Tangible results obtained as a direct result of the Canadian Fisheries Research Network

Project	Tangible Result	Prototype / Pilot	New process / product / service / knowledge	Improved process / product / service / knowledge	Knowledge applied (or applicable) toward policy or regulation	New spin-off	Other (specify)
1.2 - Lobster Node	**1. The incorporation of the "Lobster Node Inc." as a new collaborative platform to secure funding for, and to conduct, co-constructed research in support of the lobster fishery in Canada.**		New formalized collaborative platform involving lobster fishermen and their associations, government scientists (and to a lesser extent managers), and academics.	This new collaborative platform brought together existing strengths/capacity within the government and industry, and it attracted new participants from academia in lobster research in Canada.		In addition to the research done under the auspices of the CFRN, the Lobster Node Inc. is a partner of a successful NSERC Strategic Project Grant (SPG) on lobster genomics and is part of a recent application to the NSERC CREATE training program.	
1.2 - Lobster Node	**2. The development and use of standardized tools and protocols to quantify, while sampling alongside fishermen, the abundance and size of egg-bearing females, as well as their production of eggs, in all 5 provinces of eastern Canada.**		This project is the first to develop and apply standard protocols and tools, such as a standard measuring gauge, standard clutch staging sheets, and a common web-based database, to obtain and reposit data on lobster over the species' range in Canada.				
1.2 - Lobster Node	**3. Data on the catch-per-unit-effort (CPUE) and size of egg-bearing female lobsters in all 5 provinces of eastern Canada in 2011, 2012, 2013 and 2014.**		The collection of data on characteristics of lobster stocks in a standardized manner throughout the range of the species in Canada is novel.		These data provide useful indicators to support lobster stock assessment exercises, and were in fact included in the last assessment exercise in Newfoundland.	New co-constructed Master's project (NSERC Postgraduate Scholarship) prompted by fishermen who reported that the incidence of females with "abnormal clutches" had increased in recent years in certain areas (see result #4).	

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1.2 - Lobster Node	**4. Data on the incidence of female lobsters with "abnormal clutches" in all 5 provinces of eastern Canada in 2011-2014 (in progress).**		Females with abnormal clutches are found across the species' range in Canada, and their incidence varies at a relatively small scale of ≈200km (no larger patterns). There is some evidence that abnormal clutches result from the cumulative "natural" loss of small quantities of eggs over the development period, which may be accentuated by repeated catch and release during the fishing season.		Data on abnormal clutches provide a useful indicator to support lobster stock assessment exercises.		
1.2 - Lobster Node	**5. Lab experiments and field surveys assessing the contribution of food availability and sperm limitation to the incidence of female lobsters with "abnormal clutches" (in progress).**		Evidence that sperm limitation, but not food availability, contributes to the incidence of female lobsters with abnormal clutches in Canada.				

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1.2 - Lobster Node	**6. Development of statistical models to use data on egg-bearing females collected by the Lobster Node to assess spatial variation in female abundance and egg production in Canada (in progress).**		The standard tools and protocols developed by the Lobster Node enable estimates of spatial variation in lobster egg production throughout Canada, which provides useful information concerning stock health and will also be used to enhance our larval dispersal model (see below).		These data and models will help detect shifting zones of productivity (e.g., due to climate change), which will help inform decisions concerning new licences and fishing effort.	Confirming the usefulness of these data/analyses has led to a new Masters project (start fall 2016) to assess variability in egg production and hatch time along 5 transects in the Gulf of St. Lawrence/Cape Breton, as part of the new NSERC SPG on connectivity and genetic structure at "small spatial scale".	
1.2 - Lobster Node	**7. Meta-analysis of literature data providing evidence of reduction of female lobster size at sexual maturity in many (but not all) regions in Canada over the past 50-100 years (in preparation).**			This study provides the most comprehensive empirical evidence that lobster size at maturity has decreased over time in many areas, and it suggests that fishing has contributed to this decline.	Analyses are still underway, but these findings will be relevant to discussions concerning minimum legal size and its effect on phenotypic traits and egg production in lobster.		
1.2 - Lobster Node	**8. Analysis of DFO data on egg-bearing females suggesting that timing of hatch in the Gulf of St. Lawrence has been advancing over the past 25 years, and that warmer waters during development of ovaries and embryos have contributed to this pattern (in preparation).**		This pattern of advancing hatch time, and its underlying mechanisms, represent new knowledge.		Shifts in lobster phenology such as this may become useful to decision making regarding the timing of fishing activities in different regions.	These findings have led to an Honours project to validate the use of a method developed in the lab to predict hatch time in nature based on measurements of embryo eye size (proxy for development) and water temperature (see result #9).	

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1.2 - Lobster Node	**9. Validation of a technique developed in the lab to predict hatch timing of lobster in nature based on measurements of embryo eye size (proxy for development) and water temperature (published).**		Confirms that the lab technique is "transferrable" to nature, but performance differed between temperature-dependent development functions (more research needed on this).		This tool may enable hatch time to be "easily" estimated based on samples of eggs obtained with fishermen during the fishing season. Shifts in lobster phenology such as those related to hatch time may become useful to decision making regarding the timing of fishing activities in different regions.	These findings have led to a new Master's project aiming to further validate the technique and development functions to predict hatch time in two regions with contrasting summer sea-surface-temperatures (in progress).	
1.2 - Lobster Node	**10. Preliminary empirical evidence that hatch of lobster prezoea is adaptively timed to coincide with warmer sea-surface –temperature resulting in faster larval development and reduced dispersal (in progress)**			This study provides data supporting a pattern that may have been predicted based on other species, but that had not been empirically substantiated in lobster.	Shifts in lobster phenology such as this may become useful to decision making regarding the timing of fishing activities in different regions.		
1.2 - Lobster Node	**11. Results of a lab experiment suggesting that lobster larvae from the Gaspé region develop more rapidly in cold water than do larvae from warmer-water regions (published).**		Rates of development of lobster larvae from a "cold-water population" were quantified for the first time in the lab and compared to published results for "warmer-water populations".		These findings are consistent with, although not an unequivocal demonstration of, "local adaptation", which is relevant to the definition/location of management zones.		

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1.2 - Lobster Node	**12. Preliminary results of laboratory experiments suggesting geographic variation (Toney River, Anticosti, Gaspé, Caraquet) in survival, development rate, and size of lobster larvae raised in a common environment (in progress).**			These findings are consistent with a small body of literature suggesting geographic variation in phenotypic characteristics of lobster larvae raised in a common environment. These studies suggest, although they do not prove (e.g., maternal effects), geographic genetic differentiation.			
1.2 - Lobster Node	**13. A bio-physical model to predict dispersal of lobster larvae over the species' range in Canada and the United States (completed).**		This new large-scale model has been used to estimate patterns of connectivity among management areas in Canada via larval dispersal.		These data will provide useful information to support discussions concerning the definition/location of management areas.	These findings have led to a new Doctoral project (part of the new NSERC SPG) aiming to enhance the spatial resolution of the bio-physical model and validate its predictions (in progress).	
1.2 - Lobster Node	**14. Empirical evidence that the abundance of lobster postlarvae in the water column (sampled by light traps) is correlated to the abundance of young-of year in "bio-collectors" deployed in different embayments in southwest Bay of Fundy (published).**		The light traps did capture lobster postlarvae in nature, but in insufficient numbers for this to represent a cost-effective sampling tool, at least in the Bay of Fundy where water turbidity is high.	This study supports the use of the "bio-collector" as a tool to estimate the supply of competent lobster postlarvae to an area.			

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1.2 - Lobster Node	**15. Laboratory experiment demonstrating that sand shrimp, and to a lesser extent green crabs, may be important predators of settling and newly-settled lobsters in nature (published).**		This study was the first to document sand shrimp rapidly attacking lobster postlarvae attempting to settle on complex bottom, and demonstrating that green crabs could seek and capture hidden lobsters. It suggests the value of investigating these interactions in nature.				
1.2 - Lobster Node	**16. Results of three years of sampling (2010-2012) indicating that patchiness in lobster benthic recruitment in the Bay of Fundy is greatest at the spatial scale of 0.4-4 km^2 (published).**			Improved understanding of the scale underlying patchiness of lobster benthic recruitment.	The abundance of young-of-year (YOY) lobsters is a useful indicator of stock health and predictor of future landings; it is now officially used in stock assessments in the United States, and is receiving consideration in Canada. This study provides guidance concerning the spatial scale at which to monitor the abundance of YOY, to improve accuracy of estimates while minimizing sampling effort.		
1.2 - Lobster Node	**17. Preliminary results of multivariate statistical models identifying the North Atlantic Oscillation (NAO) Index, fetch, juvenile abundance, depth, and sea surface temperature as factors affecting benthic recruitment of lobster in the Bay of Fundy (in progress).**			Improved understanding of the mechanisms underlying patchiness of lobster benthic recruitment.			

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1.2 - Lobster Node	**18. Results of three years of sampling (2010-2012) indicating that lobster spatial patterns established at settlement in the Bay of Fundy remain largely unchanged until the adolescent phase (in progress).**			These results support the poorly validated expectation that the different stages of juvenile lobster do not disperse much after settling on nursery grounds.	These results are consistent with the expectation that juvenile lobsters are inconsequential to the connectivity between management areas and/or stocks of lobster.		
1.2 - Lobster Node	**19. Results of lab experiments demonstrating that competent lobster postlarvae settle as soon as they encounter cobble substrate, delay settlement if swimming over mud, and delay to a greater extent if swimming over sand, to the point of incurring development costs (in preparation).**		This laboratory experiment provides novel empirical evidence of the effect of substrate on settlement decisions and development costs of lobster postlarvae, as well as data that will be useful to enhance the settlement algorithm of our bio-physical model of larval dispersal once substrate characteristics are added to the model.				
1.2 - Lobster Node	**20. Sampling using passive collectors demonstrating that postlarvae likely settle on mud bottom in Maces Bay, Bay of Fundy (in preparation).**		These field data, combined with those associated with the previous “tangible result”, provide evidence that mud bottom may offer a demographically meaningful settlement/early development habitat to lobster.			Findings of this and the previous tangible result led to two Honours projects that compared the adequacy of mud and cobble bottom as nursery habitat for juvenile lobsters (see result #21).	

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1.2 - Lobster Node	**21. Morphometric and molecular analyses indicating that growth and body condition of juvenile lobsters sampled from mud bottom ("secondary habitat") in Maces Bay, Bay of Fundy, were comparable, or perhaps even slightly better, than for juveniles sampled from preferred cobble-bottom habitat in the same Bay (published).**		Growth rates estimated on the basis of "growth bands" in ossicles of the gastric mill suggest that juvenile lobsters sampled from mud bottom grow slightly faster, but have somewhat lower body mass at length, than juveniles sampled from cobble habitat. The RNA/DNA ratio and protein content of the abdomen of juveniles sampled on mud and cobble were comparable.			Findings of the last three "tangible results" have led to a new Doctoral project (part of the new NSERC SPG) aiming to assess the relative contribution of mud bottom and cobble bottom to benthic recruitment of lobster in Maces Bay, Bay of Fundy (in progress).	
1.2 - Lobster Node	**22. First empirical data on activity levels and movements of juvenile lobsters in nature (based on ultrasonic telemetry) in the Bay of Fundy that both confirm and challenge current understanding based on lab experiments and limited field observations (published)**		Results of this tracking study confirm that juvenile lobsters are mostly nocturnal and return to shelter following foraging excursions. They also reveal evidence of tidal rhythmicity in a highly tidal system. However, they do not show increasing activity during ontogeny of the different juvenile stages, as suggested by the literature.		These results are consistent with the expectation that juvenile lobsters are inconsequential to the connectivity between management areas and/or stocks of lobster.	Doctoral student sought and obtained funding from Atlantic Lobster Sustainability Foundation to do a pilot study, based on satellite tagging technology, of seasonal migrations of egg-bearing females in the Bay of Fundy in relation to embryo development.	

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1.2 - Lobster Node	**23. Empirical data on activity levels and movements of juvenile and adolescent lobsters in nature (based on ultrasonic telemetry) in the Baie des Chaleurs, Gulf of St. Lawrence (in preparation).**		This study covered a much larger area than our Bay of Fundy tracking study (≈2.5 km^2 versus ≈ 0.005 km^2), it was conducted in a different geographic region, and it involved adolescent lobsters in addition to juveniles. Results were largely consistent with those of our Bay of Fundy study and they demonstrated markedly greater movements by adolescents than juveniles.		These results are consistent with the expectation that juvenile lobsters are inconsequential to the connectivity between management areas and/or stocks of lobster, and that adolescents begin displaying activity levels and movement patterns that may be relevant to these questions.		
1.2 - Lobster Node	**24. Analysis of 33 historic tagging studies conducted with fishermen between 1980-1996 suggesting that the movements of adult lobsters lead to meaningful genetic, but limited demographic, connectivity between management areas in the Gulf of St. Lawrence when considering the movements of individuals (rather than a "group average") over multiple (rather than a single) years (in progress).**			A new and more in-depth analysis of an older data set that seems to confirm (still in progress) conclusions of earlier analyses concerning the negligible role of benthic movements to demographic connectivity between management areas in the Gulf of St. Lawrence, while revealing their potential importance to demographic connectivity between fishing ports and to genetic connectivity between management areas.	These results are consistent with earlier analyses suggesting that management areas in the Gulf of Saint Lawrence are sufficiently large to be considered independent of one another from the perspective of demographic connectivity mediated by adult movements.		

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1.2 - Lobster Node	**25. Successfully tagged 2 egg-bearing female lobsters in the Bay of Fundy with satellite tags in Fall 2013, with tag release as programmed in Spring 2014 (completed).**	This pilot study was the first to demonstrate that this technology can be applied to a benthic invertebrate.				This successful pilot study has led to new funding from the New Brunswick Innovation Foundation to support the research of a Master's student (NSERC PGS) to apply the technology to study seasonal migrations of egg-bearing females in relation to embryo development in the Bay of Fundy (see result #26).	
1.2 - Lobster Node	**26. Developing models to map likely movement trajectories of eight egg-bearing females equipped with satellite tags in the Bay of Fundy during the embryo incubation period (in progress).**		This project will enable tests of the link between temperature and seasonal migrations of egg-bearing females in the Bay of Fundy, which is relevant to larval hatch (time and location) and connectivity, particularly in the context of rapidly warming waters.				

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1.2 - Lobster Node	**27. Improved map of lobster genetic stock structure based on 10,000+ single nucleotide polymorphisms (SNPs) applied to lobster samples from 17 locations throughout the species' range (published).**		The results reveal the existence of a hierarchical genetic structure, first separating lobsters from the northern and southern parts of the range and then revealing weaker but significant "fine-scale" population structuring within each region.	These results demonstrate that using a large number of molecular markers and cutting-edge molecular and statistical techniques improves fine-scale population structure delineation and population assignment success in a context of weak genetic structure.		These findings have led to a new Doctoral project (part of the new NSERC SPG) aiming to: 1) enhance the spatial resolution of our "lobster genetic map", 2) investigate variability of this map among genders and life stages, and 3) explore factors that may explain this variability (in progress).	
1.2 - Lobster Node	**28. Empirical demonstration of the contribution of circulation-mediated larval dispersal to lobster genetic stock structure, and of geographic variation in adaptive genetic polymorphisms, including evidence of "cold-adaptation" genes (in preparation).**		This study provides the best empirical support to date for the contribution of larval dispersal to lobster (neutral) stock structure and for evidence of adaptive geographic variation in lobster genotype.		These findings confirm the importance of larval dispersal to lobster stock structure, and they are consistent with "local adaptation" of lobster within the species' range in Canada. Both of these findings are relevant to the definition/location of management zones.		