsters by receivers along the OTN line (Fig 10). These consisted of detections at receivers MPS002, MPS003, MPS009 and MPS011. Seven pings were recorded at the FORCE site from receivers E1, W1 and S2 during the same period. A total of five different acoustic tagged lobsters were detected at the Minas Passage receivers during November-December 2017 (Fig 11). Acoustic tags recorded were 986, 995, 1003, 1013 and 1019. Receptions commenced on November 1 immediately after tagged lobster were released in the vicinity. Lobsters 986, 1003 and 1013 remained near the receivers for extended periods, others only briefly (Table 3). Receptions at the OTN line consisted of three lobsters (two berried females and one male). Receptions at the FORCE site were from two other berried females.

A total of 6387 pings from acoustic tagged lobsters were recorded at OTN receivers during January-November 2018 (Fig 12). These consisted of receptions at receivers MPS1-MPS11. A total of only four pings

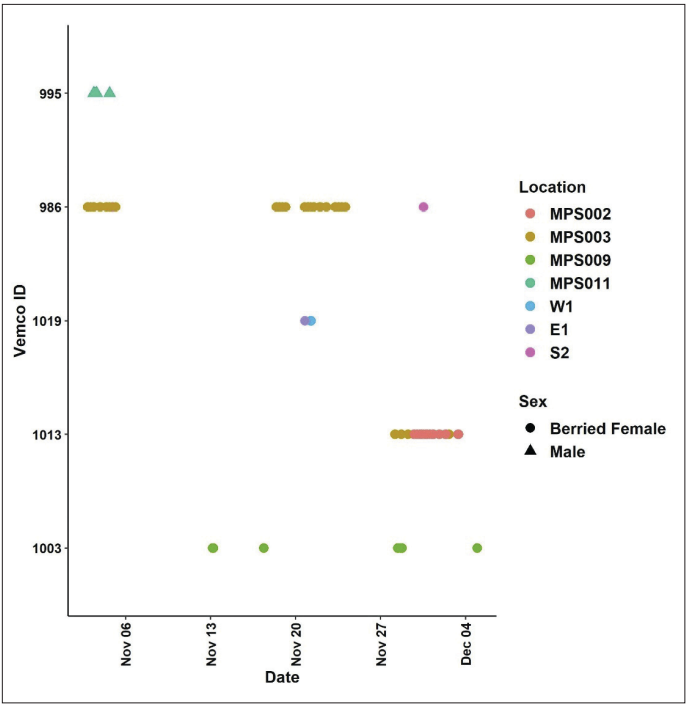


Fig 11 Receptions of individual acoustic tagged, sexed lobsters at OTN and FORCE receivers in Minas Passage during November-December 2017.

Table 3 Detection of acoustic tags at receivers in Minas Passage during 2017 and 2018 for movement of tagged lobsters. Tagging and reception sites are MB=Minas Basin, B=off Blomidon, P=off Parrsboro, MP=Minas Passage. Receivers were FORCE -E1, W1, D1, S2; OTN - 1-11; Study - M1-M6, M39-M34.

Tag #	Tagging Site	Reception Receiver and Month		
		MP 2017	MP 2018	Study MP 2018
984	MB	-	-	M34, June-July
986	P	3-S2, November	5-6-5-D1-4-3, July-August	-
989	P	-	3-2-3, May	-
991	MB	-	8, May	-
992	B	-	11, July	M39-M38-M37, June
	-	-		
995	MP	9, November	-	-
996	MP	-	-	M40, August
997	MB	-	-	M6, May-August
1003	MP	9, November	9-8-7, June-October	-
1004	MP	-	7, June	-
1007	MB	-	3, May	-
1009	P	-	7, May	-
1011	P	-	3, Apr-May	-
1012	P	-	3, May	-
1013	P	3-2-3-2, November-December	-	-
1014	P	-	11, August	-
1015	P	-	3-2-3, January-February	-
1018	MP	-	5-6-5, July-August	-
1019	MP	E1-W1, November	-	-
1027	MB	-	8, May	-
1028	MB	-	3, May	-
1030	P	1-3, May-4-3-4, August-November	M3-M5, May-June	
1031	P	-	3-3, April-May	M3, May

Acoustic tags # 982, 983, 999, 1000, 1001, 1002, 1008, 1020, 1021, 1022, 1023, 1024, 1025 were released in Minas Channel in Scots Bay, off Cape Split and off Halls Harbour but were not detected by Minas Passage receivers during the study.

were detected at the FORCE site at receiver D1. A total of 17 individual tagged lobsters were recorded at the OTN and FORCE receiver sites during January-November 2018. Acoustic tags recorded were 986, 989, 991, 992, 1003, 1004, 1009, 1011, 1012, 1014, 1015, 1018, 1027, 1028 and 1030 (Fig 13). Most lobsters passed a receiver during a short period (Table 3). Five lobsters remained near a receiver for extended periods.

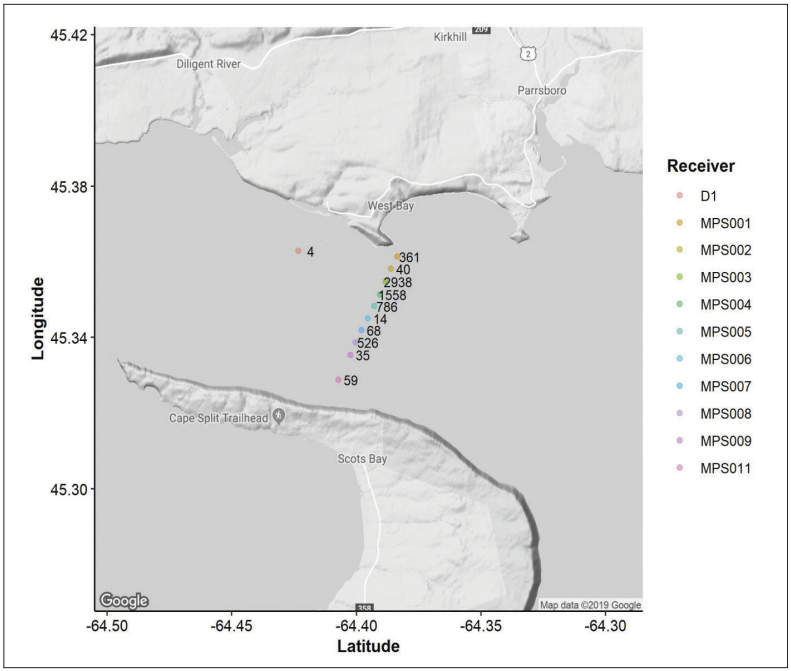


Fig 12 Total number of detections for acoustic tagged lobsters at OTN and FORCE receivers in Minas Passage during January-November 2018.

Receptions at the OTN line consisted of 15 female lobsters that had been berried when tagged and one male. Receptions at the FORCE site involved two females that were berried when tagged.

A total of 2241 acoustic pings from tagged lobsters were received at study receivers deployed from May-December 2018 on the north side of Minas Passage and a total of 1507 were detected at receivers deployed on the south side of Minas Passage during the same period (Fig 14). These included receptions at receivers M3, M5 and M6 on the north side and M34, M37, M38, M39 and M40 on the south side. A total of six individual acoustic tagged lobsters were detected at study receivers on the north and south sides of Minas Passage during May-August 2018 (Fig 15). Lobsters detected were 984, 992, 996, 997, 1030 and 1031 (Table 3). Detections included four female lobsters that were berried when tagged and two females were not berried when tagged. One lobster remained for an extended period near a receiver, the remainder for periods of a month or less.

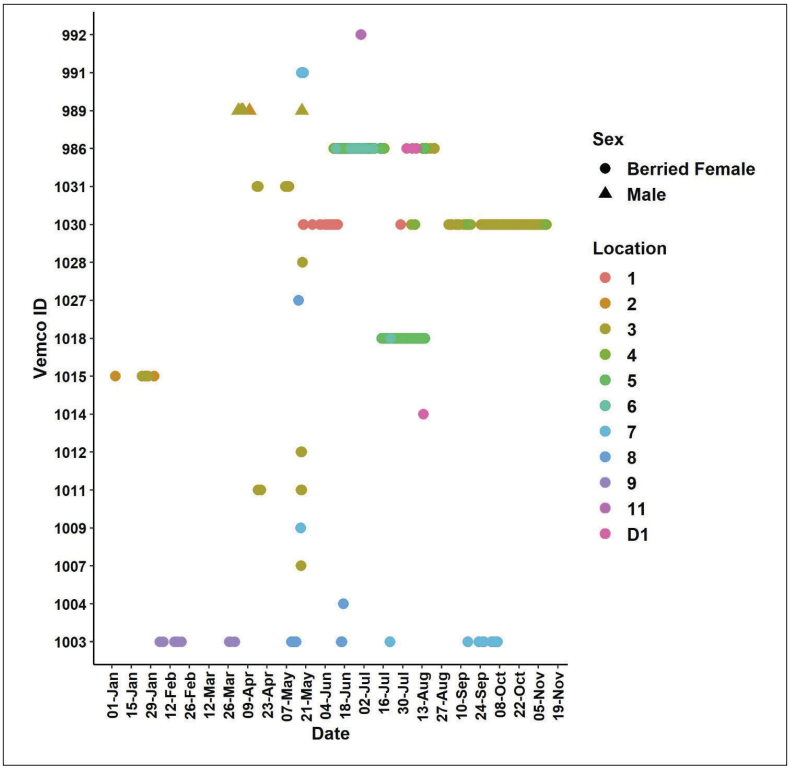


Fig 13 Receptions of individual acoustic tagged sexed lobsters at OTN and FORCE receivers in Minas Passage during January-November 2018.

Movement of American Lobster in Minas Basin, Minas Passage and the Bay of Fundy

Experimental trap deployments during August-October 2018 indicated there was a fluctuation in the abundance and sex ratio of adult lobsters in Minas Basin (Table 4). Lobster catch/trap was similar or only slightly less in Minas Basin traps than in Minas Passage during August (mean 12.4 vs 16.0) while during September into October catch/trap in Minas Basin declined to a mean of 7.7 lobsters while the catch/trap in Minas Passage increased to a mean of 20.1 by early September and remained high into late September (18.6) and early October (14.7). At the same time the proportion of females in the Minas Basin trap catches declined from a high of 37.0% in early August to 15.5% by mid-October while at the same time catch/trap increased in Minas Passage (42.2% to 52.2%, Table 4). Since the lobster fishery closed at the end of July,

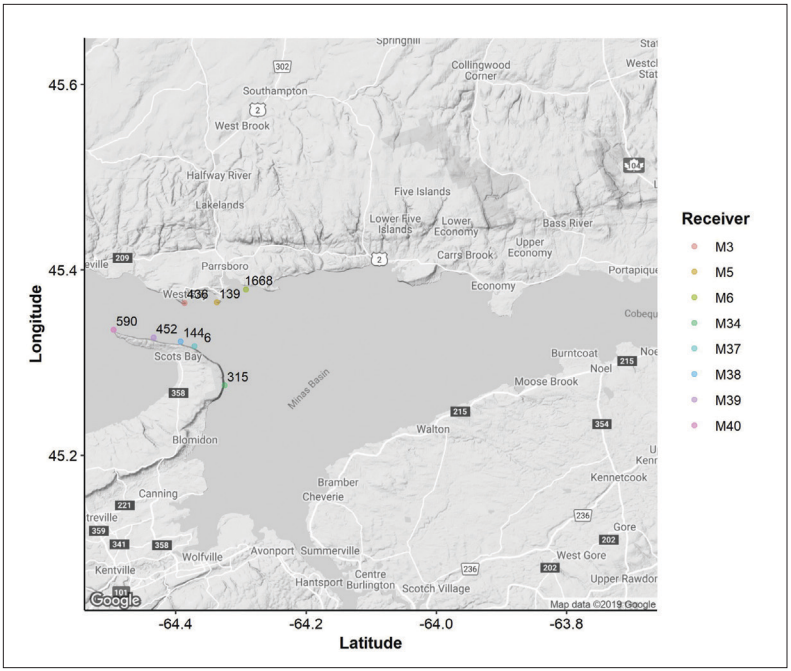


Fig 14 Total number for receptions of acoustic tagged lobsters at study receivers in Minas Passage and Minas Basin during April-December 2018.

Table 4 Catch/trap and % females for American lobster taken in experimental traps set in Minas Basin and Minas Passage during August 8-October 14, 2018.

	S Minas Basin		N Minas Basin		S Minas Passage		N Minas Passage	
Set Period	**Catch /Trap**	**% Female**	**Catch /Trap**	**% Female**	**Catch /Trap**	**% Female**	**Catch /Trap**	**% Female**
Aug 8 - Aug 14	12.6	34.5	12.3	38.7	19.6	49.6	12.5	41.8
Aug 27-Sept 4	11.2	30.2	11.1	24.2	25.1	42.6	15.1	37.6
Sep 15-Sep 24	6.7	22.4	8.2	23.5	20.8	40.9	16.4	42.2
Oct 6- Oct 14	6.6	13.7	9.3	17.4	16.3	40.9	13.1	52.2

and commercial catches would not have affected catch/trap, these data suggest there was a movement of predominately female lobsters out of Minas Basin and into Minas Passage during this period.

Movement of streamer tagged lobsters in Minas Basin and Minas Passage recaptured by lobster fishers during the period November 1-December 22, 2017, indicated that most short-term movement (mean

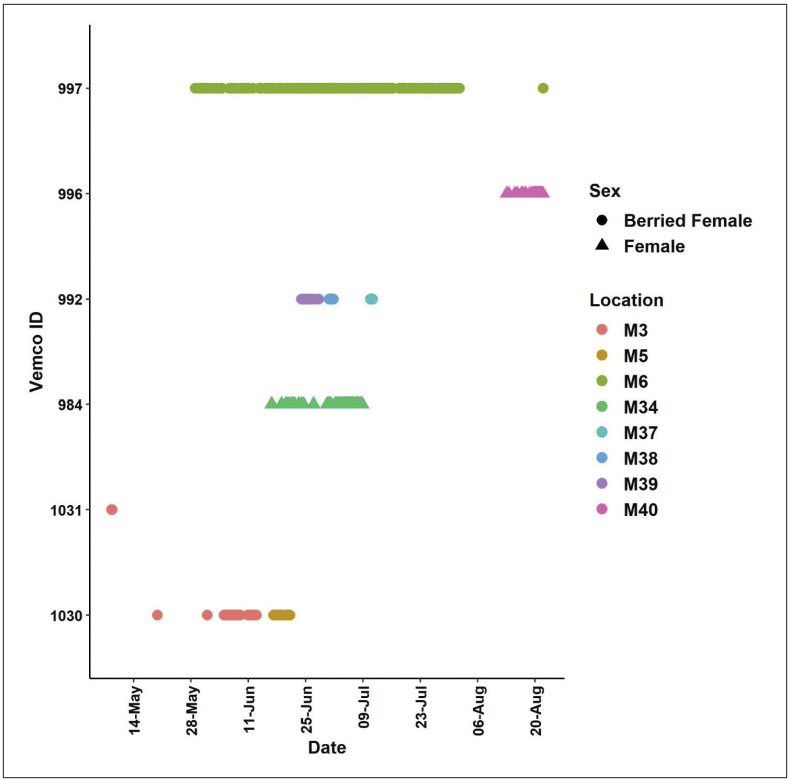


Fig 15 Receptions of individual acoustic tagged sexed lobsters at study receivers in Minas Passage and Minas Basin during May-August 2018.

distance 8.4 km) was also from Minas Basin towards Minas Passage (Fig 16). At the same time lobsters tagged in Minas Passage remained in the Passage. Lobsters tagged with streamers in Minas Channel (Scots Bay) during the same period also demonstrated short distance movement but from shallow to greater depths (Fig 16). Unfortunately tag returns ceased after fishers lifted their traps in late December 2017.

One streamer tagged lobster was captured during 2018 in our study traps (Lobster 1440). Lobster 1440 was tagged on the north side of Minas Passage on November 18, 2017, recaptured by a fisher 3 km away on November 27, 2017, and then captured in a study trap another 6 km away in West Bay on September 8, 2018. She was berried when tagged and when first recaptured but had released her larvae when captured again in September 2018.

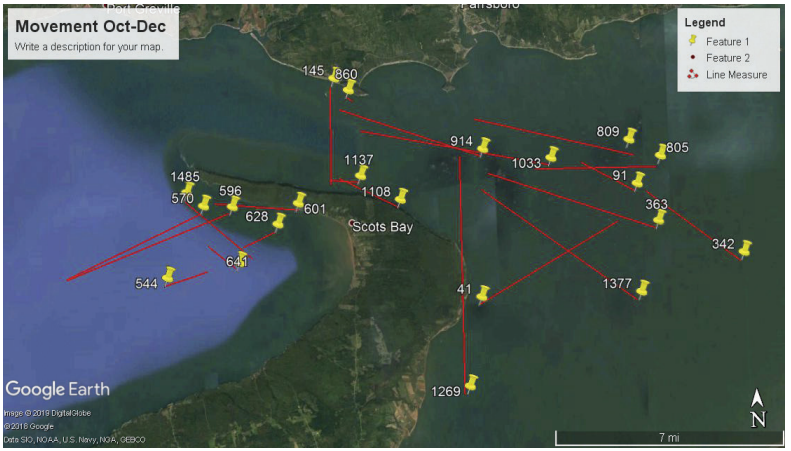


Fig 16 Movement of selected American lobster tagged with FLOY streamer tags during November-December 2017. Yellow symbols mark location of tagging in early November while numbers are the number on the tag. Tag returns ceased after fishers lifted their traps in late December.

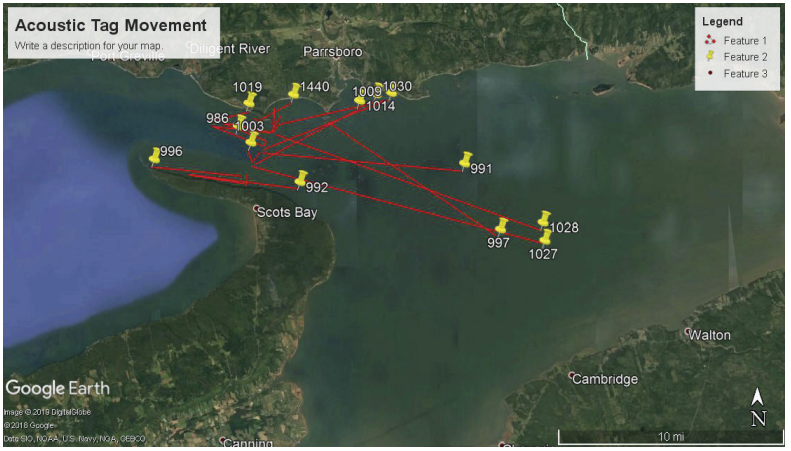


Fig 17 Movement of selected acoustic tagged lobsters in Minas Basin and Minas Passage. Yellow symbols mark the location of lobster tagging.

Lobsters marked with acoustic tags in Minas Basin during November moved from their tagging location into Minas Passage (mean distance 18.2 km; Fig 17) or were detected in the Passage during the following months (Fig 15). Those tagged in Minas Passage largely remained in the Passage or moved through the Passage later from unknown locations. Based on the high occurrence of receptions from deep-water locations

in the Passage this habitat appeared to be preferred by lobster. In addition, the most receptions were at the northern end of the OTN line (receivers 3, 4; Table 3).

Ten (58.8%) of the acoustic marked lobsters that were detected in the Passage were there for only a short period during May-June (Fig 15, Table 3). Their short period of detection and the fact all were berried females, suggests there may have been a return migration from the Bay of Fundy into Minas Basin during spring.

Six lobsters tagged on the north side of Minas Passage (Parrsboro) were only detected at the north side of the OTN line (Table 3) and two lobsters tagged on the south side of the Passage were only detected at the OTN line there (992, 996, Fig 17). Two acoustic tagged lobsters (1030, 1031) crossed from the north side of Minas Passage to the south side (Table 3). One streamer tagged lobster also moved from the north side to the south side of the Passage (Fig 16).

Streamer tags returned from commercial fishers after tagging during 2008 and 2017 demonstrated a proportion of the lobsters tagged in Minas Passage carried out long distance movements (>30 km) into the Bay of Fundy (Figs 18, 19). Most long-distance returns came after one year at large but a few lobsters moved long distances during short periods (Table 5). Lobsters L1043 and L1140 moved distances of 129 km and 106 km during June to November at estimated rates of 1.23 km/d and

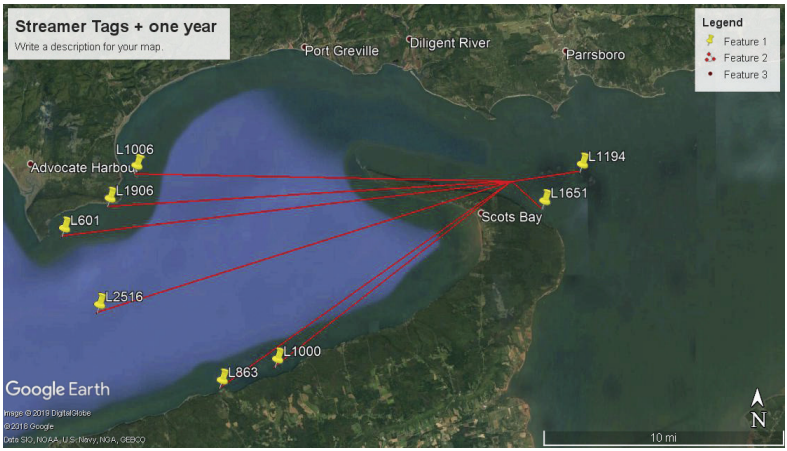


Fig 18 Movement after one year of American lobster tagged with FLOY streamer tags in Minas Passage during 2008. Yellow symbols mark the recapture point of each lobster.

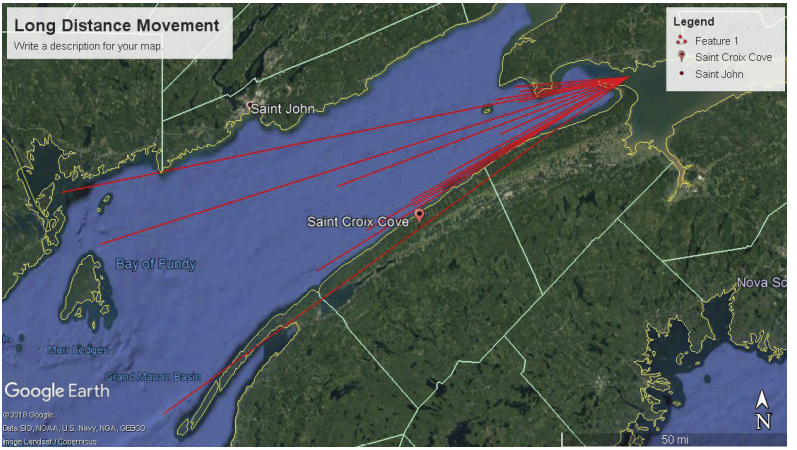


Fig 19 Long-distance movement of selected American lobster tagged with FLOY streamer tags during 2008 and 2017. Lobsters were tagged in the Minas Region (~45°20'30", 64 23'20") during the summer and fall commercial fishing seasons. Distances are straight line representations and do not represent the actual movement of individual lobsters.

1.0 km/d, respectively. Lobster 1194 moved 202 km to the lower BoF off Brier Island and lobsters MCG1424 and MCG1770 moved 195 km and 203 km, respectively, into the southwestern BoF over a period of one year (Table 5; Fig 19).

Lobsters that were streamer tagged in Minas Passage during 2008 and were recovered in the outer BoF were all smaller, immature individuals of 74-91 mm CL when tagged (Table 5). Four of five lobster's streamer tagged in Minas Passage during November-December 2017 and recovered in the BoF were mature females (118-140 CL mm) that had been berried when tagged. The fifth individual tagged in 2017 was again an immature female (85 CL mm).

DISCUSSION

The lobster fishery in the Minas region is a well defined stock that is largely fished in Minas Passage by a limited number of fishers (DFO 2021). Except for our short-term studies in the region during 2008 and 2011-2013, previous studies on population characteristics and movements in the BoF only sampled lobsters along the New Brunswick (NB) shore. All NB studies had similar results indicating that the BoF NB stock compared to other stocks in the Canadian Maritimes consisted

Table 5 **Long distance recapture locations of American lobsters in the Bay of Fundy marked with streamer tags in Minas Passage during 2008 and 2017. Distance is measured as a straight line (SLD) and probably does not represent the actual distance traveled during days at large.**

Tag Number	Date Tagged	Date Recaptured	Recapture Location	Lat	Long	SLD (km)	At large (d)
L0599	25/06/2008	11/10/2009	Isle Haute	45 16'49"	64 58'14"	47	471
L1043	08/07/2008	21/10/2008	off Digby Gut	44 45'09"	65 46'32"	129	105
L1119	12/07/2008	26/11/2009	off St. Croix Cove	44 57'04"	65 20'17"	88	347
L0890	23/07/2008	10/11/2008	off St. Croix Cove	44 58'06"	65 19'54"	86	107
L1052	28/07/2008	05/11/2008	off Port George	45 03'00"	65 11'12"	72	98
L1194	30/07/2008	15/11/2009	Lower Bay of Fundy	44 17'59"	66 27'32"	202	470
L1140	30/07/2008	15/11/2008	off Annapolis Royal	44 52'30"	65 33'02"	106	106
L2501	06/10/2008	21/07/2009	off Advocate	45 18'15"	64 51'35"	39	390
L2714	06/10/2008	28/10/2009	off Advocate	45 16'23"	64 52'50"	40	386
MCG0152	02/11/2017	25/11/2018	off Harbourville	45 10'17"	64 56'59"	49	387
MCG1119	18/11/2017	15/11/2018	mid Bay of Fundy	45 00'51"	65 40'64"	109	361
MCG1424	18/11/2017	24/11/2018	Owen Basin, NB	44 50'03"	66 44'09"	195	371
MCG1770	26/11/2017	20/11/2018	Deer Island, NB	44 59'50"	66 54'40"	203	358
MCG2690	22/12/2017	16/11/2018	off Advocate	45 19'12"	64 52'43"	40	391

of a high proportion of large lobsters, high levels of berried females (Campbell 1983, Robichaud and Lawton 1997) and some members of the population moved long distances (Campbell 1986, Campbell and Stasko 1986, Robichaud and Lawton 1997). We found similar biological characteristics and movements for the Minas region or the BoF Nova Scotia (NS) stock.

Population Characteristics

Minas region lobsters were characterized by a high proportion of large, adult lobsters. Mean size of lobster among 2017 samples were 101.7 and 121.0 mm CL for males and 102.5 and 115.7 mm CL for females. Maximum size attained in males was 200 mm CL and in females, 216 mm CL. Mean CL of berried females (124.1 mm) was significantly larger than the non-berried, female population (102.5 mm). Mean and maximum CL of Minas lobsters were similar to lobsters sampled along the NB BoF shore where mean CL was greater than 100 mm and maximum CL exceeded 180 mm (Robichaud and Lawton 1997) and both were greater than mean and maximum CL among lobster stocks sampled along the Atlantic shore of Nova Scotia (Dadswell 1979, Miller *et al*. 1987) or in the Gulf of St. Lawrence (Wilder 1963, Comeau and Savoie 2002), where mean and maximum lengths seldom exceeded 100 and 150 mm CL, respectively.

Sex ratio of lobsters in the Minas region was approximately equal numbers of males and females, similar to the proportional representation found in most other sampled populations (Cobb 1976, Goldstein *et al*. 2026). Male:female ratios found in Minas region samples were 1:1.2 during November-December and 1:0.6 during August-October. Such seasonal variation observed may have been caused by adult female movement to preferred overwintering locations (Campbell and Pezzack 1986).

The proportion of berried females in the Minas samples during late autumn (30-50%) was similar to lobster from the BoF NB stock sampled around Alma in Chignecto Bay during the same period, a region in the BoF with similar oceanographic characteristics to the Minas region (Campbell and Stasko 1986). In most other regions of the Canadian Maritimes concentrations of lobster with a high proportion of berried females are rare and the observed proportion of berried females in samples is low (<10%; Campbell and Robinson 1983, Campbell and Pezzack 1986).

Female lobsters in the Minas region began to extrude eggs during late September and early October. The proportion of berried females in the Minas region accounted for more than 30% in October-November and extrustion was complete by December when the berried female proportion of the population reached 50.4%. A proportion of 50% berried females in a sample is the highest possible situation since female lobsters only produce eggs every second year (Cobb 1976, Campbell 1983). Berried females were most abundant in Minas Passage during autumn and winter and this location is obviously extremely important to the life cycle of lobsters in the BoF NS stock. Choice of overwintering in this location is probably due to warmer temperatures in the Passage compared to Minas Basin. The threshold temperature of 3.4C^{o} for eggs to develop (Perkins 1972, Campbell and Stasko 1986) occurs there during most of the winter (Keyser *et al.* 2016).

The molt cycle of lobsters in the Minas region was opposite to the egg extrusion cycle (Cobb 1976). Hard-shelled lobsters accounted for 95-100% of lobster sampled from August to June. The Minas population molted during late-July when soft-shelled animals represented up to 42.9% in samples. By mid-August molting was complete.

Movement of Lobsters

Movement of lobsters in the Minas region demonstrated by seasonal sampling and marking with streamer and acoustic tags occurred over both short and long distances depending on season and time at large. Lobsters exhibited both short-distance movement in reponse to seasonal change (summer-winter) and long-distance movement possibly caused by life history requirements.

Based on the catch/trap and female proportion in catches, trap sampling on a two-week cycle in Minas region during August-October 2018 demonstrated a 10-30 km movement of predominately female lobsters from Minas Basin into Minas Passage. This seasonal movement between Minas Basin and Minas Passage was collaborated by both streamer and acoustic tagging. Lobsters marked by streamer tags in Minas Basin during 2017 moved up to 5-10 km towards Minas Passage during a six week period in November-December. Lobsters marked with acoustic tags demonstrated similar movement, traversing a distance of 5-20 km from Minas Basin into Minas Passage during November to December. Of the 125 acoustic tagged lobsters released in Minas Basin 3-11 km from Minas Passage during 2011-2012, 37 (29.6%) were detected in the Passage at either one of the two acoustic

receiver lines that were deployed or at the FORCE site. We also found that tagged lobsters were most commonly detected at the northern end of the OTN line and that they exhibited over-winter and long-term residence in the deepwater of Minas Passage. Time spent with lobster fishers demonstrated they knew this distribution of the lobsters well and concentrated their fishing effort in the northern, deeper area of the Passage (Dadswell, pers. obs.).

We found that acoustic tagged lobsters often moved past acoustic receiver arrays without being detected. During the acoustic study in 2011-2012, there were two receiver lines across Minas Passage east and west of the FORCE site. Numerous tagged lobsters that were released in Minas Basin were first logged at the FORCE site or the western most array proving they moved past the eastern OTN array without detection. During the 2017-2018 study lobsters tagged in November were often undetected in Minas Passage until May-June, but because of all the evidence for movement of lobsters into Minas Passage during late autumn we suggest that many passed the OTN line during November–December 2017 without being detected. Since the period of low current speed when acoustic tags would have been detected by the receivers occurs during an extremely narrow window in the Passage (Karsten 2008, Morrison *et al.* 2014) this possibility seems relatively plausible.

Trap sampling and tagging evidence lead us to propose that there may be an annual movement (migration) of lobster into and out of Minas Basin. The fact that a large proportion of the acoustically tagged lobsters observed moving through Minas Passage in MayJune were berried females (76.5%), and since the ratio of females to males in the Basin increased during this period to be highest during August suggests this migration exists. Whether the seasonal movement is related to egg release by females in the warmer water of Minas Basin or to obtain better foraging opportunities is yet to be proven.

Summer-winter movements of lobsters in the Canadian Maritimes have been well established in numerous studies. Campbell (1986) found that lobsters in the lower Bay of Fundy moved onshore to warmer water in summer and offshore to where warmer water occurred in winter and proposed that the movements were related to egg development. Similar seasonal movements have been described for tagged lobsters in the Gulf of St. Lawrence. Den Heyer *et al.* (2009) found that the distance of summer-winter lobster movement varied from 2.3-19.4 km depend-

ing on where the lobsters were tagged and the steepness of the bottom slope. Comeau and Savoie (2002) demonstrated a mean summer-winter movement distance of 12.3 km from shallow to deep water and back. Minas. In the Minas region such movement appears to be into Minas Passage for the winter, the closest winter warm area.

Long distance movement of lobsters from Minas region into the BoF was exhibited by lobsters marked with streamer tags both in 2008 and 2017. Movements of >30 km were demonstrated for both male and female immature lobster 70-90 mm CL and for large (110-140 mm CL) females that were berried when tagged. Some of the immature lobsters moved distances up to 100+ km during a period of four months (Minas Passage to Digby). Some large females moved distances up to 200 km over a period of approximately one year (Minas Passage to southern NS and the NB shore).

Long distance movement and migration, expecially by large females, has been well documented for BoF NB lobsters. Campbell (1986) and Campbell and Stasko (1986) demonstrated that female lobsters tagged off Grand Manan and off Alma in the inner BoF moved distances of 200-700 km into the Gulf of Maine. In contrast lobsters tagged on the outer coast of Nova Scotia and in the Gulf of St. Lawrence have never been found to move distances greater than 60 km (Miller *et al.* 1987, Comeau and Savoie 2002). It has been suggested that the Fundy long-distance movement is a result of the large tides and extensive drift of lobster larvae in the region (Quinn *et al*. 2017).

On the other hand, even with all the long distance movement demonstrated for the BoF NB lobster stock few tagged lobsters have been found to cross the BoF from the NB shore to the NS shore, a distance in most cases of only 40-70 km. Out of 647 tagged lobsters that had moved more than 100 km only 13 (2.0%) crossed the Bay from tagging sites at Grand Manan, Chance Harbour and Alma in NB (Campbell and Stasko 1986). Likewise, Robichaud and Lawton (1997) found that out of 100 tagged lobsters recovered, only 11 had crossed the Bay from NB to NS. In both studies lobsters predominately moved down the NB shore to the Gulf of Maine.

Long-distance tag returns from our study demonstrated similar regional movement. Lobsters tagged in the Minas region largely moved along the NS shore. Out of 26 tags recovered that had moved distances >30 km only two (7.6%) crossed the BoF to NB. We suggest that the lobster stocks on the two sides of the BoF are largely independent

due to egg release locations. Berried females from the BoF NB stock concentrate between Grand Manan and Alma, the BoF NS stock, in Minas Passage and Minas Basin.

This situation may have evolved over time because of the tidal, residual currents in the BoF (Bumpus and Lauzier 1965, Dadswell 1979). The residual current flows into the BoF along the NS shore and into Minas Basin before crossing the Bay to flow out along the NB shore. Females and their larvae released in the Minas Passage may be independent from females and their larvae released in Chignecto Bay creating two stocks, the BoF NS stock and the BoF NB stock.

Tidal Power Development and Lobsters

Tidal power development in Minas Passage has progressed slowly. An instream, propellor tidal turbine was deployed in the Passage during 2009 (AECOM 2009) and another design of the same turbine type in 2017 and 2018 (Cape Sharp Tidal 2018). Both turbines broke down after deployment periods of only a few weeks.

Propellor turbines are known to cause mortality to organisms because of mechanical strike, pressure flux, shear, and cavitation in the turbine draft tube (Dadswell and Rulifson 1994; Bangley *et al.* 2022). Since the instream propellor turbine designs are raised above the substrate (FORCE 2017) it is unlikely there will be much interaction between these turbines and benthic organisms such as lobsters. Lobster larvae, however, are pelagic and can remain in the pelagic zone for periods up to two months (Scarratt 1973, Goldstein *et al.* 2026). Since larvae have a discrete size (~1-20 mm) there is a potential level of interaction between the spinning blades of a propellor turbine and larvae. Although the calculated level of interaction is low (<1%) there will be some degree of mortality because instream turbines operate during all periods of tidal flow and an immense volume of water containing larvae will pass through the turbine (FORCE 2017). It is also known that lobster larvae are very sensitive to pressure change (Ennis 1975). Whether or not pressure flux in the propellor turbine draft tube will have deliterious effects on lobster larvae is unknown.

It is uncertain what future plans there are for tidal hydro-kinetic deployment in Minas Passage and/or what sort of devices will be deployed (Big Moon Power 2018, Bangley *et al.* 2022). Since the BoF NS lobster stock utilizes Minas Passage extensively, it may be unwise to deploy types of instream tidal turbines in this region that might

impact the lobster population. All future studies on deployment of various types of tidal turbines in Minas Passage should include studies of their potential impact on American lobsters.

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