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Basin Head Marine Protected Area: 2019-2020 Operational Management Plan Implementation Progress Report

Fisheries and Oceans Canada, Gulf Region
343 Université Avenue, P.O. Box 5030
Moncton, NB, E1C 9B6

2021

Gulf Region Basin Head Management Series 2021/02

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 consist of monitoring progress reports, operational management plans, 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 entreprises dans la zone de protection marine de Basin Head. Cette série se compose principalement de rapports d'étape sur la surveillance effectuée à Basin Head, de plans 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 de la région du Golfe du ministère des Pêches et des Océans ou furent préparés sous la direction de celui-ci. Le contenu de cette série se veut une source d'information pour une diffusion publique et interne.

Gulf Region Basin Head Management Series

2021

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LIST OF ACCRONYMS

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
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 2019-2020 fiscal year (April 2019 to March 2020). This report also highlights the different management actions taken in 2019-2020 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 associée aux quatre objectifs de conservation qui ont eu lieu au cours de l'année financière 2019-2020 (avril 2019 à mars 2020). Ce rapport met également en lumière les différentes mesures de gestion prises en 2019-2020 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 http://laws.justice.gc.ca/eng/regulations/SOR-2005-293/). The MPA was designated under the *Oceans Act* Section 35, paragraph (1) c (conservation and protection of unique habitats), as well as paragraph (1) e (to fulfil the mandate of the Minister).

The MPA encompasses Basin Head Lagoon 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 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). What is especially interesting and requiring management and protection is the giant Irish moss dependence on mussels for attachment.

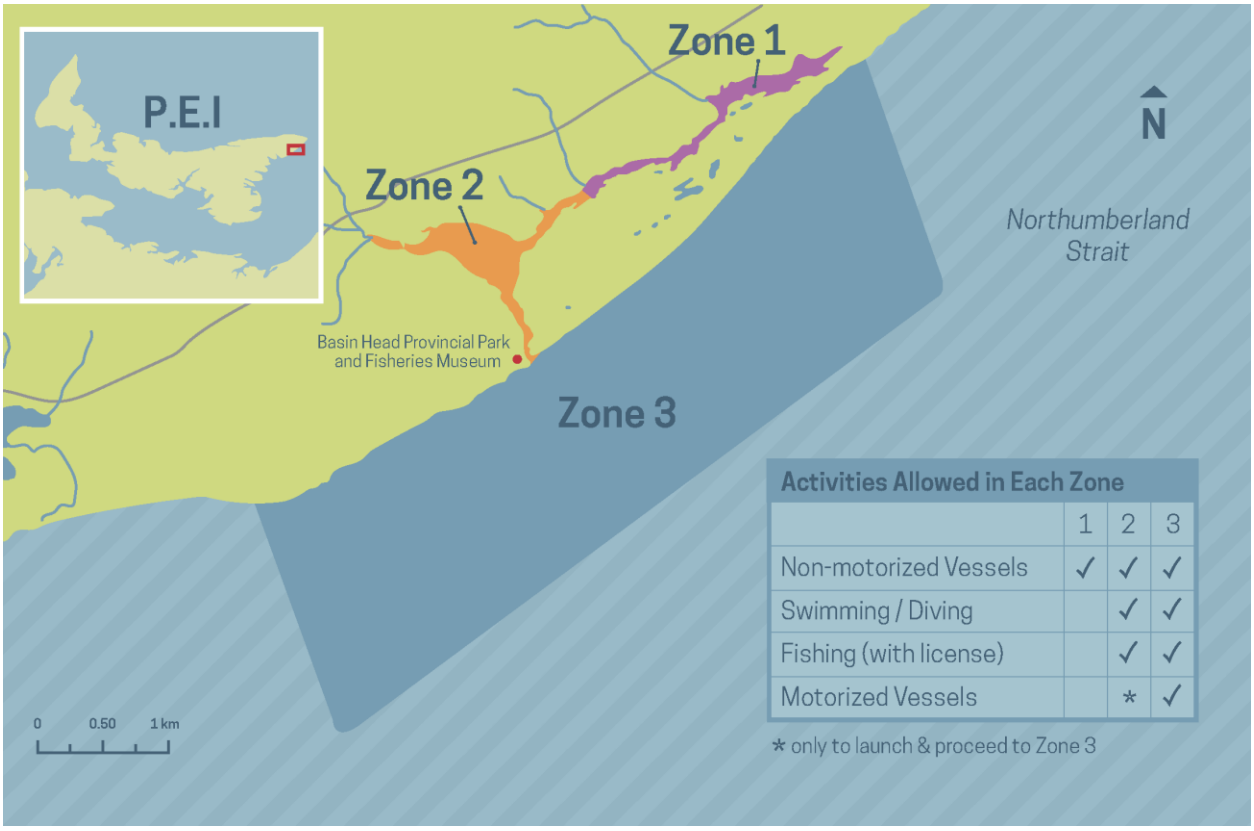

Figure 1: Basin Head Marine Protected Area and its three management zones.

Zone 1: Northeast Arm
Basin Head's Northeast Arm extends from the main basin to the east for approximately three kilometres. 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-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 Basin Head MPA Operational Management Plan (OMP) was last updated in 2014. 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. 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. The OMP is scheduled to be reviewed every five years and is now under review. 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 OMP is planned for review in 2020.

The purpose of this yearly Progress Report is to report on activities and achievements in the Basin Head MPA during the 2019-2020 fiscal year (April 2019 to March 2020) that contribute to the implementation of the management plan. This report and past reports will serve as guides for the Operational Management Plan review.

Personnel from Marine Planning and Conservation Program (formerly known as Oceans Management 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 MANAGEMENT HIGHLIGHTS FOR 2019-20

(refer to the map of Basin Head MPA Fig. 2 for locations of the areas named below)

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

Irish moss monitoring and restoration

- Sock cultivation of Irish moss in the western portion of Northeast Arm resumed in 2019 using Basin Head Irish moss supplied from on-land tank cultivation at the National Research Council (NRC) marine station at Sandy Cove, Nova Scotia. The aim was to develop biomass both for field experiments and for rehabilitating portions of the Northeast Arm where the Irish moss-mussel ecosystem had been drastically declining.
- Starting in 2015, cultivated Blue mussels from the Confederation Cove Mussel Co. Ltd were brought into Basin Head to stabilize the remnant Irish moss population and to provide anchorage for giant Irish moss that was propagated in suspended cultivation. Natural clumps of Irish moss and mussels attached by byssal threads were generated by putting them together in cultivation bags for a minimum of 48h. 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. In 2019, mussels were also acquired from a second supplier: Prince Edward Aqua Farms. These conservation and restoration activities continued in 2019 resulting in a year-to-year increase in Irish moss biomass in Northeast Arm.

- In 2019, as in 2018, subsampling along 2-m wide swaths beside permanent transects (survey swaths) instead of the full comprehensive wading survey of the past was conducted. To reduce the margins of error in estimates of % loss of Irish moss cover over winter, the number of swaths surveyed was increased to 20 (i.e. 10 pairs of 2-m swaths running along each side of the permanent transect lines established in 2018). These additional swaths at Fireweed and Main will be resurveyed in 2020 and subsequent years to improve future estimates.
- In 2019, 2964 clumps were planted in Main Bed, Corduroy Road and Fireweed Bank for a total of 12,668 clumps planted during the five-year span (2015-2019) bringing the estimated area covered by Irish moss at the end of 2019 up to 169 m^2 compared to 91 m^2 at the end of the 2018 season (see Figure 3).
- The estimated number of Irish moss plants was reduced over the winter along the outer edges of Fireweed Bank but increased in the central Fireweed swaths because planting focused on this area of good habitat. All Main and Corduroy Road swaths registered a small decline in numbers of clumps but Irish moss cover was maintained because average frond size increased in every bed, especially at Fireweed Bank where average diameter went from 9.98 cm in 2018 to 17.1 cm in 2019. Although many Irish moss plants disappeared over winter, mussel clumps were more numerous than in 2018. This was likely due to the fragmentation of large clumps into several smaller ones, as single mussels (not counted) and clumps of fewer than 10 mussels were commonly observed.
- Monitoring of a test plantation at Oyster Cross (immediately west of Main Bed) continued in 2019. The estimated total cover of Irish Moss on the plantation was 0.72 m^2 in 2019, which is less than an estimated 0.87 m^2 in 2018. There has been an overall reduction in Irish Moss cover on the Oyster Cross since it was planted in 2015 which appear to be due to smothering by mobile sediments and Ulva during spring through autumn.
- During the winter of 2019-20, half hourly photographs taken by a field camera at Main Bed in Northeast Arm were catalogued to allow for comparative evaluation of ice conditions year to year in relation to clump retention over winter. In August 2019, a second field camera was installed at Elliot's Marsh, the furthest eastern tip of the Northeast Arm, in order to further document ice conditions as well as Ulva blooms.
- In August 2019, DFO conducted an in-house drone survey and collected images in the 3 Irish moss beds which will be used to test whether Irish moss coverage can be calculated using drone imagery.

Water quality monitoring and hydrodynamic model

- In 2019, DFO deployed continuous temperature, dissolved oxygen, light flux density and tidal flux loggers in the Basin Head MPA. After retrieving the light flux logger in the fall we noticed it was damaged and no light flux data were recorded in 2019. Monthly water samples were also taken at four stations from June to September for pH analysis.
- Recommendations from the Canadian Science Advisory Secretariat (CSAS) meeting that took place in June 2019 indicated that nutrient loading instead of nutrient concentration needed to be collected. In place of extensive estuarine point sampling, it was recommended to quantify nitrogen loading (product of base flow and average nitrate concentration) at freshwater inputs. Stream flow monitoring, in combination with water sampling for nutrients including monitoring at two outlet control points (at Northeast Arm into Main Basin, from Main Basin to the Gulf) is recommended to calculate loading of nutrients to Basin Head. Taking these recommendations into account, water quality monitoring sites in 2019 were reduced from 11 to 9 and measured monthly instead of weekly. From these 9 sites, 6 were in streams above head of tide, flowing into the MPA, and 3 sites where located within the MPA.

- In 2017, seven water pressure loggers to measure tidal flux and two Acoustic Doppler Current Profilers (ADCPs) to measure current strength were deployed in Basin Head to test the pre-existing hydrodynamic model developed in 2011 for Basin Head. Information on abiotic conditions such as current flow, sediment thickness and bathymetry were gathered to identify areas that favour giant Irish moss and mussel growth to be mapped. The updated hydrodynamic model was also used to predict the location of habitat most suitable for Irish moss, based on average current speed (i.e.,10-15 cm/s) and bottom type; this has proven to be useful for guiding restoration activities.
- Water renewal time was estimated using the updated hydrodynamic model. A typical distribution for coastal lagoon is observed in Basin Head with renewal times shorter close to the opening to the ocean and increasing in areas further away, up to more than 3 days at the head of the Northeast Arm. Compared to other coastal systems in the region, Basin Head waters are renewed fairly quickly which is due in part to the overall small volume of water to be exchanged (see Figure 4).

Marsh edge erosion

- Monitoring of rebar posts along the edge of the salt marsh near the Main Bed continued in 2019. At some points along the bank, the marsh had eroded to the point where the posts had fallen out of the marsh. In these cases they were removed, and placed 30cm back from the edge of the marsh to allow for continued monitoring. The rate of erosion from January 2017 – June 2019 was 0.14 cm/week.
- Over the winter, freeze-thaw cycles resulted in extensive marsh edge erosion that was especially evident along the south side of Corduroy Road where no such cracking had been seen since surveys of the area began in 2014. During swath surveys in the Irish moss beds, eroded sods were sometimes found on top of Irish moss clumps. In Main Bed, where sods were most noticable, there were 11 sods in the East survey swath and 3 in the Center swath.

Green Crab trapping

- In 2019, invasive European Green crabs (*Carcinus maenas*) were trapped over 49 days between May and November. Fishing was conducted each month from July to November. The number of fishing days per month was based on the Department of Fisheries and Oceans contract service with Souris and Area Branch of the PEI Wildlife Federation (SAB). As per the CA, eight consecutive days of fishing was conducted in July, 12 consecutive days in September, 22 days in October and 2 days in November (November days were to make up for missed days due to inclement weather). Only 7 days (non-consecutive) were completed in August due to adverse weather conditions
- During the 2019 trapping season, 15,415 Green crabs were removed from Basin Head. A 33% sub-sample was measured and sexed. From this, 49.8% were males, with a proportion of 45.7% measuring over 55 mm, 49.0% measuring between 35-55 mm, and 5.7% measuring below 35 mm. From that same sub-sample, 50.2% were females with a proportion of 27.8% measuring over 55 mm, 60.9% measuring between 35-55 mm, and 11.3% measuring below 35 mm. The average catch per unit effort (CPUE) for traps in the Main Basin was 36.70 green crabs per trap per day, and the average CPUE for traps in the Northeast Arm was 4.30 green crabs per trap per day.

Thermal regime: influence of seeps and springs

- Starting in summer of 2019, a master student from Dalhousie Univeristy started his project in Basin Head to characterize the volumetric discharge, temperature and nitrogen concentration of the different water inputs in the Basin Head estuary and assess how the different water input control the overall temperature and nutrient regime.

- Preliminary drone thermal surveys were conducted to identify near-shore springs and thermal refugia within Basin Head Harbour. Multiple springs were identified and photographed throughout the Main Basin and the Northeast Arm of Basin Head Harbour and will be the subject of future study. One near-shore spring was instrumented with a temperature sensor to monitor the thermal patterns of groundwater discharge.
- Three streams were instrumented with Dalhousie stilling wells. Stream gauging was conducted on the four primary tributaries in the watershed throughout the Summer and Fall. These four streams were instrumented with temperature sensors and the largest stream (Ching's Main) also had a conductivity sensor installed near its outlet to the harbour. Additional temperature and conductivity sampling were conducted within the harbour itself.
- A remote climate station, air pressure transducer, and groundwater well were installed near the aluminum staircase at Robertson's field to monitor climatological and subsurface properties at the site. The groundwater well was subject to a slug test (i.e., aquifer test where water is quickly added or removed from groundwater well), yielding a lower bound estimate of the hydraulic conductivity of the overlying till in the watershed.

Basin Head MPA Science Advice Meeting

- The Marine Planning and Conservation Program in the DFO Gulf sector requested a CSAS meeting to review and assess the monitoring activities undertaken in Basin Head over the last decade to determine their effectiveness in providing the information needed to evaluate whether the conservation objectives are being met. As a result, many DFO scientists and researchers, provincial, academia and SAB representatives attended the regional science peer review in Charlottetown PEI from June 11-12, 2019.
- A Science Advisory Report was published where adequacies, deficiencies and modification to the monitoring regime were proposed for each of the conservation objective. This report is publicly available online (https://waves-vagues.dfo-mpo.gc.ca/Library/40875714.pdf).
- A research document providing additional details on the different monitoring protocols and results for each of the conservation objectives and for the restoration work has also been finalized and will be published shortly.
- Several current monitoring activities were considered adequate for the purpose of assessing the attainment of conservation objectives. Modifications to some monitoring activities and several new monitoring initiatives were proposed. Below are some recommendation examples.
- Continue, and enhance where required, the monitoring of temperature, dissolved oxygen, and salinity using continuous probes to gather temporal data series. Discontinue the chlorophyll *a* sampling. Nutrient loading is to be determined from this point forward, instead of nutrient concentration.
- Eelgrass, oysters and sediment loading are to be monitored more closely. Basin Head's bathymetry profile is also to be investigated further.
- A drone survey at Basin Head is to be undertaken a minimum of once every 5 years, or more often if possible, to monitor Irish moss coverage. Meanwhile, analysis of completed drone surveys, as a potential means to assess Irish Moss coverage, is to continue. Monitoring of survey swaths is to continue, with monitoring of nearby eelgrass and Ulva included.
- Surface sampling and sediment core sampling every five years is an option that will be explored, in order to monitor biodiversity in Basin Head. Additionally, in terms of biodiversity, presence and relative abundance of shellfish on intertidal flats could be evaluated during wading surveys along transects. eDNA analyses, which were experimented with in 2019, to determine Irish Moss location presence at Basin Head, could be used to measure abundance of other species in the estuary.

Overall ecosystem health in Basin Head

- As of 2015 we have seen an improvement in the overall ecosystem health where natural recruitment of oysters has improved bottom conditions by filtering and trapping otherwise mobile sediments. A resurgence of eelgrass was noted in 2018, and in 2019, there was a large increase in visible eelgrass throughout the Northeast Arm. There is still seasonally heavy coverage of large areas of the bottom by fast-growing macroalgae (*Ulva lactuca* and associated algae).

Highlights – Various

- In November 2018, a major storm surge hit Basin Head, which damaged the dunes, and inundated the run and entrance to the lagoon with sand. In spring 2019, the Province of PEI conducted an inspection of the run and discovered that the water depth was less than 1 m at low tide and no more than 2.4m at high tide, only half of the normal depth. A decision was taken to dredge the area for safety reasons, prior to the start of tourist season. The dredging project was led by the Department of Transportation and Infrastructure with the support of the Department of Tourism, and the approval of DFO. On July 2nd and July 3rd, the run at Basin Head was dredged using a long reach excavator from the wharf, removing sand, and restoring the water depth in that area to generally what it had been in the recent past. Structural repairs to the wharf were also done at the same time.
- The Interdepartmental Letter of Agreement (ILA) between DFO Gulf Region and the NRC, for the maintenance of 10 kg of Basin Head *Chondrus* at the NRC's Sandy Cove facility, was renewed for 2019. Biomass from the holding stock at NRC was reintroduced to Basin Head and placed into cultivation on site to provide plants for restoration work.
- In May 2019, water samples from Basin Head were taken and analyzed for presence of Giant Irish Moss using e-DNA technology. DFO was able to detect Irish Moss in these samples, but not able to distinguish between Giant Irish Moss unique to Basin Head and regular coastal Irish Moss. In addition, relative density of Irish Moss could not be determined.
- The Basin Head Marine Protected Area Advisory Board met on November 26, 2019. The members were updated on monitoring and research and a focused discussion took place to review different sections of the management plan that is due for update in 2020.
- Eelgrass restoration in the Northeast Arm was tested in 2017 and 2018. At the beginning of 2019, there were three 10 m^2 test plots of planted eelgrass, which were monitored. Nine quadrats withing each plot were photographed in June and September in order to determine % coverage. Overall, eelgrass plots were successful except for one located in the Northeast Arm which was covered by sediments and Ulva. The 2019 monitoring revealed an increase from last year and naturally occurring eelgrass shoots were also observed.
- In 2019, SAB conducted approximately 3 km of stream restoration work on Basin Head Creek, which drains into the MPA boundaries.
- The coastal fish community has been monitored since 2003 in Basin Head at six stations in the main basin using the Community Aquatic Monitoring Program protocol. The regular sampling continued once per month in 2019 from June to August.
- On June 4 2019, a survey was performed of the free-floating *Ascophyllum nodosum forma mackii,* an marine algea*,* and the warm temperate ribbed mussel *Geukensia demissa* populations on the southern marsh at Main Bed. Quarter meter quadrats were sampled at 5m intervals, for a total of a 75m stretch of marsh. There was very little of both species found. More work was determined to be needed to develop a clear picture of the status of these organisms.

- In 2019, two 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. In 2019, a small amount of star tunicate and violet tunicate were detected.

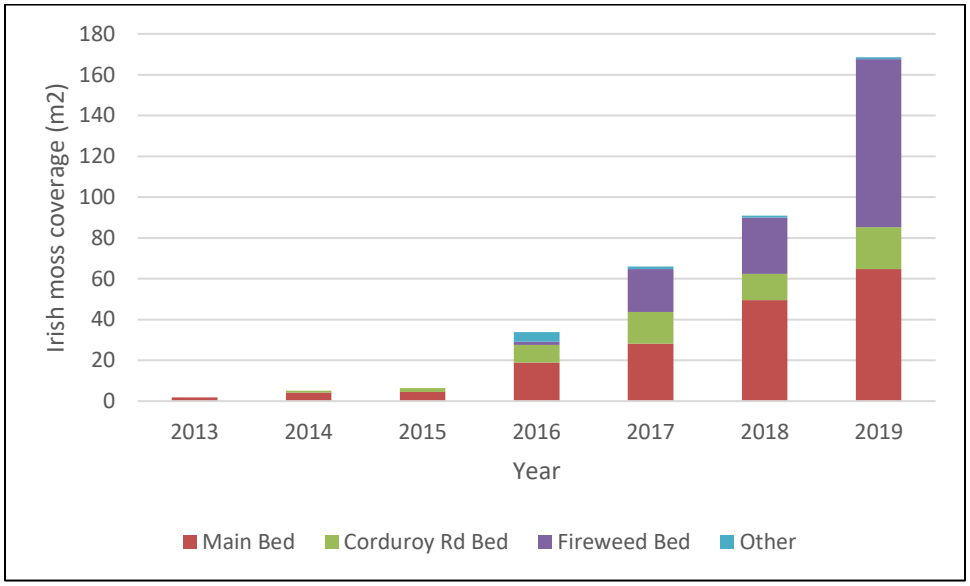

Figure 3: Chondrus cover (m^2) in Northeast Arm from 2013-2017 (determined by comprehensive surveys) and in 2018-2019 (estimated from surveys of 2-m wide permanent transect swaths and tallies of planted clumps).

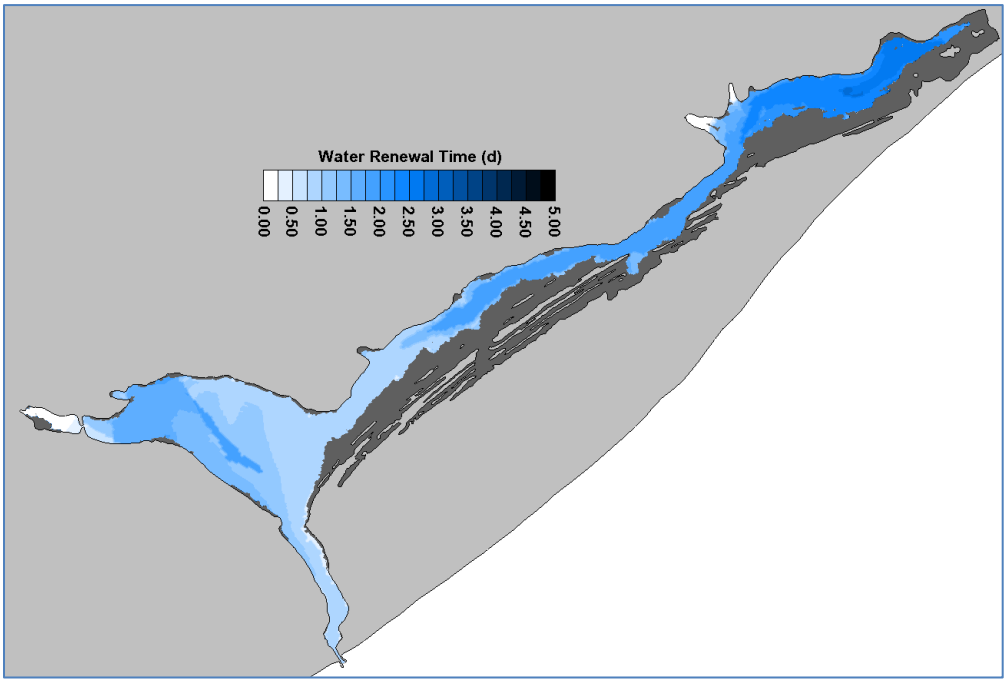

Figure 4. Estimated water renewal time in days in the Basin Head MPA.

3.0 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 *Chondrus crispus.*

Conservation objective 2: Maintain the physical structures of the ecosystem supporting the *Chondrus crispus*.

Conservation objective 3: Maintain the health (biomass and coverage) of the Basin Head *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 2019-20 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.

	Management Goals	**Action Taken in 2019-2020**
Regulatory Conservation Objective: Maintain the quality of the marine environment supporting the Basin Head *Chondrus crispus*	**Short Term Goals (3 years):** To maintain twice monthly water quality monitoring (May through October) at 11 water stations within the MPA. Information will be collected on nitrate, nitrites, phosphates, chlorophyll, turbidity, temperature, dissolved oxygen and salinity.	Water quality for nutrient loading at 6 freshwater sites and three estuarine sites were sampled near high tide monthly from May to November instead of nutrient concentration at 11 estuarine sites as recommended by the CSAS. Dissolved oxygen continuous loggers were deployed at three locations in the Northeast Arm in 2019. Monthly water sampling for pH analysis also occurred at four stations from June – September in 2019.

	Management Goals	Action Taken in 2019-2020
	To monitor continuous water temperature in the Inner Channel station and the main basin.	Only one of the three temperature loggers at permanent locations were retrieved, downloaded, and re-deployed to provide year-round monitoring. Temperature was recorded every 60 minutes. The other two temperature loggers could not be found and were left in the water to continue recording.
	Long Term Goals (10 years): By using the data collected, determine if there is a significant decline in the quality of the marine environment supporting the Basin Head Irish moss.	DFO researchers have analyzed the 2001-2019 water chemistry data and preliminary results suggests there are no signs of consistent improvement or decline in water quality over this time period.
Regulatory Conservation Objective: Maintain the physical structures of the ecosystem supporting the *Chondrus crispus*	**Long Term Goals (10 years):** Monitor the land use activities and erosion of the watershed area.	Continued measuring marsh edge erosion relative to rebar posts inserted into the southern bank at Main Bed's western end. Analysis of the 2017 land use survey data continued into 2019. Soil erosion into the lagoon was documented photographically. Provincial government assessed entrance channel, detected sand buildup and obtained a permit to dredge 1 m of sand from between the wharves
	Develop a water circulation model to evaluate water circulation changes.	In 2019, tide flux (water level) loggers were re-deployed at Robertson's, Main Bed and Corduroy Rd. One new site was added this year outside of the estuary, in the Northumberland Strait to document the water coming into the lagoon.
Regulatory Conservation Objective: Maintain the health (biomass and coverage) of Basin Head *Chondrus crispus*	**Short Term Goals (3 years):** Establish monitoring transects within the *Chondrus crispus* bed to evaluate biomass and coverage. Due to drastic decline in *Chondrus*, aerial photography and glass bottom boat deemed no longer useful and Irish moss survey is now done by walking/swimming along transects spaced 4 m apart until biomass increases.	Sampling for clump retention along permanent selected 2 m wide swaths in each Irish moss bed was repeated in 2019. Clump retention on Oyster Cross was documented. Drone-based photography from 2017 was further examined in 2019 to determine whether georeferenced and processed photomosaics are useful for surveying Irish moss.

	Management Goals	Action Taken in 2019-2020
	Continue weekly photo mosaic at three locations (i.e. eastern end of the arm, vicinity of the *Chondrus* bed and Ching's Bridge) to quantify the green algae (*Ulva lactuca*) coverage.	Photographs were taken at Ching's Bridge, and Elliot's Look out from July to October 2019, to establish a record of green algal (Ulva) bloom development and decline. Photography at Foul Point was discontinued. Camera surveillance of Main Bed provided additional information on near-shore development of Ulva mats in central Northeast Arm. A second camera was set up to monitor Ulva at Elliot's marsh.
	Long Term Goals (10 years): Maintain the biomass and coverage of the Basin Head *Chondrus crispus* at healthy and sustainable levels.	Sock cultivation of Irish moss in western Northeast Arm (below Robertson's field) continued through 2019 using cultivated stock from the NRC marine station at Sandy Cove. The ILA with NRC was renewed for the maintenance of Basin Head *Chondrus crispus* (minimum 10 kg) at the NRC research facility in Sandy Cove, NS. In 2019, for a fifth season, artificially constructed mussel clumps with Irish moss 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.
Regulatory Conservation Objective: Maintain the overall ecological integrity of the Basin Head lagoon and inner channel.	**Short Term Goals (3 years):** To continue the Community Aquatic Monitoring Program (CAMP) to monitor trends in community abundance and diversity of fish and benthic invertebrates within the Basin Head lagoon.	The CAMP Program was conducted in 2019 from June to August in Basin Head.
	To create detailed maps of percent cover by major aquatic plant species.	A drone was used to collect images for mapping and monitoring of Irish moss in the Basin Head MPA. The survey was focused on three identified Irish moss beds: Fireweed, Main, and Corduroy. Collection occurred between July 30th and August 2nd, during some of the

	Management Goals	Action Taken in 2019-2020
		lowest annual tides of the summer, as *Ulva* presence is in decline, thus reducing risk of obscuring Irish moss clumps on the seabed. Some additional images of Basin Head were captured.
	Long Term Goals (10 years): Maintain the diversity of indigenous flora and fauna within the Basin Head MPA by evaluating the effectiveness of the monitoring plans, indicators and triggers up to date.	Conditions revealed by systematic sampling since 2014 were dramatically different from the baseline data on *Zostera*, *Ulva* and *Chondrus* that were collected prior to 2007. *Zostera* was almost completely absent from Northeast Arm in 2014 and the Irish moss had been reduced by 99.9%. Ongoing research has flagged Green crab and eutrophication as the primary threats to the giant Irish moss population that remains. Rising summer seawater temperatures may also pose a threat in the future. Planting of clumps made from commercial mussels and cultivated giant Irish moss between 2015-2019 has stabilized and augmented the Irish moss population and increased biodiversity on the bottom. Oysters and eelgrass have both increased naturally over the same period.

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

	Management Goal	Action Taken in 2019-2020
Non-Regulatory Objective: To ensure the participation of interested and affected stakeholders in the operation of the MPA.	**Short Term:** Continuation of annual Advisory Board meetings to ensure stakeholder support and involvement.	An Advisory Board meeting was held in Souris on November 26, 2019.
Non-Regulatory Objective: To increase the public awareness of the Basin	**Short Term:** To develop a Basin Head MPA website	There is an existing link to Basin Head MPA information on the DFO website. No update to the website was done in 2019.

	Management Goal	Action Taken in 2019-2020
Head *Chondrus crispus,* the ecosystem of the Basin Head MPA and its conservation measures.	To enhance the existing on-site laboratory to maximize education potential.	The on-site wet lab at the cannery wharf was not used in 2019 since no laboratory work was done. A new shed at Robertson's field was installed to store field equipment and a new interpretative day park with a building facility was completed in 2019 and will be used going forward instead of the cannery. There is an interactive computer kiosk and brochures about the MPA in the Basin Head Fisheries Museum
	Long Term: To increase public awareness through publication of brochures, interpretive touchscreen kiosk, and involvement in community events.	Eco tours in the main basin were conducted by SAB in 2019. SAB communicates regularly with local stakeholders through the "Souris and Area Watershed News" on activities that involve Basin Head. In 2019, an interpretive day park opened on the shore of Basin Head lagoon. The park contained several information panels that explain the significance of Basin Head MPA. A presentation on Basin Head was made to the Gulf of St Lawrence Symposium in Charlottetown PEI in June. A field site tour for Holland College students was conducted in September 2019.
Non-Regulatory Objective: To promote scientific research to increase the level of understanding of the Basin Head MPA.	**Short Term (3 years):** To continue to collaborate with Island Nature Trust, SAB and UPEI to meet the monitoring requirements identified in the Operational Management Plan.	A contribution agreement with SAB was in place for the summer and fall water monitoring program. In 2019, SAB also conducted a Green crab removal contract. UPEI faculty and students performed research on barnacles and mussels in 2019-2020 to measure the barnacle settlement rates in the Basin Head Lagoon.

	Management Goal	Action Taken in 2019-2020
	Development of Activity Plans and Approvals as outlined in Section 5.0 of the Basin Head MPA Regulations.	Approval Process in Place; 14 activity plans for 2019 season were submitted and approved.
	Long Term (10 years): To continue to identify potential partners for collaborative research projects.	Doctoral student from UPEI continued to develop publications to report on research in Basin Head MPA. Dalhousie University, a new academic partner, started a research in 2019 looking at the dynamics of hydraulic thermal and nitrogen concentrations regimes in the Basin Head MPA, both possibly influencing the regrowth of *Chondrus crispus* and of *Mytilus edulis*.
Non-Regulatory Objective: To maintain and enhance the quality of the Basin Head ecosystem.	**Long Term (10 years):** To implement best management practices to reduce the impacts of nutrient enrichment on marine environmental quality within the Basin Head ecosystem.	Through the land use survey it was reported that farmers are more diligent in the use of fertilizer, partly because of the cost; also new farm practices are being examined or considered for soil conservation.
	To reduce the spread of aquatic invasive species in the Basin Head ecosystem by public awareness or stewardship initiatives.	Efforts are on-going through the monitoring and education being done by the Aquatic Invasive Species (AIS) program at DFO and the Community Aquatic Monitoring Program (CAMP) as well as the Eco-Tours

4.0 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 3. Activity Approvals in Basin Head MPA during 2019-20.

	Study Name	Researcher	Affiliation	Purpose	Date Approved
1	Water quality and nutrient loading monitoring.	Keila Miller	Souris Area Branch Wildlife Federation of PEI	Monitor long-term changes in Basin Head water and inflowing water.	April 24, 2019
2	Water quality monitoring using continuous probes	André Nadeau	DFO - Gulf	Annual water quality monitoring (temperature, dissolved oxygen and hydrographic parameters) (May – November 2019).	April 24, 2019
3	Ecotours (“Beyond the Beach”)	Keila Miller	Souris Area Branch Wildlife Federation of PEI	Provide “hands-on” educational experience to explore the marine life in Basin Head. (Twice a week, July – August 2019 and no more than 6 additional times in June and September for schools)	April 24, 2019
4	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 24, 2019
5	Giant Irish moss and mussel bed monitoring and recovery in the Basin Head MPA	Dr. Irene Novaczek	Souris Area Branch Wildlife Federation of PEI	Enhancing the Irish moss biomass by cultivation of giant Irish moss, engineering of mussel-moss clumps, and planting of clumps (April – November 2019)	April 24, 2019
6	Green crab removal	Keila Miller	Souris Area Branch Wildlife Federation of	To reduce and control the population of the invasive European Green crab, which are predating on Blue mussels in the	April 24, 2019

			PEI	Basin Head MPA.	
7	Community Aquatic Monitoring Program	Monica Boudreau	DFO - Gulf	Monitor the diversity of fauna and flora captured in the Basin Head lagoon (June to August 2019)	April 24, 2019
8	Eelgrass restoration monitoring	Keila Miller	Souris Area Branch Wildlife Federation of PEI	Monitor eelgrass shoot density and area coverage for three eelgrass plots planted in the Basin Head lagoon and North East arm in 2017 and 2018 to determine if restoration is successful.	April 24, 2019
9	Water depth and sediment thickness	Dr. Irene Novaczek	Souris Area Branch Wildlife Federation of PEI	Check extent of change to water depth and sediment thickness as a result of November 2018 storm surge.	April 24, 2019
10	Hydraulic thermal and nitrogen concentration regimes	Dr. Barret Kurylyk	DAL	Studying the dynamics of the hydraulic thermal and nitrogen concentration regimes in Basin Head. Monthly field trips between May – October 2019.	April 24, 2019
11	Marsh edge erosion and Influence of ice	Dr. Irene Novaczek	Souris Area Branch Wildlife Federation of PEI	Document the influence of ice within and below the main Irish moss bed and the marsh erosion (May – November 2019).	April 24, 2019
12	Irish moss eDNA	André Nadeau	DFO - Gulf	Explore the use of environmental DNA to determine relative coverage of Irish moss in the northeastern arm.	April 24, 2019
13	Barnacles and mussels	Dr. Pedro Quijon	UPEI	Measuring barnacle settlement rates in Basin Head and assess light	April 26, 2019

	settlement			influence on settlement rates.	
14	Dredging Basin Head run	PEI Department Transportation Infrastructure and Energy	PEI Government	Dredging approximately 1600m^3 of sand between 2 wharves at Basin Head provincial park (June 2019).	June 11, 2019

5.0 ENFORCEMENT AND COMPLIANCE

As the Basin Head area is a frequent tourist destination and high traffic area for both visitors and locals, the local DFO Conservation and Protection (C&P) officers patrol the area regularly to ensure compliance under the Management of Contaminated Fishery Regulations (MCFR) and the Basin Head Marine Protected Area Regulations (BHMPAR) as well as the Maritime Provinces Fishery Regulations (MPFR).

These C&P land-based patrols are conducted throughout the year but more frequent in the operational fishing season when commercial and recreational fisheries are more prevalent. The harvesting of Oysters under the Spring Relay Program, within the authorized Zone 2, was the only commercial fishing recorded in Basin Head in the spring of 2019. There are 2-4 fishers that fish this area and although not required, those fishers usually call the local C&P office to advise of their activity prior to their fishing activities in the event we receive any public complaints. 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. Activity in Zone 3 is essentially noted as recreational watercraft activity and 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.

There has been no non-compliance issues identified that required an enforcement action in regard to contraventions of the MCFR, BHMPAR or MPFs in the fiscal year 2019-20, except for one complaint to C&P against an oyster fisherman raking too close from boundary zone 1 which has been informed to be careful not to cultivate in zone 1. 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.

6.0 PUBLIC AWARENESS AND EDUCATION

Public education and outreach are critical factors in ensuring the long-term success of an MPA. Greater compliance with MPA regulations is observed when community members, MPA users and the general public are aware of objectives and management strategies of an MPA. Education and outreach tools are most effective when they target appropriate user groups, stakeholders and the public, present a straightforward message, and use the most appropriate product to communicate the message.

Currently 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 and used by its visitors in 2019.

During the summer of 2019, SAB continued to lead “Beyond the Beach” experiential experiences. These educational activities consisted of a beach seine haul with “hands-on” experience to explore the marine community within the Basin Head MPA. This was part of an authentic PEI experience and occurred on select Tuesdays and Thursdays in July and August.

The work on the Basin Head Interpretive Park was also completed in 2019, with the official opening taking place in June 2019 (Figure 5). The upgrades and work completed will improve visitors’ experience, while promoting education and protection of the Basin Head Lagoon. This project was completed with the financial help of Atlantic Canada Opportunities Agency, the Government of PEI and DFO and was led by the Souris and Area Branch of the PEI Wildlife Federation. New interpretive panels, a floating dock, upgrades to the boat launch, a new picnic shelter, a research building and improved parking were all completed between 2018-2019. The Interpretive Park is located next to the Basin Head Provincial Park, Basin Head Beach and the Basin Head Fisheries Museum; an ideal location for the interpretative activities related to the Basin Head MPA.

Figure 5. New Gazebo and boardwalk with interpretive panels at the Basin Head Interpretive Park.

7.0 NEXT STEPS AND PRIORITIES

DFO will focus on several priorities related to the implementation of the management plan in the next fiscal year (April 2019 to March 2020). Priorities include:

- Following the CSAS recommendations, refocus and augment water sampling to support development of a groundwater and streamflow discharge model for Basin Head.
- Continue to work with land use and weather data to strengthen understanding of nitrogen loading and how it interacts with *Ulva* blooms.
- Augment and redistribute water pressure loggers to improve hydrodynamic modelling of the estuary so that climate change scenarios can be tested.
- 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.
- Continue to develop drone-based aerial photography as a potential comprehensive survey method.
- Document the width of the dune at Elliot's, as this is the weak point that may be most vulnerable to a storm-driven breach of the dune system.
- Continue to monitor marsh edge erosion, development of eelgrass patches, and the biomass and spatial distribution of *Ascophyllum* and *Geukensia*.
- Continue and improve the Green crab removal program.
- Explore other ways of mitigating nutrient and sediment input in the system.
- Enhance educational and outreach efforts.
- Connect with the new UPEI Climate change research program to be situated at St. Peters, to ensure that Basin Head lagoon becomes a climate change research site.

8.0 REFERENCES

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