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Basin Head Marine Protected Area: 2021-2022 Operational Management Plan Implementation Progress Report

Fisheries and Oceans Canada, Gulf Region
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Moncton, NB, E1C 9B6

2023

Gulf Region Basin Head Management Series 2023/01

Canada

Gulf Region Basin Head Management Series

The Gulf Region Basin Head Management Series publications are reports on management initiatives and monitoring undertaken in the Basin Head Marine Protected Area. This series consists of monitoring progress reports, operational management plan, consultant reports, scientific studies, workshops and other public documents related to the Basin Head Marine Protected Area. The Basin Head Management Series was established in 2014. Reports in this series have been written by or prepared under the guidance of staff of the Department of Fisheries and Oceans - Gulf Region. The content of this series is intended to be a source of information for public and internal dissemination.

Série sur la gestion de Basin Head dans la région du golfe

La série de publications sur la gestion de Basin Head de la région du golfe regroupe des rapports au sujet d'initiatives de gestion et de surveillance entrepris dans la zone de protection marine de Basin Head. Cette série se compose principalement de rapports de progrès sur la surveillance effectuée à Basin Head, plan de gestion opérationnel, d'études scientifiques, de rapports de consultants, d'ateliers et d'autres documents publics reliés à la zone de protection marine de Basin Head. La série sur la gestion de Basin Head fut créée en 2014. Ces rapports furent rédigés par le personnel du Ministère des Pêches et des Océans ou furent préparés sous la direction de celui-ci – dans la région du golfe. Le contenu de cette série se veut une source d'information pour une diffusion publique et interne.

Gulf Region Basin Head Management Series

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AIS ..... Aquatic Invasive Species
BHMPAR ..... Basin Head Marine Protected Area Regulations
CA…….. Contribution Agreement
C&P .....Conservation and Protection
CAMP .....Community Aquatic Monitoring Program
CPUE……Catch per unit effort
DAL ..... Dalhousie University
DFO .....Fisheries and Oceans Canada
MCFR .....Management of Contaminated Fishery Regulations
MPA ..... Marine Protected Area
MPFR ..... Maritime Provinces Fishery Regulations
NRC .....National Research Council
OMP .....Operational Management Plan
UPEI…….....University of Prince Edward Island
SAB .....Souris and Area Branch of the Prince Edward Island Wildlife Federation

ABSTRACT

This Progress Report for the Basin Head Marine Protected Area outlines the activities and monitoring, associated with the four conservation objectives, that occurred during the 2021-2022 fiscal year (April 2021 to March 2022). This report also highlights the different management actions taken in 2021-2022 and the future steps and priorities for the integrated management of the Basin Head Marine Protected Area.

RÉSUMÉ

Ce rapport d'étape pour la zone de protection marine de Basin Head décrit les activités et la surveillance associées aux quatre objectifs de conservation qui ont eu lieu au cours de l'exercice 2021-2022 (d'avril 2021 à mars 2022). Ce rapport met également en lumière les différentes mesures de gestion prises en 2021-2022, ainsi que les prochaines étapes et les priorités pour la gestion intégrée de la zone de protection marine de Basin Head.

1.0 INTRODUCTION

The Basin Head Marine Protected Area (MPA) was designated on September 26, 2005, via regulations under the statutory authority of Canada's *Oceans Act* (Basin Head Marine Protected Area Regulations) under Section 35, paragraph (1) c (conservation and protection of unique habitats), as well as paragraph (1) e (to fulfill the mandate of the Minister). The MPA encompasses Basin Head Lagoon (divided into the Northeast Arm and the Main Basin) and an adjacent offshore buffer zone in eastern Prince Edward Island within the Northumberland Strait (Figure 1).

The MPA was designated by regulations to conserve and protect a distinct form of an otherwise common marine alga, Irish moss (*Chondrus crispus*). This form of *Chondrus,* also known as the giant Irish moss, is thought to exist only within the confines of Basin Head. It reproduces only by fragmentation, does not reproduce sexually or by producing spores (Tummon Flynn et al. 2018), and has no holdfast but is held in place by byssal threads of Blue mussels (*Mytilus edulis*). Sheltered habitats often influence morphology of algae; this has resulted in relatively expanded blades for the giant Irish moss in Basin Head. However, spriggy outer coastal plants (i.e., narrow blades) sharing the habitat are attached to hard objects by holdfasts and have not developed into the giant form. The exploration of genetic differences between this and the other Irish moss population is a logical next step to try to understand the uniqueness of this strain. The use of microsatellite genomes to compare Irish moss strains may provide further insight on the differences among populations (see studies by Krueger-Hadfield et al. 2011, 2013, 2015).

Figure 1: Basin Head Marine Protected Area and its three management zones.

Zone 1: Northeast Arm
Basin Head's Northeast Arm extends from the main basin to the east for approximately three kilometers. This inner channel has been given the highest level of protection because this is where the unique form of Irish moss is found. Because of its vulnerability, motorized vessels are not permitted in this zone; there is no commercial or recreational fishing, nor any other potentially destructive activities allowed. Swimming and diving are also not permitted in this zone, except under a scientific research activity plan.

Zone 2: Main Basin
This zone includes the main basin of the lagoon, the western end of Northeast Arm and the channel leading to the entrance to Northumberland Strait. This zone acts as a buffer for the more sensitive inner reaches of Northeast Arm. The zone can tolerate minor disturbance; therefore swimming, diving, and non-motorized vessel based fishing activities are allowed. It includes a boat slip from which motorized vessels may be launched, but these vessels must proceed directly to the open water (Zone 3).

Zone 3: Outer Coast
The outer coastal area protects the integrity of Basin Head's sand dune structure. This zone extends seaward from the mouth of the lagoon for one nautical mile and covers an area of coast three nautical miles long (southwest to northeast) adjacent to the entrance channel. In this zone, the only restrictions are on those activities that could alter the coastline in such a way as to endanger the fragile dune system, and therefore the lagoon itself. All other activities are allowed.

The latest update to the Basin Head MPA Operational Management Plan (OMP) was published in March 2022. The OMP serves as a guide to support decision making in the management of this unique ecosystem and forms the basis for the development of comprehensive conservation and management strategies. It provides information on regulatory and non-regulatory measures, monitoring, governance structure, enforcement and compliance and management actions once ecological triggers have been reached and thresholds exceeded. It also provides the details required to ensure that management decisions, prohibitions, and activity applications and processes are clearly understood.

The Basin Head MPA OMP is intended to serve as a "living" document which may be amended as required to ensure management objectives and monitoring requirements are met and are regularly reviewed on a 5-year cycle. The periodic reviews examine the conservation objectives of the MPA to determine if they remain appropriate, evaluate the success of management actions in achieving the conservation objectives, and identify emerging priorities for subsequent reviews of the OMP.

The purpose of this yearly Progress Report is to report on activities and achievements in the Basin Head MPA during the 2021-2022 fiscal year (April 2021 to March 2022) that contribute to the implementation of the operational management plan. This report and past reports will serve as guides for the OMP review.

Personnel from Marine Planning and Conservation Program, Fisheries and Oceans Canada (DFO), Gulf Region are responsible for efforts aimed at achieving the conservation objectives described in the OMP. Management of the MPA is also guided by the advice of DFO science, the local community and stakeholders, other federal and provincial government departments, academic partners and Indigenous groups, acting through the Basin Head MPA Advisory Committee.

2.0 CONSERVATION OBJECTIVES AND ACTIONS TAKEN

Conservation objectives describe the desired ecological outcome of establishing an MPA and are based on the best available scientific and traditional ecological knowledge. These objectives guide the MPA establishment and management process by providing the basis for determining management measures. They also allow the setting of limits within which the nature and magnitude of human impacts on ecosystems and/or key ecological features of the MPA are assessed. Economic opportunities compatible with these conservation objectives may be permitted within the MPA or within specific zones.

There are four conservation objectives for Basin Head MPA:

Conservation objective 1: Maintain the quality of the marine environment supporting the Basin Head Irish moss (*Chondrus crispus*).

Conservation objective 2: Maintain the physical structures of the ecosystem supporting the Basin Head Irish moss (*Chondrus crispus*).

Conservation objective 3: Maintain the health (biomass and coverage) of the Basin Head Irish moss (*Chondrus crispus*).

Conservation objective 4: Maintain the overall ecological integrity of the Basin Head lagoon and inner channel. This includes avoidance of excessive *Ulva* growth, maintenance of adequate oxygen levels, and maintenance of diversity of indigenous flora and fauna.

Management and monitoring actions taken during the 2021-22 fiscal year to fulfill short and long-term management goals for both regulatory and non-regulatory conservation objectives are shown in Table 1 and 2, respectively.

Table 1: Basin Head MPA Regulatory Conservation Objectives and Monitoring/Management Actions.

Conservation Objective and Management Strategies	**Ecological Monitoring Activities**	**Actions Taken in 2021-2022**
CO1: Maintain the quality of the marine environment supporting the Basin Head Irish moss.	**Nutrient Loading:** Measurements of stream flow in combination with water samples for nitrate, nitrite and phosphate concentration from early spring to fall	Water quality for nutrient loading at six freshwater sites and three estuarine sites were sampled on an outgoing tide monthly from April to November (plus two additional samples). Flow rate monitoring also occurred at the freshwater sites.
Management Strategies: Ensure that water quality indicators are maintained at levels conducive to Irish moss survival.	Develop a watershed nutrient model also taking into factor groundwater concentration.	Temperature and nutrient regime modeling underway (research conducted in collaboration by Dalhousie University): (1) characterize the temperatures and nitrogen concentrations of the different water inputs to the Basin Head estuary; (2) assess how the different water inputs control the overall temperature and nutrient regimes of the estuary and their spatial heterogeneity;

		(3) to study the sensitivity of temperature and nitrogen dynamics to climate and land use changes. **Threshold Crossed?** No eutrophication threshold has been defined in the OMP.
	Water Temperature: Monitor continuous water temperature year-round, at three locations within the MPA (two in NE Arm over the Irish moss Main Bed and Corduroy Road bed and one in the Main Basin). **Dissolved Oxygen:** Monitor continuous dissolved oxygen over Irish moss beds and mouth of NE Arm annually during ice free season.	Three temperature loggers were deployed throughout the MPA. **Threshold of prolonged exposure of 28°C crossed?** No. Temperature reached 28°C for 4 consecutive hours at Corduroy Road on August 14th but did not exceed it long enough to trigger additional management actions. Three dissolved oxygen (DO) loggers were deployed within the MPA. One DO probe was an Innovasea Real-time logger accessible online while deployed. **Threshold of hypoxic stress of 4mg/L for fish and 2mg/L for invertebrate crossed?** 2021 data has not been analyzed yet.
CO2: Maintain the physical structure of the ecosystem supporting the Basin Head Irish moss. **Management Strategies:** Monitor and where possible restore the integrity of the physical environment.	**Dune and Salt Marsh Structure:** Monitor changes in dune structure at the ocean opening and at the top of the Northeast Arm. Monitor salt marsh edge erosion every 5 years with remote sensing techniques. Ground truth salt marsh erosion yearly.	Continued measuring marsh edge erosion relative to rebar posts inserted into the southern bank at Main Bed's western end and along Corduroy Road. **Threshold Crossed?** There is no known threshold for this factor in Basin Head.
	Water circulation and depth: Update hydrodynamic model every 5 years or when major changes occur. Monitor salinity continuously to better understand tidal influence and freshwater inputs. Monitor morphology of ocean opening and document if any dredging has occurred. Monitor changes in water	Three water level loggers and three salinity loggers were deployed throughout the MPA to predict the tidal cycle for the 2022 field season (Figure 3). Provincial government assessed the entrance channel, detected sand buildup and obtained a permit to dredge between the wharves. This occurred in June 2021. **Threshold of ideal current speed for Irish moss suitable habitat of 10-15 cm/sec crossed?** This factor will be analyzed on a 5-year cycle when the hydrodynamic model gets updated.

	depth at low-tide, sediment thickness and bottom type at 5-year intervals or if major storm surges occur.	
	Land Use Pattern: Monitor land use patterns using provincial aerial photo information, interviews with local farmers, or ground truth surveys. Monitor municipal land use and permit approval data in the Basin Head watershed.	The Rural Municipality of Eastern Kings informed DFO of a residential development project falling within the watershed boundaries bordering the MPA and will keep DFO apprised of any progress. **Threshold Crossed?** There is no defined threshold which defines how land use threatens estuarine ecosystem viability.
CO3: Maintain the health (biomass and coverage) of the Basin Head Irish moss. **Management Strategies:** Ensure a healthy and sustainable level of Irish moss in the MPA. Augment Irish moss coverage by planting Irish moss-mussel clumps to reach at least 50% of original 2005 establishment coverage (baseline=2254 m^2). Manage human activities and pressures to minimize negative impacts that can kill or damage Irish moss.	**Irish Moss:** Continue annual Irish moss subsampling by wading surveys to detect major Irish moss changes that would indicate the need for a full bed assessment. At least once every 5 years, conduct a drone-based photographic survey of all beds in order to locate and measure Irish moss clumps.	Ongoing annual Irish moss subsampling by wading surveys along 2-m wide swaths on both sides of the 10 permanent transects to detect Irish moss changes. A total of 181.4 m^2 of Irish moss was calculated for the three Irish moss beds in 2021. Artificially constructed Irish moss-mussel clumps were planted in areas similar in depth and bottom type to the preferred habitat of the remnant population. Sandy Cove Irish moss cultivars and depurated commercial mussels were brought in and used to make the clumps. Capacity building of Souris Wildlife to conduct the drone surveys in the future by providing funding for the purchase of a drone and photomosaic creation software. Training is also being provided for the creation of the photomosaics. Measures to mitigate pressures on Irish moss such as planting in the riparian zone for the stabilization of the bank and through the Living Lab program to implement BMPs to reduce sedimentation into the system are ongoing. **Threshold of Irish moss coverage below 25% (564 m^2) of baseline crossed?** Yes, Irish moss coverage has not yet rebounded to above the threshold mark defined in the OMP; therefore, restoration efforts continued.
CO4: Maintain the overall ecological integrity of the Basin Head lagoon and inner channel.	**Abundance and Diversity of Fish and Benthic Invertebrates:** Continue the Community Aquatic Monitoring Program (CAMP) to monitor trends of	Souris Wildlife facilitated CAMP again in the Basin Head lagoon throughout June-August 2021. A Contribution Agreement between DFO and

Management Strategies: Maintain diversity of indigenous flora and fauna. Monitor eelgrass coverage, which is considered an Ecologically Significant Species. Monitor Ulva blooms which can provide an indication of eutrophication. Control Aquatic Invasive Species entering the Basin Head MPA.	abundance and diversity of fish and benthic invertebrates. Initiate sampling within each Irish moss bed to document changes in benthic diversity, abundance of sessile communities and shellfish.	UPEI was finalized in the Winter of 2022, which will fund the investigation of the interactions between Irish moss and eelgrass, and the biodiversity within the Irish moss-mussel clumps. This work will begin in Spring 2022. **Threshold Crossed?** Thresholds specific to Basin Head have not been identified.
	Eelgrass: Continue documenting eelgrass bed coverage yearly within and adjacent to Irish moss survey transects. Analyze collected drone-based images, satellite imagery, or acoustic survey data to estimate eelgrass coverage.	Eelgrass patches were traced within and surrounding three Irish moss permanent survey transects. Patches were measured using GIS software. A total of 251.6 m^2 of eelgrass was calculated within the Irish moss beds in 2021. Aerial images collected by the province were obtained by DFO and will be used to analyze eelgrass cover. **Threshold Crossed?** There is no threshold known, but natural re-establishment is currently ongoing.
	Green Algae: Continue photomosaics to document the timing and extent of seasonal growth and die-off of green algae. Continue documenting the percent sea lettuce coverage along Irish moss survey transects and in CAMP. Continue proof testing the use of time-lapse cameras to document intertidal sea lettuce development and develop metrics of sea lettuce dynamics.	Bi-weekly panoramic photos at Ching's Bridge and Elliott's Marsh were continued throughout April-November. Two time lapse cameras at Main Bed and Elliott's Marsh captured approx. 17,520 images each (one photo taken every half-hour) to document the Ulva blooms intertidally. Percent Ulva coverage was taken along each of the 10 Irish moss permanent survey swaths. **Threshold Crossed?** A eutrophication threshold is still to be determined for Basin Head in order to determine whether Ulva levels surpassed a certain threshold.
	Shellfish: Perform periodic non-destructive quadrat sampling to document demographics of mussels and oysters and compare with an established baseline.	No work to assess the shellfish population occurred in 2021.
	Aquatic Invasive Species: Continues yearly deployment of biofouling collectors for early detection and	AIS collector plates were deployed at three sites throughout the MPA. **Threshold of newly detected AIS species**

	monitoring of AIS. Continue CAMP sampling in the Main Basin to monitor temporal signal in Green crab abundance. Continue the yearly targeted Green crab removal program. Calculate Catch per Unit Effort and changes in size distribution.	**crossed?** No new AIS species were detected in 2021. The Green crab removal program occurred from July-October 2021 (50 days of fishing), removing 107,682 Green crab from the MPA. The CPUE found in the Main Basin and Northeast Arm was 58.91 and 73.58 Green crab/trap/day respectively, which is categorized as 'poor' (Table 3). **Threshold Crossed?** The CPUE of Green crab is currently defined as poor within both the Main Basin and the Northeast Arm (Table 3). Target average carapace width is to reduce the Green crab size to below 5 mm such that the predation pressure on the mussels is lessened.

Table 2: Basin Head MPA Non-Regulatory Conservation Objectives and Monitoring/Management Actions.

Non-Regulatory Conservation Objectives	**Management Actions**	**Actions Taken in 2021-2022**
Ensure the participation of interested and affected partners and stakeholders in the management of the MPA.	Continue the annual Advisory Committee meeting to report on management progress and challenges.	The 2021 Advisory Committee meeting took place during the morning of December 1st.
	Encourage partner and stakeholder involvement in the management of the MPA and provide funding to advance the monitoring and management of the MPA.	A total of two new multi-year Contribution Agreements (CAs) were signed between DFO and Dalhousie University and UPEI to conduct research in the MPA.
	Review Advisory Committee terms of reference and membership every 5 years.	DFO has begun revising the terms of reference and will be completed in 2022. Cindy Crane with the Province has joined the Advisory Committee and Patrick Eastman has stepped down as the fisheries representative.
Foster public stewardship of the Basin Head MPA through education and awareness of the ecosystem and the existing conservation measures.	Update the DFO Basin Head MPA website.	Website updates began in March 2022.
	Continue collaborating with SAB to increase public awareness through community events.	SAB conducted two outreach events: one with Transitions, the other with Wild Outside.
	Increase involvement of Indigenous groups to raise public knowledge of the cultural significance and Traditional	Discussions began and will continue throughout the next fiscal year to bring more indigenous involvement to the MPA through

	Indigenous Knowledge connected to the MPA.	educational activities.
	Conduct information sessions for residents, farmers, recreational fishers and waterfowl hunters on the work undertaken at Basin Head.	No information sessions have been hosted about the Basin Head MPA since 2019.
To promote scientific research and monitoring to increase the level of understanding of the Basin Head MPA.	Continue to collaborate with universities to promote research.	Two new multi-year Contribution Agreements (CA) were signed between DFO and Dalhousie University and the University of PEI to conduct research in the MPA.
	Continue to support SAB for their monitoring and restoration efforts.	An amendment to add an additional 2 years was added to the CA with SAB.
	Continue to identify potential partners for collaborative research, monitoring or restoration projects within the Basin Head watershed.	A surface water biologist from the PEI Department of Environment, Energy and Climate Action was added to the Advisory Committee, and a request to join the committee was received from the Native Council of PEI (NCPEI) which is in review.
To promote, and if possible, enhance social and environmental conditions in the surrounding watershed as required to avoid adverse impacts on the Basin Head ecosystem.	Promote and implement relevant BMPs to reduce the impacts of nutrient enrichment and sediment loading within the Basin Head ecosystem.	SAB has continued to work with the Living Labs program on implementing BMPs in Eastern PEI, two of which fell within the Basin Head watershed in 2021 (see non-regulatory CO4).
	Reduce the spread of AIS in the Basin Head ecosystem by promoting public awareness and stewardship initiatives.	DFO continues to work with the DFO AIS section and other partners to bring awareness on preventing the spread of AIS into the MPA and other bodies of water. The Activity Plan submission form was updated to include steps on preventing the introduction of AIS into the MPA.
	Continue supporting habitat restoration activities to maintain and enhance the quality of the Basin Head ecosystem.	SAB conducted 400m of stream restoration within the tributaries of the watershed.
	Continue supporting educational and stewardship activities which may promote tourism.	Two media outlets reported on work that occurred in Basin Head: CBC PEI and The Eastern Graphic each published an online article.

3.0 MANAGEMENT HIGHLIGHTS FOR 2021-2022

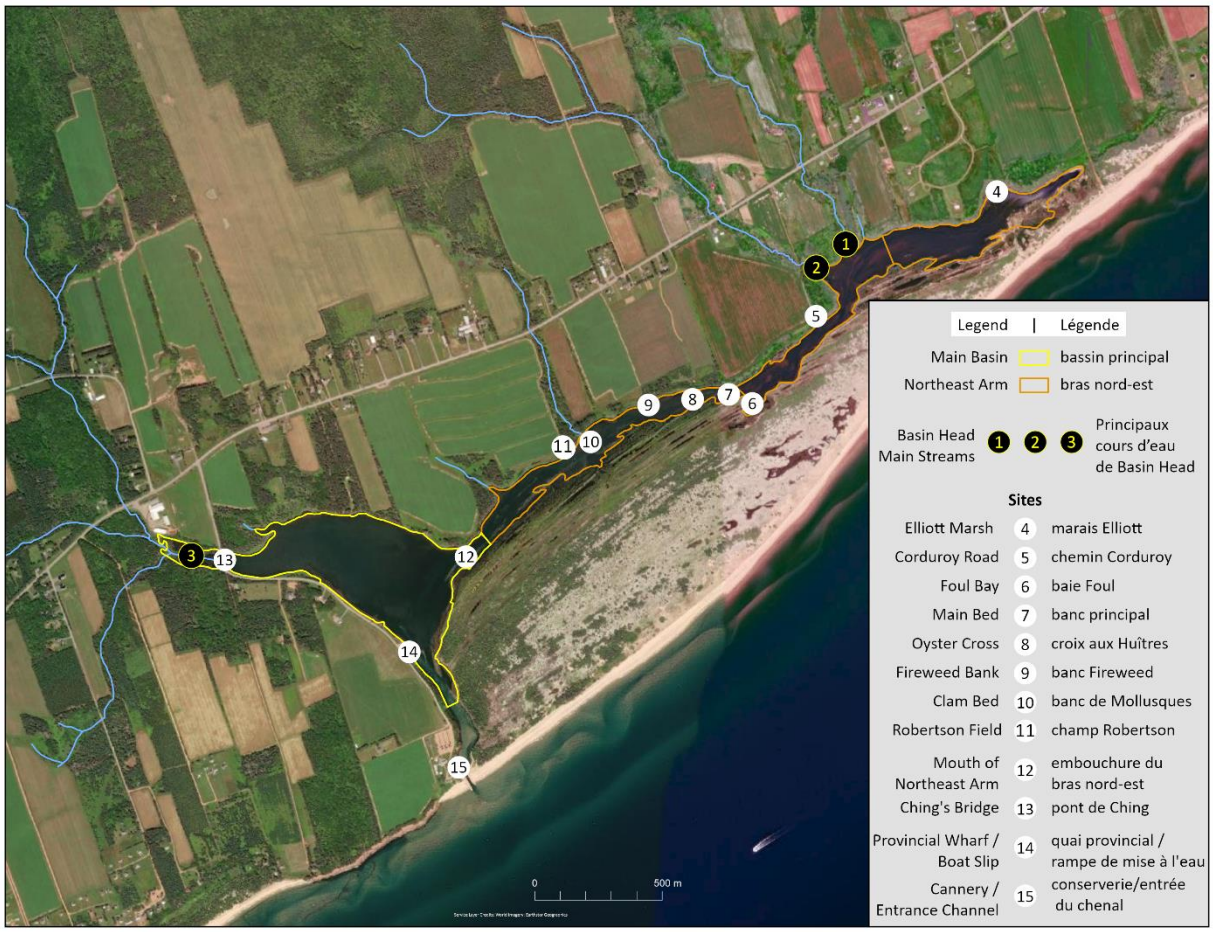

Figure 2: Map of Basin Head Marine Protected Area with numbered streams and sites.

CO1: MAINTAIN THE QUALITY OF THE MARINE ENVIRONMENT SUPPORTING THE BASIN HEAD IRISH MOSS

Water quality monitoring

- Stream flow monitoring and water samples were taken in order to quantify nutrient loading (product of base flow and average nitrate concentration) at freshwater inputs. A total of nine sites were sampled in 2021; six freshwater (above head of tide, flowing into the MPA) and three estuarine (within the MPA). This was repeated monthly from April-November, as well as additional monitoring that took place once during a dry period, and once during a heavy rain event. This additional monitoring occurs at the same locations as the regular monthly monitoring, but is conducted at times that exemplify a dry period and a heavy rain event, to help showcase how water quality is affected by these differences in weather. In 2021 the dry period monitoring (an extended period with no rain) occurred October 13th, and the heavy rain monitoring (a period with a lot of rain in 24hrs) occurred September 3rd.

- The Science Review Process in 2019 (DFO 2020) advised to quantify nutrient loading from the streams rather than only look at nitrogen concentrations. Measuring stream flow and nitrogen concentrations, DFO Science staff have used this data to calculate the nitrogen load

entering the Basin Head MPA from the tributaries. Using this calculation, it was determined that the nitrogen load associated to streams in Basin Head is 54.1 Kg/ha/yr (for the growing season May-October), however additional upcoming data will provide more information on total nitrogen loading due to other sources (such as springs within the estuary and released from sediment). With the nutrient concentration data that has been collected within the MPA since 2001, DFO has been able to hindcast the nutrient load to determine any potential trends. Based on this hindcast, no observable trend was found; nutrient load remained relatively steady between 2001-2020. DFO Science will complete a DFO technical report detailing how this calculation was conducted by the end of next fiscal (March 2023).

- Three continuous probes each of dissolved oxygen (DO), salinity, temperature and water level, were deployed throughout the MPA in 2021 (a total of 12 probes; Figure 3) after being unable to deploy in 2020 due to the pandemic. One additional water level probe was deployed on land to measure air pressure that will be used to correct the water level data.

- A real-time hub that transmits data from its probes to an app, which allows the user to see the desired parameters at that point in time, was installed for the first time in Main Bed. Of the previously mentioned probes deployed in Basin Head, one of the DO probes and all three salinity probes have the capability to connect to the main hub if within range. Given that the salinity probes are intentionally not in Main Bed and therefore fall out of the transmission range of the real-time hub, the data associated with these probes cannot be accessed via the app. However, the DO probe (that also measures temperature) can transmit data in real-time due to their location in the Main Bed, adjacent to the real-time hub (Figure 3). This allows SAB and DFO staff the opportunity to clean the probe if any indication of biofouling from Ulva is detected, thus providing more accurate long-term data.

- Blue mussel stress occurs at 20°C, and mortality is likely at 28°C. While the 2021 continuous probe data will begin to be analyzed by the end of next fiscal (March 2023), preliminary results of the temperature probes showed that the Corduroy Road site reached an afternoon water temperature of 20°C June 5th, 2021. In August, the water temperature was over 20°C for most of each day; moreover, this site reached 28°C for four consecutive hours on August 14th, 2021. It is likely that temperatures exceeding 20°C were consistent beyond August, but the probe malfunctioned due to water damage on August 21st, 2021, and no further data was collected at this site for the remainder of the year. This probe, and the other temperature probes throughout the MPA, have been replaced with HOBO TidbiT wireless probes that are tolerant of brackish water.

Thermal and nutrient regime investigations

- Dalhousie University and DFO have an active Contribution Agreement that broadly outlines their commitment to research the thermal and nutrient regimes of Basin Head. This research continued in 2021, with a focus on: (1) investigating the thermal regime of the Basin Head groundwater system and its influence on the thermal regime of the lagoon and (2) investigating the drivers and patterns of water quality parameters (e.g., water temperature and nutrients), and their sensitivity to climate change. The following objectives were accomplished:
  - Continued stream flow monitoring in the three main streams and continued monitoring of the water table level, temperature, and conductivity of groundwater in the installed well;
  - Operation and maintenance of the climate station and air pressure transducer;
  - Thermal monitoring of surface and bottom water temperatures in the upper NE Harbour channel;

- Paired fiber-optic distributed temperature sensing (Silixa XT-DTS) and thermal imaging via an unmanned vehicle aircraft (Matrice 210 RTK with Zenmuse XT2 thermal sensor);
- Development of thermal and visual orthomosaic imagery;
- Short-term deployment of the freshwater nitrate sensor (SUNA V2 nitrate sensor) at stream 3 (Figure 2).
- Discrete sampling of DO, conductivity, temperature, pH, and nutrients of selected springs and tributaries; and,
- Test deployment of the acoustic doppler current profiler (ADCP) unit used to measure water current velocities.

Figure 3: Location of 2021 continuous probes within the Basin Head MPA.

Riparian Zone Planting

- SAB planted 261 native trees and shrubs along the bank of the western portion of the Northeast Arm. This was done to strengthen the soil holding capacity along the riparian zone as well as reduce the rate of erosion in some of the most susceptible areas of shoreline. They had a riparian zone plan created by Gary Schneider of MacPhail's Woodlot to guide them in planting the best trees/shrubs in the most beneficial places.
- The Province of PEI created a Forest Management Plan to allow for the riparian planting of native trees and shrubs on provincially owned land. This was created and put up for public comment January 2022, and formally approved April 2022. Planting in this area will occur in the fall of 2022.

CO2: MAINTAIN THE PHYSICAL STRUCTURE OF THE ECOSYSTEM SUPPORTING THE BASIN HEAD IRISH MOSS

Marsh edge erosion

- Monitoring of rebar posts along the edge of the salt marsh near the Main Bed continued in 2021. The rate of erosion in 2021 is greater than the average from previous years, approximately 30% greater. From January 2017 – August 2020 average rate of erosion was measured to be 7.8 cm/yr.; in 2021, the rate was measured to be 10 cm/yr. Erosion in the Main Bed threatens the Irish moss-mussel clumps as it can smother and bury the mussels, and indirectly impact the survival of the Irish moss. Erosion at the Main bed is a priority for mitigation, and alternative control methods may be explored in coming years.

- The erosion rate observed at Corduroy Road for 2021 was 11 cm/yr. Since these rods were placed in the marsh in 2020, this is the first erosion rate measurement for the Corduroy Road marsh.

- Within the next few years, this method of marsh erosion evaluation will be phased out in favour of less invasive methods, such as drone imagery. This means that no new rebar will be placed into the marsh, but existing rebar will continue to be monitored.

Water circulation and depth

- In June 2021, the entrance to Basin Head (locally known as *the run*) needed to be dredged to deepen the channel for the safety of people using the beach. This was contracted by the Province of PEI as it relates to public health and safety and navigation and did not require approval through an MPA activity plan.

- Building off the results of the sediment transport study commissioned by the Department of Transportation, Infrastructure and Energy in 2020, during the winter of 2022, the Province of PEI installed groynes by the area determined to have the highest erosion rate. The goal of this is to build up the sediment behind the groynes and move the channel towards the center of the area.

Winter ice monitoring

- Ice monitoring continued in Main Bed in winter 2022 for the second consecutive year. Regular checks were made from the bank above Main Bed to determine if ice had formed and if it was stable and safe to allow for work. On February 16th, 2022, the ice was deemed stable enough to work on. Seven holes were drilled into the ice every 5 meters perpendicular to the shore, taking measurements of ice thickness, water depth, salinity, and temperature at each hole. Four photos were taken at each hole (North, East, South and West) to show beneath-ice conditions and assess if any clumps were sticking to the bottom of the ice. Ice thickness ranged from 11-16 cm (12.6 cm average) across the seven holes that were drilled with water depth ranging from 67-112 cm (87 cm average). No ice scouring could be observed from the samplers and there was no evidence of Irish moss or other macro algae attached to the ice. This was the only event of the year where ice conditions were stable enough to conduct on-ice monitoring. This monitoring began mid-January and continued until mid-March, when ice began to recede from the arm.

- Two year-round time-lapse field cameras were installed in the Northeast Arm, one in Elliott's Marsh and the other in Main Bed (Figure 2) and are used to assess the ice cover in the winter (and Ulva cover in the summer). Photos are taken every half hour throughout the year. The field camera in Main Bed malfunctioned during the winter of 2022, resulting in data for this time frame being unavailable; data from the Elliott's Marsh camera survived, but has not yet been retrieved or analyzed.

Ulva monitoring

- The same year-round time-lapse cameras used to monitor ice thickness in the winter are used to measure Ulva cover throughout the summer. Two cameras, one in Main Bed and one in Elliott's Marsh, produce photos every half hour and were later analyzed to compare annual differences and trends. At Main Bed, the first fragments of Ulva were evident April 21st, 2021, and the first Ulva bloom began on May 10th, 2021. The first bloom observed at Elliott's marsh was on April 21st, 2021, coinciding with the first observation of Ulva fragments, likely showing that the first fragments of Ulva observed in Main Bed came from the Elliott's Marsh bloom, which later lead to the Main Bed Ulva bloom two weeks later. This is earlier than the first bloom in Main Bed in 2020 which occurred on May 16th, 2020.

- Panoramic photos taken biweekly at Ching's Bridge and Elliott's Marsh were another form of Ulva monitoring that occurred throughout April – November. This monitoring has shown that there is a consistent presence of this fast-growing macroalgae that can be deleterious to the Irish moss through smothering, blocking sunlight, and reducing available DO.

CO3: MAINTAIN THE HEALTH (BIOMASS AND COVERAGE) OF THE BASIN HEAD IRISH MOSS

Irish moss restoration

- Under the multi-year Interdepartmental Letter of Agreement (ILA) between DFO Gulf Region and the National Research Council (NRC), the maintenance of 10 kg of Basin Head *Chondrus* at the NRC's Sandy Cove on-land tank cultivation facility continued. Biomass from the holding stock at NRC was reintroduced to Basin Head and transferred into sock cultivation in the western portion of Northeast Arm to provide plants for 2021 restoration work.

- Blue mussels were acquired at Atlantic Aquafarms in Orwell Cove PEI. Approved Shellfish Transfer permits allowed mussels from Malpeque Bay, Savage Harbour and Tracadie Bay to be brought into the Basin Head MPA after a 24-hour depuration period to remove any invasive species.

- Irish moss-mussel clumps were made by combining the cultivated Irish moss and Blue mussels within a mesh bag and hanging it within the water column for at least 48 hours. This allowed the byssal threads of the mussels to attach to the Irish moss and anchor it. The Irish moss-mussel clumps were then introduced into areas similar in depth and bottom type to the preferred habitat of the remnant population and monitored. Locations of where the Irish moss clumps were planted within the three beds were captured using GPS devices and recorded (see Appendix 1).

- In 2021, 3,467 clumps were planted throughout Zone 1; specifically, in Main Bed (2,459 clumps), Corduroy Road (223 clumps) and Fireweed Bank (783 clumps) for a total of 18,693 clumps planted during the seven-year restoration span (2015-2021). Figure 4 shows the planting effort in each Irish moss bed that has occurred since restoration began in 2015. It is important to note that Irish moss clumps were being planted in Fireweed Bank prior to 2018 but were used in experiments and not recorded in the same way until 2018.

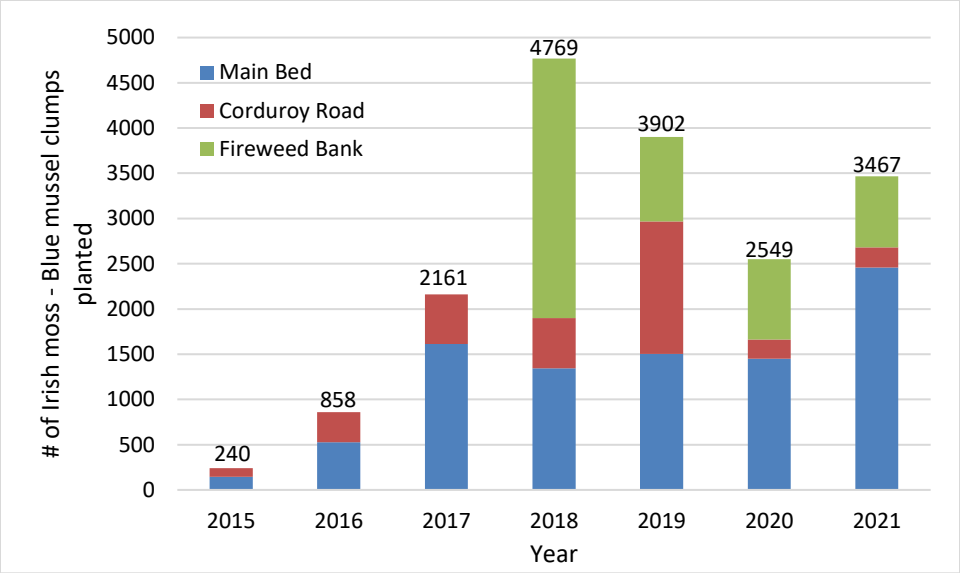

Figure 4: Planting effort of Irish moss-Blue mussel clumps in the Northeast Arm, 2015-2021.

Irish moss survey

- In 2021, subsampling along 2 m wide swaths on both sides of the permanent transects (survey swaths) was conducted, for a total of 20 swaths surveyed (10 permanent transects surveyed on either side; four meters per permanent transect). This was done to reduce the margin of error when estimating the percent loss of Irish moss cover over the winter.

- Fireweed Bank was measured to have an overall decline of 48% of Irish moss, whereas Main Bed saw an increase of 41%, and Corduroy Road remained largely unchanged (7% decline) from 2020. The estimated area covered by Irish moss at the end of 2021 declined slightly from 184 m^2 in 2020 to 182.4 m^2 (Figure 5). This coverage is below the threshold stated in the Operational Management Plan of 25% (564 m^2) relative to the coverage of Irish moss throughout the MPA at its time of establishment in 2005. This threshold was created as an arbitrary starting point for effective management; below a 25% threshold, restoration efforts must continue until a minimum of 50% of historical coverage is achieved.

- Irish moss average frond size increased in Fireweed Bank, where average diameter improved from 12.1 cm in 2020 to 13.4 cm in 2021, though decreases in average frond size were observed in Main Bed and Corduroy Road. Corduroy Road saw a decrease from 16.2 cm to 12.9 cm between 2020 and 2021. The decrease in Main Bed fell from 15.9 cm to 13.8 cm between 2020 and 2021, likely due to the influx of new clumps being planted after the 2020 survey, bringing down the average frond size despite there being an increase in the number of clumps in this bed.

- Monitoring of a test plantation at Oyster Cross (west of Main Bed, Figure 2, #8) continued in 2021. The estimated total cover of Irish moss on the plantation was 0.83 m^2 in 2021, up from 0.64 m^2 in 2020. Clumps within the Oyster Cross plantation have become more dispersed, causing difficulty in distinguishing clumps while surveying from one arm to the next. The original oyster shell cross has sunken into the mud.

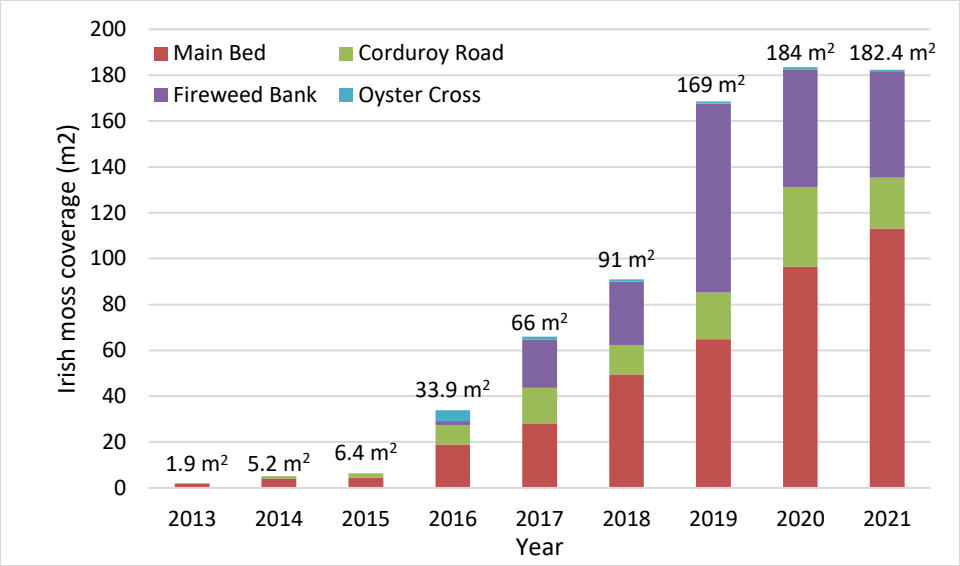

Figure 5: Chondrus crispus cover (m^2) in Northeast Arm from 2014-2021 (determined by comprehensive surveys of each moss bed).

Creation of photomosaics

- Through an ongoing knowledge transfer between DFO Science and SAB, SAB's training on how to effectively conduct the drone flight surveys to capture Irish moss coverage and how to create photomosaics of the images continued. During a summer low tide, SAB staff went *in situ* to test their drone over one of the permanent survey transects and collected images at a 6m height every 1-2 seconds. During winter 2022, DFO provided SAB a brief training on how to use the software Pix4D to create photomosaics of the images they captured and provided advice on how to obtain better quality images. Further training and knowledge transfer of the identification and quantification of Irish moss clumps is planned to continue until the end of the next fiscal year (March 2023).

CO4: MAINTAIN THE OVERALL ECOLOGICAL INTEGRITY OF THE BASIN HEAD LAGOON AND INNER CHANNEL

Community aquatic monitoring program (CAMP)

- The Community Aquatic Monitoring Program (CAMP) was conducted by SAB in Basin Head. The nearshore fish community has been monitored since 2003 in Basin Head at six stations in the main basin using the CAMP protocol but was unable to be run in 2020 due to the pandemic. CAMP was completed by SAB in 2021/22.

Aquatic invasive species monitoring

- Biofouling collector lines for early detection of aquatic invasive species (AIS) were deployed in Basin Head as part of the larger annual AIS biofouling monitoring program in the Gulf Region (Figure 6). No new invasive species were identified in Basin Head in 2021, but the presence of several previously identified species continue to be detected, such as the Golden star tunicate (*Botryllus schlosseri*), Violet tunicate (*Botrylloides violaceus*), Vase tunicate (*Ciona intestinalis*), Clubbed tunicate (*Styela clava*) and European green crab (*Carcinus maenas*). All these species have been detected to varying degrees in the MPA over time; however, the most prevalent AIS in 2021 was the European green crab. Larvae of the tunicate species were found on the settling plates but are not found widespread throughout the MPA. The most recent AIS to be discovered in the MPA was the Golden star tunicate on the settling

plates in 2019 and a confirmed case of the non-native Baltic shrimp in 2020, though no new species have been identified since.

Figure 6: Location of AIS collector lines with associated identification numbers.

Green crab removal program

- Invasive European Green crabs were trapped over 50 days from mid-July to the end of October 2021. The number of fishing days per month was based on the DFO contract with SAB; as per the contract, one week of fishing in July and three weeks of fishing in August, September, and October occurred. Most of the days fished were done consecutively, though some exceptions occurred due to adverse weather in September and October. All missed days were made up for to fulfill the contract obligations.

- The ten permanent monitoring sites (Traps 2, 4, 5, 7, 10, 13, 21, 23, 24, and 28) were deployed in the same locations as 2020 and were subsampled up to 50 crabs for size and sex identification and the rest of the crab counted. All other traps were deployed in varied locations and all the crab counted within each trap (Figure 7).

Figure 7: Green crab trapping locations in 2021.

- During the 2021 trapping season, 107,682 Green crabs were removed from Basin Head. Of the 10 traps subsampled (16,380 crab), 50.5% were males, and 49.5% were female. Of the males, 5.1% were less than 35 mm, 44% were between 35-55 mm, and 50.9% were above 55 mm. Of the females, 2.8% were less than 35 mm, 80.5% were between 35-55 mm, and 16.7% were above 55 mm. Figure 8 shows the comparison between 2019, 2020 and 2021.

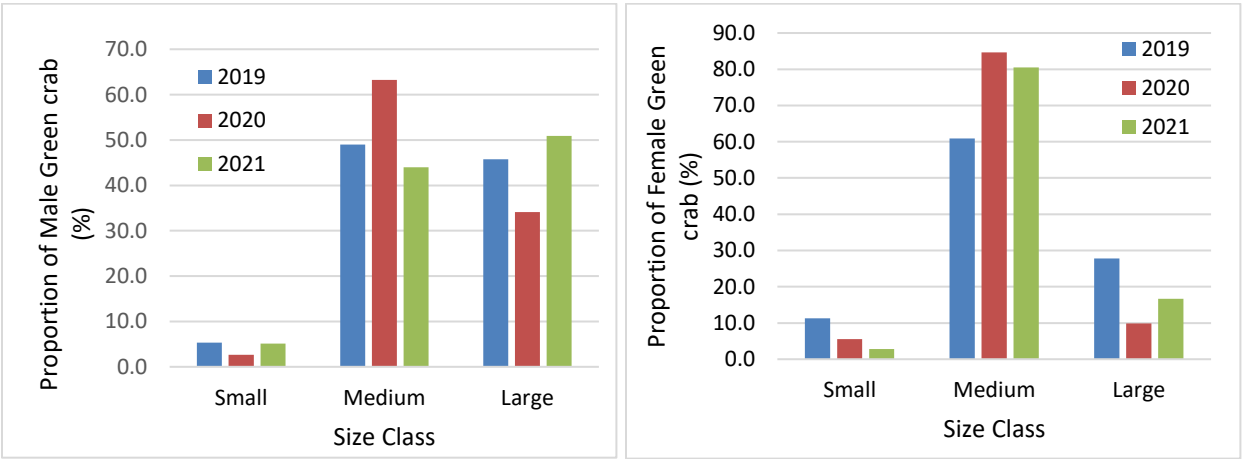

Figure 8: Proportion (%) of Green crab size for male (left) and female (right) in 2019, 2020 and 2021; Small: <35mm, Medium: 35-55mm, Large: >55mm.

- The average catch per unit effort (CPUE) for traps in the Main Basin was 58.91 green crabs per trap per day down from 77.68 in 2020. The average CPUE for traps in the Northeast Arm was 73.58 green crabs per trap per day, up from 34.09 in 2020. This increase was expected due to the overall increase in the number of Green crabs throughout the entire Northeast Arm and Main Basin and a mild winter. The decrease in the Main Basin may be explained by the crab migrating into the arm from the Main Basin, or the fact that there are not enough monitoring traps in the Main Basin to get a proper estimate of CPUE. The CPUE indicates that Basin Head is within the poor threshold target that was developed using the 2020 Green crab data, as shown in Table 3. The CPUE has remained in the "poor" range since 2020 when the permanent monitoring stations were implemented, and this threshold system established.

Table 3: Green crab trapping thresholds targets.

Thresholds (Crab/Trap/Day)			
	Poor	**Fair**	**Good**
Measure	<25% CPUE reduction from inferred reference	25-50% CPUE reduction from inferred reference	>50% reduction from inferred reference
Main Basin	>58	39-58	<39
Northeast Arm	>26	17-26	<17

Eelgrass

- Eelgrass has been present at Basin Head since pre-MPA designation and is noted to have historically co-existed in the marine ecosystem alongside the bivalves and Irish moss. Since 2018, when very little eelgrass could be found, eelgrass meadows within the MPA boundary have been increasing in area and density; researchers have utilized several monitoring techniques to survey its health and coverage over time. The current method is to trace the eelgrass meadows or patches with a GPS around the permanent monitoring swaths for Irish moss. This technique is limiting such that it doesn't comprehensively survey all eelgrass within the MPA; however, it does allow researchers to determine the health and coverage of eelgrass adjacent to the Irish moss beds, and if this relationship may be beneficial to either or both species. An area of 251.6 m^2 of eelgrass was traced within the three Irish moss beds in 2021 (Appendix 1).

- It is unknown what the impact of the eelgrass resurgence will have on the Irish moss, but historically, Irish moss and eelgrass have coexisted within the MPA and thrived. The literature supports that eelgrass and bivalves (such as mussels and oysters) are mutually beneficial when near one another, as the eelgrass helps solidify the seafloor with its roots so that the bivalves do not sink into the soft sediment (as was the case with our Oyster cross experimental site) while also sheltering the bivalves from the sun and high temperatures (which are known to cause stress and mortality). In turn, the bivalves support the eelgrass by filtering the water column, and thus reducing the epiphytic load on the eelgrass fronds, thus supporting their photosynthesis and overall health. A Contribution Agreement between DFO and UPEI will allow UPEI researchers to investigate the interactions between eelgrass and Irish moss clumps to see what the effect of a growing eelgrass population may have on the moss.

- Tracing the eelgrass around the Irish moss beds is being decided as to whether this survey technique will continue. In 2020, satellite imagery was purchased with the intent of analyzing these images to assess eelgrass cover throughout the MPA to allow for a greater

understanding of its health, coverage, locations, and trends. The results from satellite imagery analysis will be presented in the following fiscal year.

Other ecosystem components

- There has been continued growth in both the oyster and eelgrass cover throughout the Northeast Arm in 2021. Sedimentation continues to be a problem for the bivalves (smothering, fouling, or burying/sinking), but the increase in eelgrass cover may be helping to mitigate some of these negative effects by settling and securing the sediment with their fronds and roots, respectively.

- A survey was performed of the free-floating Knotted Wrack (*Ascophyllum nodosum var. mackaii),* a marine alga*,* and the warm temperate Ribbed Mussel (*Geukensia demissa)* populations on the southern marsh from Corduroy Road to Main Bed. This species of knotted wrack are good carbon sequestration plants, with Basin Head being at their most Northern point of their geographic range. Basin Head is also in the northern portion of Ribbed Mussel's geographic range, providing an opportunity to track the migration of these species into Basin Head as a possible climate change indicator (i.e., warming waters). Quarter meter quadrats were sampled at the edge of each plant found, the percent cover estimated, the plants removed, cleaned and then weighed. In total, 60 isolated plants and 9 patches were counted and measured, with the average fresh weight in 38 samples equaling 131 g. Only two *G. demissa* (42 and 55 mm long) were seen along the entire length of marsh inspected; both were in association with the *Ascophyllum.* The number of *Ascophyllum* plants and *G. demissa* mussels are consistent with what has been observed over the last couple of years, though the number of patches are slightly down.

NON-REGULATORY CO1: ENSURE THE PARTICIPATION OF INTERESTED AND AFFECTED STAKEHOLDERS.

- The Basin Head Marine Protected Area Advisory Committee (BHAC) met virtually in 2021 due to the pandemic. Conducted during the morning of December 1st, 2021, the BHAC members were updated on research and monitoring by DFO (MPC, Science, AIS) and SAB, and were briefed on the proposed contribution agreement activities by Dalhousie University and UPEI. A draft of the final layout of the Operational Management Plan was also presented to the committee.

- A new member from the PEI Department of Environment, Energy and Climate Action joined the Advisory Committee in October 2021; this new member is a surface water biologist. A request for membership was received from the Native Council of PEI (NCPEI) and discussions between DFO and NCPEI were conducted to begin the process of welcoming them to the committee.

NON-REGULATORY CO2: FOSTER PUBLIC STEWARDSHIP THROUGH EDUCATION AND AWARENESS.

- Brochures and display panels explaining the purpose of the MPA are available to the public at the nearby Basin Head Fisheries Museum. An interactive display kiosk was installed at the Basin Head Museum in 2014 using a computer monitor with touch-screen technology to give historical and biological information on Basin Head, as well as general information on the Canadian MPA program. This kiosk was still displayed in the Basin Head Museum in 2021, but unfortunately was not operational due to a broken hard drive. The hard drive was picked up, sent to be fixed, and was finished winter of 2022 for later installation in the spring of 2022.

- SAB hosted two school groups in Basin Head the fall of 2021: Transitions and Wild Outside. Transitions is a Holland College course that is hosted by Souris Regional School that offers high school students the chance to visit different occupations in a variety of fields. Over two events, 11 students experienced the MPA. The second, Wild Outside, is a conservation-based program for youth aged 15-18 funded by the Canadian Wildlife Federation (CWF) that had seven students participate. Both groups learned about the ongoing projects at Basin Head and helped to plant native trees and shrubs in the riparian zone.

- The Basin Head MPA was also in the media, with SAB talking with CBC about the drone work goals at Basin Head, and again with The Eastern Graphic about the winter ice monitoring conducted within the MPA.

- The graphics of a new interpretive panel for the Basin Head MPA Interpretive Park was developed. This panel displays a poem entitled "Queer Seaweed: Oeuvre on the desires and inclinations of Basin Head's Chondrus crispus" written by Alix Villanueva, an artist from Scotland, who wrote about the Basin Head Irish moss and its connection to its surrounding environment. This panel will be installed at the interpretive park in the fall 2022.

NON-REGULATORY CO3: PROMOTE SCIENTIFIC RESEARCH AND MONITORING.

- Two new Contribution Agreements were signed in 2021/2022, one each with Dalhousie University and the University of Prince Edward Island (UPEI).
    - Dalhousie University has been conducting research within the Basin Head MPA since 2019. The improved understanding of nitrogen and sediment loading in Basin Head achieved with this project will guide potential management measures for the MPA. The models resulting from this research will inform management decisions and contribute as required under the Basin Head MPA Operational Management Plan.
    - The ongoing research by UPEI builds on the previous Academic Research Contribution Program from 2014-2019. The improved understanding of the benthic biodiversity associated with the Irish moss clumps and their surrounding habitat will allow us to better understand the ecological importance of this structural habitat and better support its protection. Enhanced knowledge on the interactions of Irish moss and blue mussel clumps with other foundation species (i.e., eelgrass, oysters) in Basin Head will guide potential management measures for the MPA. Finally, an assessment of the short-term effectiveness of the green crab removal trapping program will allow us to improve this control program if needed and identify potential biotic resistance by native rock crab population.

NON-REGULATORY CO4: PROMOTE AND ENHANCE SOCIAL AND ENVIRONMENTAL CONDITIONS IN THE SURROUNDING WATERSHED.

- In 2021, SAB conducted approximately 400m of stream restoration work on Basin Head Creek, which drains into the MPA boundaries. Stream restoration consists of clearing down trees and other blockages to fish passage to allow free water movement.

- There were two beneficial management practices (BMPs) through the Living Lab Atlantic program by Agriculture and Agri-Foods Canada that were being conducted within the Basin Head watershed. The first was a slow-release nitrogen trial (BMP 7) and the second was an oat cover crop trial before potato rotation (BMP 2) (see Figure 9).

Figure 9: Location of the two fields with Beneficial Management Practices (BMPs) being trialed in 2021 within the Basin Head MPA watershed. Note: BMP 2 (blue) was the use of fall-seeded cover crop (oat) trial before potato rotation and BMP 7 (yellow) was the reduction of nitrogen losses using slow-release fertilizer products trial.

4.0 ENFORCEMENT AND COMPLIANCE

The Basin Head area is a frequent tourist destination and high traffic area for both visitors and locals, though activity was slightly reduced due to the pandemic. The local DFO Conservation and Protection (C&P) officers patrol the area regularly to ensure compliance under the Management of Contaminated Fishery Regulations (MCFR), the Basin Head Marine Protected Area Regulations (BHMPAR), The Atlantic Fishery Regulations (AFR's), The Fishery (General) Regulations (FGR's), The *Fisheries Act* as well as the Maritime Provinces Fishery Regulations (MPFR).

C&P conducts both land and sea-based patrols in all Zones within the MPA boundary throughout the year. Patrols are more frequent in the operational fishing season when commercial and recreational fisheries are more prevalent. Patrols of all areas were conducted by the Aerial Surveillance Program for C&P by means of both plane and helicopter. The harvesting of oysters under the Spring Relay Program (within Zone 2) and some rock crab and lobster fishing within

Zone 3, were the only commercial fisheries observed within the confines of the Basin Head MPA in the spring, summer and fall of 2021. There are between two and four fishers that harvest oysters within Zone 2 and those fishers usually notify the local C&P office to advise of their activity prior to entering the zone in the event any public complaints are received. Fishers are aware they are not to use their motors in Zone 2. Water-based patrols are also conducted to observe any activity within Zone 3. There are potentially only two rock crab fishers that will fish in Zone 3, but their activity is limited and only one fisher was active in 2021. Other activity in Zone 3 is noted as recreational watercraft activity and recreational fisheries such as striped bass and a small amount of bar clam. This activity occurs primarily in the months of July and August. C&P staff have witnessed very little activity of watercraft transiting from the boat launch within Zone 2 into Zone 3 as permitted by the BHMPAR. These vessels usually launch out of Souris or have a home base at the Souris Marina.

There have been no non-compliance issues identified that required an enforcement action regarding contraventions of the MCFR, BHMPAR or MPFs in the fiscal year 2021-2022. Also, those involved in Scientific Monitoring of the BHMPA were also observed in the area at various instances throughout the operational season carrying out their respective duties. The presence of Scientific Staff, we believe, is helpful as a deterrent to any potential non-compliance issues that could occur.

5.0 NEXT STEPS AND PRIORITIES

DFO will focus on several priorities related to the implementation of the management plan in the next fiscal year (April 2022 to March 2023). Many of these priorities are ongoing and multi-year projects, and not all will be finished within the fiscal year. All uncompleted priorities will carry forward into the next fiscal year until completed. Priorities include:

1. Continue to work with land use and weather data to strengthen understanding of nitrogen loading and how it interacts with *Ulva* blooms.
2. DFO Science to publish a report on the calculation method to determine nutrient load into Basin Head to further the changes in water sampling and stream flow updates in the methodology.
3. Analyze the Southern Gulf of St. Lawrence Coalition on Sustainability echosounder data collected in July 2020 to determine bathymetry for future hydrodynamic modeling.
4. Continue ecosystem restoration, with periodic monitoring to document the expected increases in species diversity and productivity associated with Irish moss beds, oyster reefs and eelgrass patches.
5. Explore the interactions between Irish Moss clumps and eelgrass patches to determine if eelgrass contributes to smaller Irish Moss frond size and clump survival.
6. Continue to develop drone-based aerial photography as a potential comprehensive survey method and provide proof of concept that the photomosaic accurately identifies clump location and Irish moss coverage.
7. Continue to monitor marsh edge erosion, development of eelgrass patches, and the biomass and spatial distribution of *Ascophyllum* and *Geukensia*.
8. Continue and improve the Green crab removal program.

9. Explore other ways of mitigating nutrient and sediment input in the system.
10. Enhance educational and outreach efforts and promote the MPA to various stakeholders.
11. Develop a photo and video bank of professional quality Basin Head images and videos.
12. Attend and present at the IMPAC5 conference in Vancouver to highlight the Basin Head MPA to an international audience.
13. Connect with the new UPEI Climate change research program situated in St. Peters, to ensure that Basin Head lagoon becomes a climate change research site.

6.0 REFERENCES

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7.0 APPENDIX 1: IRISH MOSS AND EELGRASS LOCATIONS

Figure 10: Location of Irish moss clumps through survey identification and through planting in Main Bed, 2021.

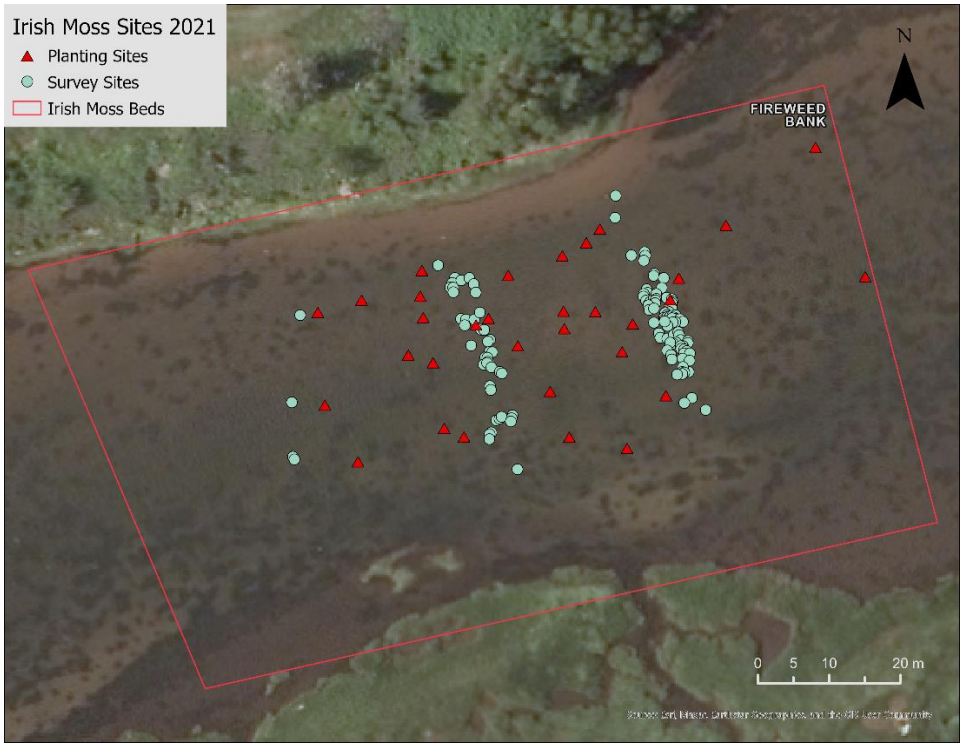

Figure 11: Location of Irish moss clumps through survey identification and through planting in Fireweed Bank, 2021.

Figure 12: Location of Irish moss clumps through survey identification and through planting in Corduroy Road, 2021.

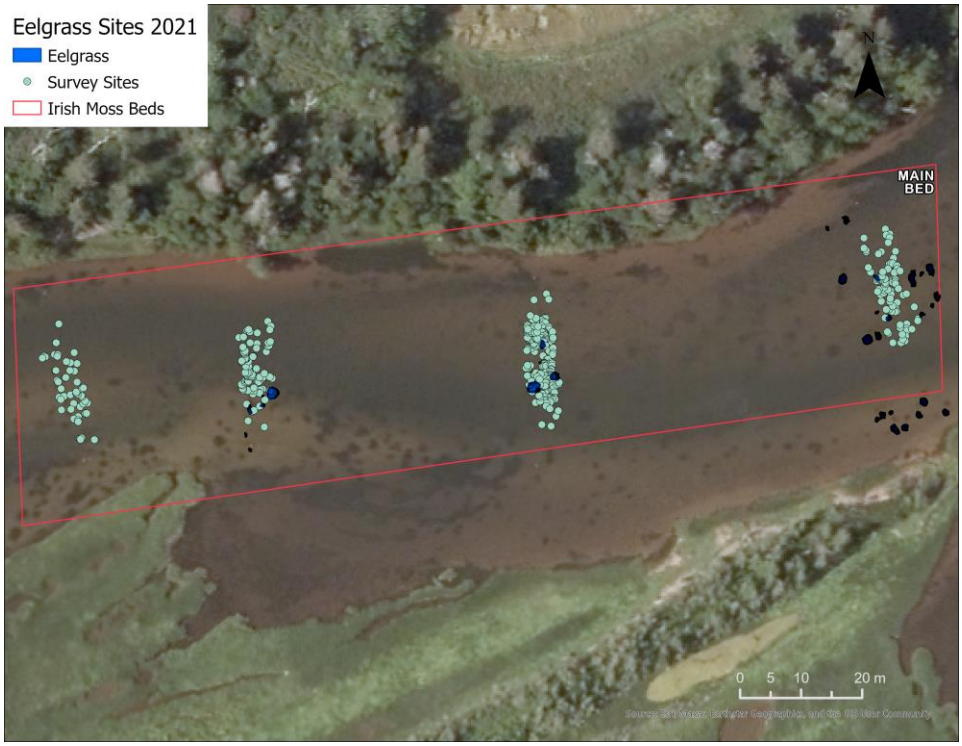

Figure 13: Location of eelgrass tracings in relation to the Irish moss survey sites in Main Bed, 2021.

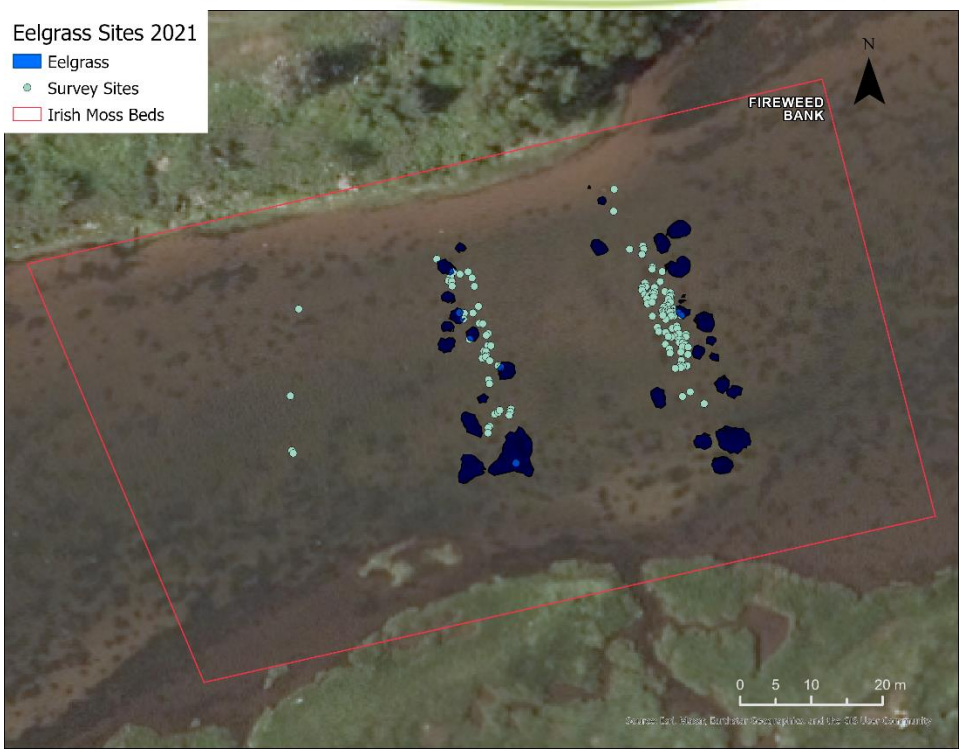

Figure 14: Location of eelgrass tracings in relation to the Irish moss survey sites in Fireweed Bank, 2021

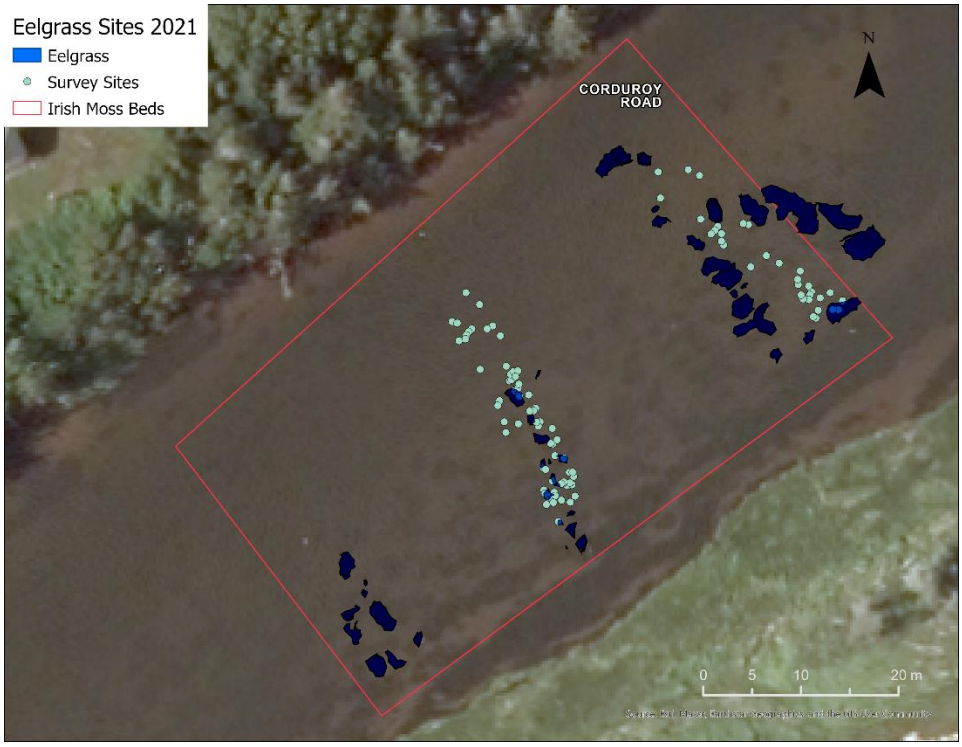

Figure 15: Location of eelgrass tracings in relation to the Irish moss survey sites in Corduroy Road, 2021

8.0 APPENDIX 2: ACTIVITY PERMIT APPLICATIONS

MPA regulations recognize that certain activities within an MPA may be consistent with conservation objectives. For some of these activities, Basin Head MPA regulations require the submission of an activity plan and specify approval conditions. Ministerial approval of activity plans is one of the primary means of governing the activities proponents undertake in MPAs.

Proposed activity plans are reviewed to assess environmental impacts of the individual activity along with the cumulative effect of all activities in the MPA, and to ensure that the activity is for the purpose of the conservation and/or management of the MPA, or for allowable scientific or educational purposes. Thus, the requirement of the submission of an activity plan for certain activities is an important regulatory mechanism used to limit human impacts in MPAs before they occur.

Table 4: Activity Approvals in Basin Head MPA during 2021-22.
*Note that some activity plans were submitted by the proponents but were not approved since it was decided that the activity would not take place in summer 2021 due to the pandemic.

	Study Name	Researcher	Affiliation	Purpose	Date Approved
1	Thermal and Nutrient Regime Monitoring	Dr. Barret Kurylyk	Dalhousie University	Studying the dynamics of the hydraulic thermal and nitrogen concentration regimes in Basin Head.	March 25, 2021
2	Water quality monitoring using continuous probes	Andre Nadeau	DFO - Science	Annual water quality monitoring (temperature, dissolved oxygen and hydrographic parameters) (July – November 2021).	March 25, 2021
3	Nutrient and Ulva Monitoring	Keila Miller	Souris and Area Branch of the PEI Wildlife Federation	Water sampling and stream flow monitoring at 3 estuarine and 6 freshwater sites (April – November 2021) and panoramic photos for Ulva monitoring	March 25, 2021
4	Green crab removal	Keila Miller	Souris and Area Branch of the PEI Wildlife Federation	To reduce and control the population of the invasive European Green crab, which are predating on Blue mussels in the Basin Head MPA.	April 29, 2021
5	Giant Irish moss and mussel bed monitoring and	Keila Miller and Irene Novaczek	Souris and Area Branch of the PEI Wildlife	Enhancing the Irish moss biomass by cultivation of giant Irish moss, engineering of mussel-	April 29, 2021

	recovery in the Basin Head MPA		Federation	moss clumps, and planting of clumps (April – November 2021)	
6	Marsh edge erosion and Influence of ice	Keila Miller and Irene Novaczek	Souris and Area Branch of the PEI Wildlife Federation	Document the influence of ice within and below the main Irish moss bed and the marsh erosion (May – November 2021).	April 29, 2021
7	Aquatic invasive species (AIS) biofouling monitoring program	Chantal Coomber	DFO - Gulf	Deploy 6 biofouling collector lines for early detection of aquatic invasive species (AIS biofouling monitoring program).	April 29, 2021
8	Community Aquatic Monitoring Program	Keila Miller	Souris and Area Branch of the PEI Wildlife Federation	Monitor the diversity of fauna and flora captured in the Basin Head lagoon (June to August 2021)	June 22, 2021
9	Ecotours (“Beyond the Beach”)	Keila Miller	Souris and Area Branch of the PEI Wildlife Federation	Provide “hands-on” educational experience to explore the marine life in Basin Head. (Twice a week, July – August 2021 and no more than 6 additional times in June and September for schools)	Plan withdrawn and not submitted for approval