Atlantic Canada Environmental DNA Workshop Report

September 2019

Workshop hosted by:

OCEANS NORTH

NOVA SCOTIA SALMON ASSOCIATION

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Introduction

On April 8, 2019, participants gathered at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia for the first Atlantic Canada Environmental DNA (eDNA) Workshop. While there is growing interest in eDNA research and its applications, there had been little discussion and coordination between researchers within Atlantic Canada prior to this meeting. Hosted by Fisheries and Oceans Canada (DFO) in partnership with Oceans North and the Nova Scotia Salmon Association, researchers from government, the academic sector, the private sector, and non-profits shared their experiences, knowledge, and thoughts about this burgeoning field. This workshop connected researchers working on marine and freshwater eDNA projects in Atlantic Canada and identified opportunities to coordinate and synergize research efforts. Projects were mapped to facilitate knowledge transfer and collaboration, and to set the stage for future cooperation (page 6-7).

What is eDNA?

Broadly speaking, environmental DNA (eDNA) is DNA that has been released into the environment and then collected rather than being sampled directly from an individual plant or animal. Sources of eDNA could include skin cells, waste, or gametes.

Workshop presentations emphasized both the exciting potential of eDNA and how much remains to be learned.

The current and future applications of eDNA are numerous, such as detecting invasive species or reducing the need for bottom-trawl surveys. However, from collection to analysis, there are many things that can affect the results of an eDNA test: the size of the filter used; when and where the sample was collected; the volume of water collected; and the primers used to identify species, to name only a few. Incorporating data obtained from eDNA research into management therefore requires being upfront about both the strengths and limitations of using eDNA.

Participants highlighted the importance of sharing knowledge and data across borders and sectors as eDNA research continues to progress. Sharing knowledge might take the form of regular intersectoral meetings, as well as the creation of online platforms where researchers can engage with one another and exchange project details. As eDNA becomes used more frequently to augment existing environmental monitoring techniques and as more data are collected, it is important that scientists are not working in isolation. Transparency and cooperation are needed to establish best practices, which will ensure that sampling techniques and analysis are reliable and replicable.

This report provides recommendations for next steps, highlights the key presentations, brings together all the existing and planned projects in one map and includes information on workshop participants.

How is eDNA used?
Current and potential uses of eDNA include:

biodiversity monitoring; detecting rare, at-risk or invasive species; studying habitat use; estimating relative abundance; monitoring marine protected areas; assessing climate change impacts; understanding how aquaculture affects the surrounding environment; fisheries management.

Recommendations

1. Workshop participants agreed that eDNA research would benefit from a more comprehensive data management system. Currently, little information exists on previous and ongoing eDNA projects. Access to both data and metadata would be valuable for future research. Participants suggested that storing this data in a centralized, accessible repository could help advance the field.

   Looking ahead: The creation of dedicated eDNA labs within DFO, which has yet to occur, may offer possibilities in this regard.

2. A platform should be created that allows eDNA researchers to interact with one another and access data. This platform could take the form of a simple listserve, or a more complex medium that visualizes projects and associated data spatially.

   Looking ahead: Oceans North has offered to create a listserve that can serve as an initial gathering place.

3. Standards relating to the collection, processing, analysis, and storage of eDNA need to be further developed. At the same time, it is important to realize that certain standards may not be universally applicable in all instances. Sharing methods—including those that were unsuccessful—can help provide insight on what works and what does not in specific situations.

   Looking ahead: Going forward, in-person meetings should continue to be held. Additionally, there are two ongoing projects that may lead to improved standards:

   - a collaboration between the Canadian Standards Association (CSA) in partnership with Pathway to Increase Standards and Competency of eDNA Surveys (PISCeS) and the University of Victoria
   - a Canadian Science Advice Secretariat (CSAS) response on eDNA standards and data collection.

Presenter Information

The eDNA application for Canadian coastal management: progress, challenges and solutions

Dr. Anaïs Lacoursière
Research Scientist, Fisheries and Oceans Canada, St. Andrews Biological Station
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My eDNA studies aim to better understand the origin (including the effect of life-cycles) and the spatio-temporal eDNA variation in coastal ecosystems. I am hoping that my results will encourage all to 'think out of the box' and develop complementary eDNA bioindicators to track ecosystem changes in space, across time and throughout the tree of life of which are unfathomable using our current population and community surveys. Research in this direction I hope will lead to the development of new scientific hypotheses and understanding large-scale impacts of human stressors

eDNA Solutions for Species Detections in Tidal Energy Environmental Effects Monitoring

Dr. Marc Skinner
Marine Ecology Technical Leader, Stantec Consulting Ltd. / Dalhousie University
Marc.Skinner@stantec.com

This project aimed to assess the use of eDNA for marine environmental effects monitoring in challenging, dynamic ecosystems like the Bay of Fundy where tidal energy development is planned. Our research was novel in that it experimentally assessed relationships between striped bass densities and eDNA concentration. Our results validate and advance eDNA approaches towards environmental monitoring efforts and demonstrate the potential for eDNA tools to quantify and identify the spatial and temporal distribution of species-at-risk in an open ocean environment.

Monitoring of pelagic prey species in a whale feeding area in the St. Lawrence Estuary (Quebec) using hydroacoustics and pilot study to ground truth forage fish species using eDNA

Nadia Menard
Ecologist, Team leader, Saguenay-St. Lawrence Marine Park, Parks Canada
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The Centre for Environmental Genomics Applications: Advancing eDNA technologies for real-world applications

Nicole Fahner
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The Centre for Environmental Genomics Applications (CEGA), located in St. John's, NL, is a fast-paced and quickly growing independent research centre. CEGA is focused on developing technologies to support new, world-leading environmental assessment and monitoring programs. Expertise covers all stages of an eDNA analysis from experimental design, sampling provisioning, and logistics to sequencing, software development, and data interpretation. We work with state-of-the-art sequencing technology and automation to create scalable solutions for increasing biomonitoring demands with an emphasis on marine ecosystems. Through research collaborations with DFO in the Atlantic region, CEGA is helping to develop standards in the field to address questions related to aquatic invasive species or rare species detection, spatial and temporal community structure, and characterization of ecological communities.

eDNA for Microbial Ecology & Biogeochemistry

Dr. Jennifer Tolman
LaRoche Working Group, Department of Biology, Dalhousie University
J.Tolman@Dal.Ca

Work in our lab focuses on the dynamics of marine microbial communities in changing environments. We collect eDNA to study microbial community composition and structure in the Northwest Atlantic in the context of global climate change, with a particular focus on biogeochemical cycling. We also study microbial interactions with and in response to shellfish & finfish aquaculture.

STREAM: Linking CBM and eDNA Monitoring

Catherine Paquette
Specialist – Freshwater, WWF-Canada
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WWF-Canada, the University of Guelph, Environment and Climate Change Canada and Living Lakes Canada have partnered to create STREAM, Sequencing the Rivers for Environmental Assessment and Monitoring. This project looks to fill in data gaps identified by WWF-Canada's Watershed Reports by combining the adaptability and geographic range of community-based monitoring groups and the exciting 21st century science of eDNA and metabarcoding.

Use of eDNA for aquatic invasive species (AIS) and aquatic species at risk (ASAR) detection: Opportunities and challenges

Francis LeBlanc
Aquatic Science Biologist, Fisheries and Oceans Canada, Gulf Fisheries Centre
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The use of eDNA and a targeted species-specific qPCR approach was evaluated for the detection of marine invertebrates considered invasive in Eastern Canada. A similar approach was also evaluated for the detection of a freshwater mussel species of interest in Eastern Canada, the Brook Floater, which is currently listed as Special Concern by both COSEWIC and SARA. Based on the results obtained a decision framework was created to help with the interpretation of eDNA results and to provide guidance on logical next steps.

Advancing environmental DNA as a national standardized biomonitoring tool in three oceans to support Canada's Marine Protected Areas (MPA) Program

Dr. Nick Jeffery
Aquatic Science Biologist, Department of Fisheries and Oceans, Coastal Ecosystem Science Division, Bedford Institute of Oceanography
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This work will investigate the use of eDNA as a non-invasive biodiversity monitoring tool in Marine Protected Areas with sensitive bottom features, such as kelps, eelgrass, corals, and sponges.

The following map (p. 8-9), created and verified by workshop participants, depicts past, current and future projects in Atlantic Canada that involve the use of eDNA. Workshop participants do not represent the entirety of the work being done in Atlantic Canada on eDNA, and they were not necessarily able to provide an exhaustive account of eDNA projects within their organization. However, several themes emerged from the information gathered and provide for a general overview of eDNA projects in Atlantic Canada.

Of the projects identified:

- The most **common species** being studied are: Atlantic salmon; the microbial community; chain pickerel; lobster; striped bass; smallmouth bass; and the wood turtle. However, many participants indicated that the eDNA is being used to identify "all" species.
- In terms of participants' **purpose for using eDNA**, the most common reasons are for: identifying species presence or absence; estimating population; estimating species abundance and distribution; comparing or complementing data using other methods of sampling; cataloguing biodiversity; identifying life history stages; detecting aquatic invasive species; and detecting species at risk.
- The most **common location** for projects is in nearshore, coastal or inland areas, with just a handful of projects located in offshore ecosystems or in deep waters past the continental shelf.

Of the projects identified, 5 were completed, 27 are in progress and 21 are planned in the future. Projects were being undertaken by a range of proponents, including government, universities, not-for-profit organizations focused on wildlife conservation and private companies.


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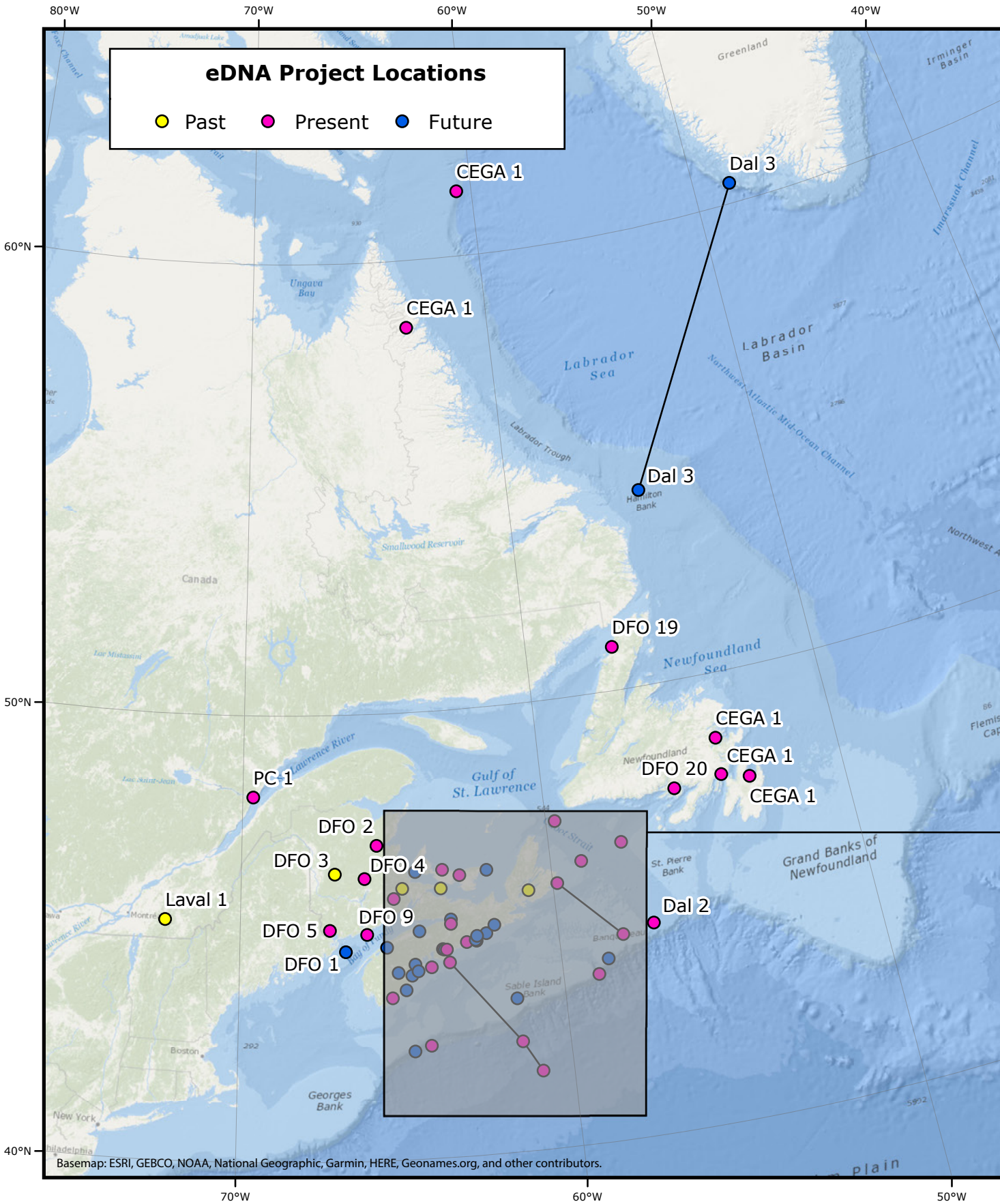
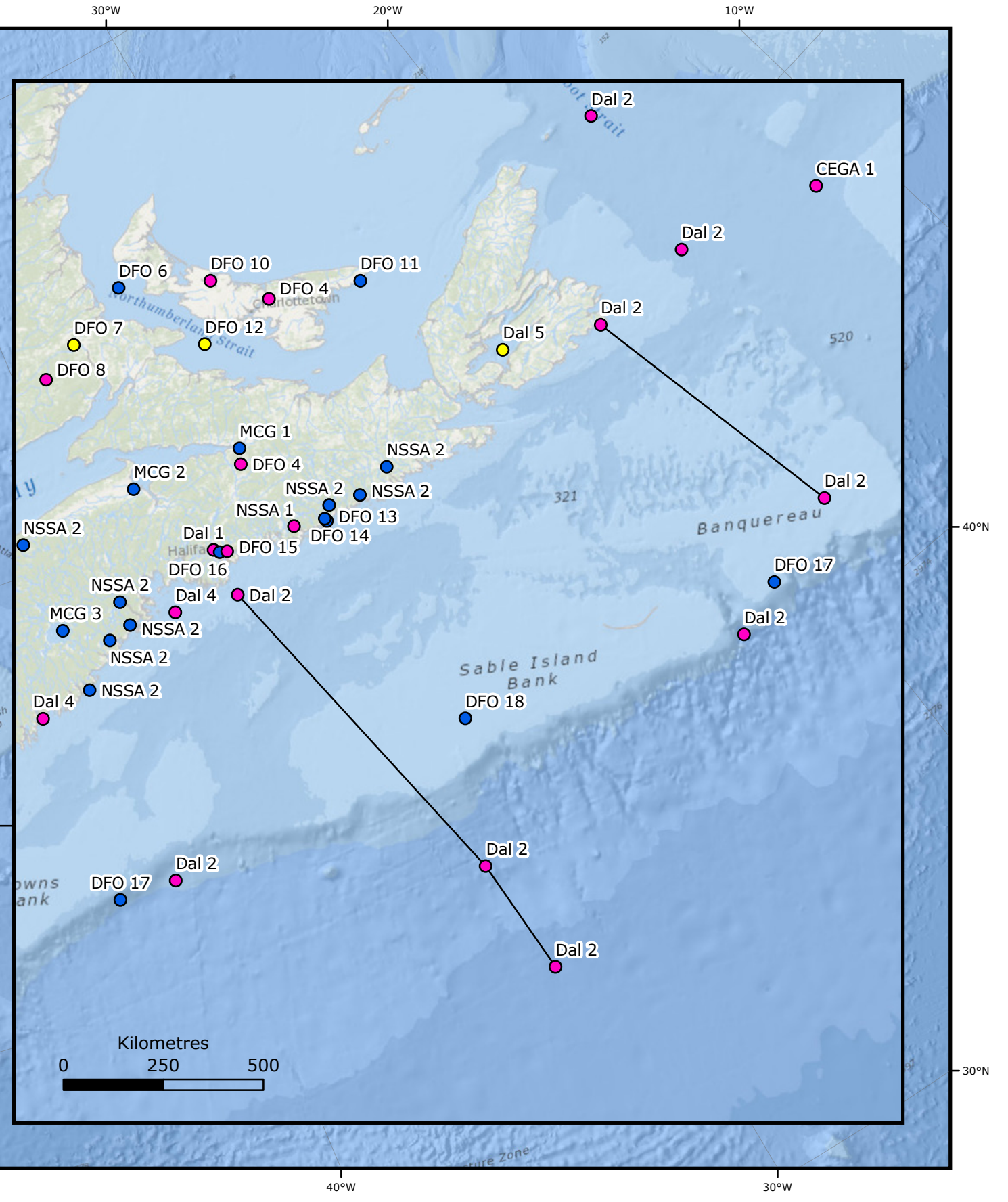

eDNA Project Locations
Past
Present
Future
CEGA 1
Dal 3
CEGA 1
Dal 3
DFO 19
CEGA 1
CEGA 1
DFO 20
CEGA 1
PC-1
DFO 2
DFO 3
DFO 4
Laval 1
DFO 9
DFO 5
DFO 1
Dal 2
80°W
70°W
60°W
50°W
40°W
60°N
50°N
40°N
Greenland
Irminger Basin
Ungava Bay
Labrador Sea
Labrador Basin
Labrador Trough
Hamilton Bank
Smallwood Reservoir
Canada
Newfoundland Sea
Gulf of St. Lawrence
Newfoundland
St. Pierre Bank
Grand Banks of Newfoundland
Sable Island Bank
Georges Bank
Boston
New York
Basemap: ESRI, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors.


30°W
20°W
10°W
40°N
30°N
40°W
30°W
Dal 2
CEGA 1
Dal 2
DFO 6
DFO 10
DFO 11
DFO 4
Dal 2
DFO 7
DFO 12
Dal 5
DFO 8
MCG 1
NSSA 2
DFO 4
MCG 2
NSSA 2
NSSA 2
Dal 2
NSSA 1
DFO 13
NSSA 2
Dal 1
DFO 14
DFO 15
DFO 16
DFO 17
NSSA 2
Dal 4
Dal 2
MCG 3
NSSA 2
Dal 2
NSSA 2
NSSA 2
Dal 4
DFO 18
Dal 2
Dal 2
DFO 17
Dal 2
Kilometres
0
250
500
Banquereau
Sable Island Bank
Charlottetown
Northumberland Strait
520
321

Map Points: Legend Descriptions

The following legend depicts the points identified on the map on page 6-7 in greater detail. **Some projects do not have a corresponding point on the map as they were outside of the geographical boundaries of the map. These are identified with a "*" symbol**.

CEGA 1
Location: Newfoundland (Conception Bay, Placentia Bay), Labrador, Labrador Sea and offshore Newfoundland.
Group: CEGA (Lab Manager – Nicole Fahner), multiple collaborations – regulators, universities and industry (also international collaborations).
Timeframe: Since 2017 (seasonal, annual and monthly).
Species: All species. Emphasis on eukaryotes (including metazoans), harmful algae, aquatic invasive species (AIS), fish, phytoplankton, zooplankton.
Purpose: Environmental baseline surveys, AIS and rare species detection, methods optimization (field collection, sample preservation, molecular techniques), temporal and spatial variability, ecosystem characterisation and biological inventories, community structure.

Dal 1
Location: Bedford Basin.
Group: LaRoche Lab, Dalhousie (in collaboration with DFO's Bedford Basin Monitoring Program).
Timeframe: Weekly since 2014.
Species: Microbes (16S/18S) at 4 depths.
Purpose: Microbial ecology and biogeochemistry.

Dal 2
Location: Hydrographic stations on AZMP lines (Browns Bank, Halifax, Louisbourg , St Ann's Bank, Cabot Strait , Laurentian Channel, The Gully MPA.
Group: LaRoche Lab, Dalhousie (in collaboration with DFO's Atlantic Zone Monitoring Program).
Timeframe: Bi-annually (Spring and Fall) 2014, 2016 – ongoing.
Species: Microbes (16S/18S).
Purpose: Microbial ecology.

Dal 3
Location: Labrador Sea – AR7W line.
Group: LaRoche Lab, Dalhousie (in collaboration with DFO's Atlantic Zone Offshore Monitoring Program).
Timeframe: Starting June 2019.
Species: Microbes (16S/18S).
Purpose: Microbial ecology (also future McLane phytoplankton sampler deployment).

Dal 4
Location: Cooke aquaculture sites (Shelburne and Chester).
Group: LaRoche Lab, Dalhousie.
Timeframe: Began 2018, ongoing.
Species: Microbes (16S).
Purpose: Microbial ecology in the context of aquaculture site fallowing, water column and sediments.

Dal 5
Location: Bras d'Or Lakes.
Group: LaRoche Lab, Dalhousie.
Timeframe: 2016-17.
Species: Microbes (16S/18S).
Purpose: Microbial ecology (ocean acidification and shellfish), water column and oyster tissue.

DFO 1*
Location: Arctic.
Group: DFO, Laval University (Research Scientist – Anaïs Lacoursière, Kimberly Howland).
Timeframe: 2015-19 summer, monthly and tidal.
Species: All.
Purpose: Detecting coastal biodiversity changes.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DFO 1*
Location: Bay of Fundy & Arctic.
Group: DFO Science branch, coastal ecosystem science division. (Research Scientist – Anaïs Lacoursière, Kimberly Howland).
Timeframe: Ongoing, Monthly.
Species: All.
Purpose: Baseline monitoring survey (biodiversity).

DFO 2
Location: Miramichi.
Group: DFO
Timeframe: Winter (under-ice transect).
Species: Striped bass.
Purpose: Estimate striped bass population size.

DFO 3
Location: Miramichi Lake, NB.
Group: DFO Gulf Region.
Timeframe: 2018.
Purpose: Smallmouth bass detection in and around Miramichi Lake.

DFO 4*
Location: Rivers in PEI, NB, NS, QC, South Nation, ON, and Athabasca oil sands.
Group: DFO, ECCC and AAFC.
Timeframe: Fall 2016, 2017, 2018, 2019.
Species: Benthic invertebrates.
Purpose: CABIN monitoring and salmon gut vs. river benthos (PEI).

DFO 5
Location: Gulf and Maritimes regions.
Group: DFO Gulf and Maritimes. (Anaïs Lacoursière, Nellie Gagné, Francis Leblanc, Marc Trudel et al.)
Timeframe: 2020.
Species: Atlantic salmon.
Purpose: Using Atlantic salmon to model eDNA dispersal in rivers and coastal areas (sentinel cages).

DFO 6
Location: Several Sites in the Southern Gulf of St Lawrence.
Group: DFO.
Timeframe: Summer 2019.
Purpose: eDNA compared trawl metabarcoding.

DFO 7
Location: Various NB rivers.
Group: DFO Gulf Region.
Timeframe: 2017-2019.
Species: Brook Floaters and Eastern pearlshell.
Purpose: eDNA freshwater mussel species survey.

DFO 8
Location: Pollet river, Upper Salmon river.
Group: DFO .
Timeframe: 2018, 2019, 2020.
Species: Atlantic salmon.
Purpose: Presence, calibration of DNA shedding against temperature, life stages and flow.

DFO 9
Location: Bay of Fundy.
Group: DFO (Research Scientist – Anaïs Lacoursière) and University of New Brunwick (Remy Rochette).
Timeframe: August – October 2019 weekly.
Species: Lobster.
Purpose: Detecting the reproduction period of American lobster.

DFO 10
Location: Bays where shellfish aquaculture occurs .
Group: DFO Science branch, coastal ecosystem science division. (Research Scientist – Anaïs Lacoursière, Peter Cranford).
Timeframe: February 2019.
Species: Zooplankton.
Purpose: Detect zooplankton depletion as a result of shellfish aquaculture.

DFO 11
Location: Basin Head.
Group: DFO Gulf Region.
Timeframe: Summer 2019.
Species: Eelgrass.
Purpose: Mapping eelgrass in Basin Head.

DFO 12
Location: Coastal sites in the Northumberland Strait.
Group: DFO Gulf Region.
Timeframe: 2017-19.
Species: Marine aquatic invasive species (Tunicates and European green crab).
Purpose: Use of eDNA in DFO's AIS monitoring program.

DFO 13
Location: Eastern Shore Islands.
Group: DFO Maritimes (Nick Jeffery, Ryan Stanley, Susan Heaslip, Anaïs Lacoursière).
Timeframe: Summer 2019.
Species: All fish and invertebrates.
Purpose: Biodiversity monitoring comparing beach seine and eDNA to assess community composition.

DFO 14
Location: Nearshore/coastal sites within Eastern Shore Islands AOI, NS.
Group: DFO Maritimes and in collaboration with NSSA – 1.
Timeframe: TBD.
Species: All.
Purpose: Water sampling related to freshwater influence for acidification, carbon dynamics and potential eDNA samples.

DFO 15
Location: In-lab processing.
Group: DFO Maritimes Region (Aquatic Biotechnology Lab).
Timeframe: 2018-2019.
Species: Lobster.
Purpose: Develop and test a lobster COI (Taqman) assay and apply this to experiment and field collected eDNA samples.

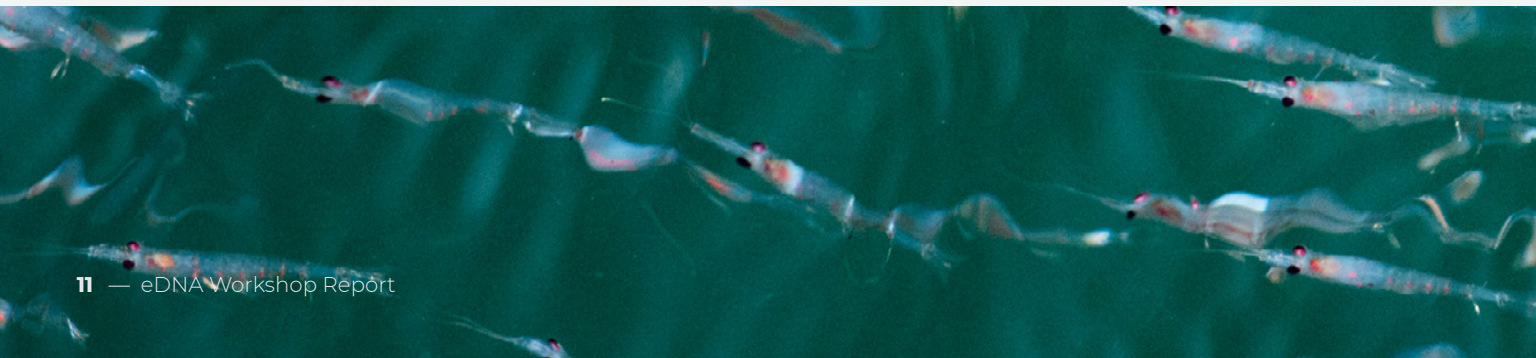
DFO 16
Location: In-lab processing
Group: DFO Maritimes Region (Aquatic Biotechnology Lab).
Timeframe: 2018-2019.
Species:
Purpose: Optimize qPCR assay, from the literature, for Antibiotic Resistance Genes (ARGs) and apply assays to 300 eDNA samples.

DFO 17
Location: The Gully MPA, Fundian Channel.
Group: DFO Maritimes Region (Nick Jeffery, Ryan Stanley, Susan Heaslip, Kenchington Lab).
Timeframe: 2019 – ongoing.
Species: All.
Purpose: Deep sea eDNA samples.

DFO 18
Location: Scotian shelf (whole shelf offshore samples).
Group: DFO Maritimes (Nick Jeffery, Ryan Stanley, Susan Heaslip, Anaïs Lacoursière).
Timeframe: Summer 2020.
Species: All fish and invertebrates.
Purpose: Biodiversity monitoring comparing RV Survey trawls and eDNA to assess community composition.

DFO 19*
Location: 10 rivers across Newfoundland at salmon counting sites.
Group: DFO Newfoundland (Ian Bradbury).
Timeframe: Sampled July 2018.
Species: Atlantic salmon.
Purpose: Species presence and relative abundance in comparison to actual counts at fences.

DFO 20*
Location: 40 rivers in southern Newfoundland.
Group: DFO Newfoundland (Ian Bradbury).
Timeframe: Sampled July – August 2018.
Species: Atlantic salmon.
Purpose: Species presence, wild/farm detections and relative abundance.



DFO 21*
Location: 10 rivers in northern Labrador.
Group: DFO Newfoundland (Ian Bradbury).
Timeframe: Sampled July 2018.
Species: Atlantic salmon, Arctic char, striped bass.
Purpose: Species presence and relative abundance.

Laval 1
Location: Quebec .
Group: Quebec government (MFFP), Laval University (Research Scientists – Anaïs Lacoursière and Louis Bernatchez).
Timeframe: 2013-15, Spring.
Species: Lake trout, Brook char.
Purpose: Population quantification.

Laval 2
Location: Quebec.
Group: Quebec Government (MFFP), Laval University (Research Scientists – Anaïs Lacoursière and Louis Bernatchez).
Timeframe: 2013-15.
Species: Wood Turtle, amphibious.
Purpose: Detection and population quantification.

MCG 1
Location: Stewiacke River Watershed.
Group: Mi'kmaw Conservation Group.
Timeframe: Summer 2019, 2020.
Species: Chain pickerel, brook floater.
Purpose: To determine extent of chain pickerel invasion to prioritize barrier remediations and removals, and to fill knowledge gaps on the distribution of brook floater.

MCG 2
Location: Cornwallis River Watershed.
Group: Mi'kmaw Conservation Group.
Timeframe: Summer 2019.
Species: Wood turtle.
Purpose: To help determine distribution of Wood Turtle and aid in assessing threats to the population.

MCG 3
Location: Southern Uplands.
Group: Mi'kmaw Conservation Group.
Timeframe: 2020.
Species: Atlantic salmon.
Purpose: To assist with identifying habitat and to guide population assessment efforts.

NSSA 1
Location: Main branch of historic salmon rivers in Nova Scotia.
Group: Nova Scotia Salmon Association, Oceans North and DFO.
Timeframe: May/June 2019.
Species: Atlantic salmon, possibly others.
Purpose: Current distribution of Atlantic salmon in support of recovery planning, presence/absence in relation with water chemistry.

NSSA 2
Location: 9 priority watersheds in Nova Scotia's southern uplands.
Group: Nova Scotia Salmon Association, Oceans North, DFO and 9 partners.
Timeframe: May 2020 – November 2021.
Species: Atlantic salmon, brook floater, American eel, aquatic invasive species (smallmouth bass, chain pickerel).
Purpose: Species distribution in support of recovery planning for species at risk.

PC 1
Location: St. Lawrence-Saguenay Marine Park.
Group: Parks Canada and Laval University (Nadia Menard and Louis Bernatchez).
Species: Whale forage fish (e.g. capelin, redfish).
Purpose: Comparing eDNA with fisheries acoustic surveys.

Workshop participants

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