Credit: Nick Hawkins

ECOLOGICALLY SIGNIFICANT AREAS | CASE STUDY: EELGRASS MEADOWS

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Case studies have been developed to inform the federal government consultation on the regulatory process to establish "ecologically significant areas" under Section 34 of the *Fisheries Act*.

I. OVERVIEW

Seagrass meadows are highly productive coastal habitats that support diverse food webs and provide a wide range of valuable ecosystem services.[1] For example, by creating structurally complex benthic habitat, seagrasses provide shelter and foraging habitat for the juvenile life stages of many fish species and adult stages of many small-bodied species.[2] These include key species that support industrial and small-scale fisheries.[3] In addition, seagrass meadows buffer coastlines from storm surge and erosion, improve water quality and sequester large amounts of atmospheric CO_2.[4]

Despite their importance, seagrasses are declining around the world at an accelerating pace.[5,6] Increased focus on protecting, restoring and monitoring seagrass meadows is needed to ensure that these habitats continue to support nearshore ecosystems, fisheries and coastal communities, and help secure a stable climate.

The long, jagged coastline of Nova Scotia contains many sheltered, shallow bays and estuaries with soft bottom types that are ideal for eelgrass (*Zostera marina*). As such, eelgrass meadows are found along much of Nova Scotia's Atlantic and Gulf coasts as well as in many parts of the Bay of Fundy, particularly the lower bay. While we lack adequate monitoring data to quantify long-term trends in many of Nova Scotia's eelgrass meadows, there are published reports of large-scale declines at multiple locations around the province in recent decades,[7] as well as in parts of New Brunswick, PEI and the northeastern US.[8]

Because of its many values, eelgrass has been deemed an ecologically significant species by Fisheries and Oceans Canada.[9] Place-based protections for eelgrass meadows do not currently exist in Nova Scotia; however, DFO could help protect eelgrass meadows using the Ecologically Significant Areas tool under the modernized *Fisheries Act*. An ESA designation would mitigate threats associated with harmful local-scale activities (e.g. dredging, shading from overwater structures) as well as land-based influences (e.g. nutrient loading, sedimentation) and spur the monitoring and research needed to preserve their function for the long term. Moreover, ESA designation could generate resources to evaluate and mitigate other stressors whose long-term effects could be highly detrimental but remain poorly quantified, such as the impacts of invasive European green crab (*Carcinus maenas*).

1 Costanza R et al. (1997). The value of the world's ecosystem services and natural capital. Nature 387: 253-260.
2 Joseph V et al. (2013). Use of eelgrass habitats by fish in eastern Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/138. ii + 12p.
3 Unsworth RKF et al. (2018). Seagrass meadows support global fisheries production. Cons. Lett. 2019: e12566.
4 Mcleod E et al (2010) A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. Front. Ecol. Environ. 2011: 552-560
5 Orth RJ et al. (2006). A global crisis for seagrass ecosystems. BioScience 56: 987–996.
6 Waycott M et al. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proc. Nat. Acad. Sci. 106: 12377-12381.
7 Hanson AR (ed) (2004). Status and conservation of eelgrass (Zostera marina) in Eastern Canada. Technical Report Series No. 412. Canadian Wildlife Service, Atlantic Region. viii. + 40 pp.
8 Neckles HA et al. (eds). (2009). Status, Trends, and Conservation of Eelgrass in Atlantic Canada and the Northeastern United States: Workshop Report. [Report]. Portland, ME: University of Southern Maine, Muskie School of Public Service, Casco Bay Estuary Partnership.
9 DFO. (2009). Does eelgrass (*Zostera marina*) meet the criteria as an ecologically significant species? DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/018.

II. DESCRIPTION OF AREA

The Port Joli inlet is a shallow, 10-km-long estuary on the south shore of Nova Scotia that ranges in width from 1-4 km and is home to expansive intertidal and subtidal flats, including patchy eelgrass meadows.[10] The area is of great cultural importance for the Mi'kmaq[11] and is one of the few relatively pristine coastal areas in Nova Scotia. Port Joli has been identified as an Ecologically or Biologically Significant Area (EBSA) as it meets the criteria of high aggregations resilience, and it is one of the coastal areas in Nova Scotia with the highest level of interest for conservation.[12]

Eelgrass has been documented in Port Joli inlet on sandy or gravel substrates in the inner, shallow portions of the bay (Figure 5). Diverse and abundant algae, including Irish moss (*Chondrus* spp.), fucoid brown algae (*Fucus* spp.) and green and red turf algae has been recorded in the bay, with the latter two occurring on rocks in deeper areas toward the mouth of the bay. A local green alga (*Chaetomorpha* spp.), present in Port Joli inlet, has seen an increase in abundance along the Atlantic coast of Nova Scotia in recent years. Kelps (*Laminaria* spp., *Saccharina* spp., *Agarum* spp.) are also present on hard substrates in the deeper waters toward the mouth of the bay. Vandermeulen (2017) reports that macrophytes observed in the bay during drop-camera deployments were in good condition, meaning that the eelgrass is relatively free of epiphytic algae growth. Snorkel and SCUBA surveys by CPAWS-NS (R Harvey, pers. comm., 2021) documented a diversity of invertebrates at several sites throughout the inlet, including juvenile lobster (*Homarus* spp.). Atlantic rock crab (*Cancer* spp.) was noted to be in equal abundance to the invasive European green crab (*Carcinus* spp.). A recent review found that human influence on eelgrass meadows in Port Joli are relatively minor compared with other Atlantic Nova Scotian sites due to higher coastal land protection, lower riparian land alteration and lower bay-scale and localized stressors.[13] Nutrient loads are lower than in the adjacent Port Mouton Bay.

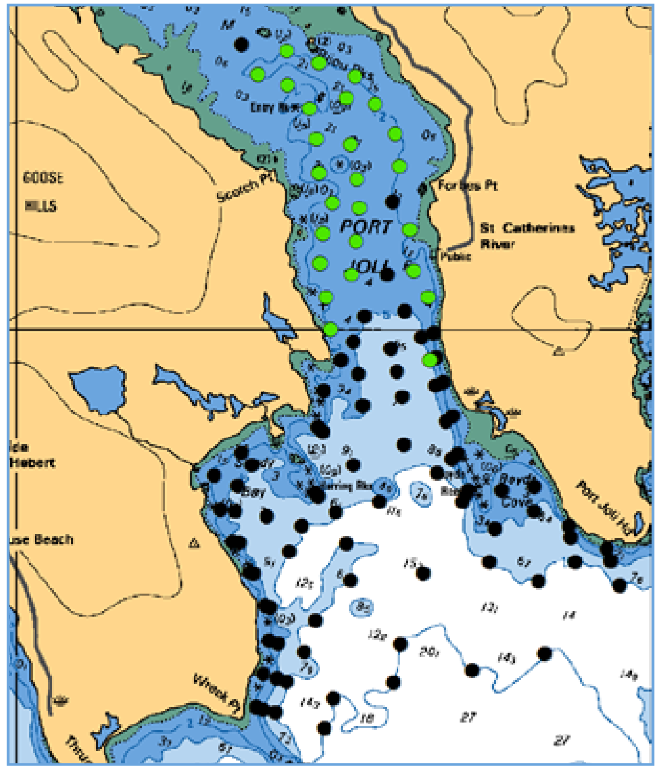

Figure 5: Map of Port Joli inlet showing sites where eelgrass was observed during drop-camera surveys in 2017 (green dots) and those where it was absent (black dots) (Vandermeulen 2017).

A 280-ha Migratory Bird Sanctuary, established in 1941, aims to protect waterfowl populations (e.g. Canada goose, American black duck) at the head of the inlet where the eelgrass meadows are found (Figure 7). The sanctuary regulates activities that could kill, harm or harass migratory birds. However, there are no specific protections in place for the eelgrass meadows themselves, which help draw these species to the site. An ESA designation could add a layer of protection to the eelgrass meadows in Port Joli to ensure that the habitat value and ecosystem services that now characterize the site remain intact for the long term. This would be a largely proactive protection of a relatively pristine site, although mitigation of some key existing threats may also be needed (see below). Protecting Port Joli's eelgrass meadows would complement existing terrestrial protection

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10 Vandermeulen H. (2017). A drop camera survey of Port Joli, Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 3215: viii + 59 p.

11 Betts M. (2019). Place-Making in the Pretty Harbour: The Archaeology of Port Joli, Nova Scotia.

12 Gromack AG et al. (2010). Ecological and Human Use Information for Twenty Areas on the Atlantic Coast of Nova Scotia in Support of Conservation Planning. Can. Tech. Rep. Fish. Squat. Sci. 2880: xiv + 226 p.

13 Murphy GEP et al. (2019). A human impact metric for coastal ecosystems with application to seagrass beds in Atlantic Canada. FACETS 4: 210-237.

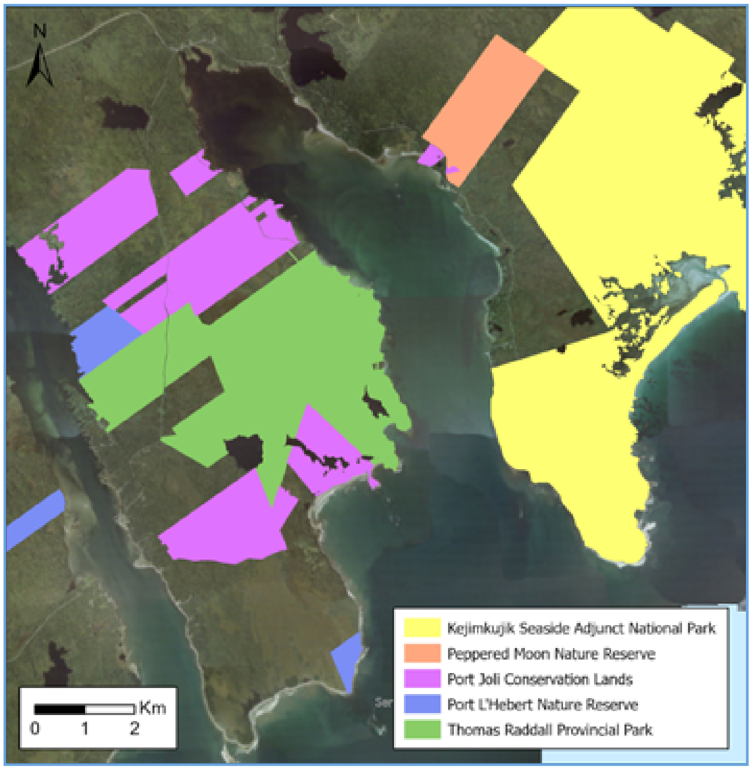

Figure 6: Map of terrestrial protected areas adjacent to Port Joli Inlet (CPAWS NS).

on adjacent land: the inlet is nestled between Kejimkujik National Park Seaside, Peppered Moon Nature Reserve and Thomas Raddall Provincial Park, and the Nature Conservancy of Canada protects a growing number of coastal lots around the two parks (Figure 6). The coastal protection presents an opportunity for intergovernmental collaboration, which can provide a framework for future ESA designations.

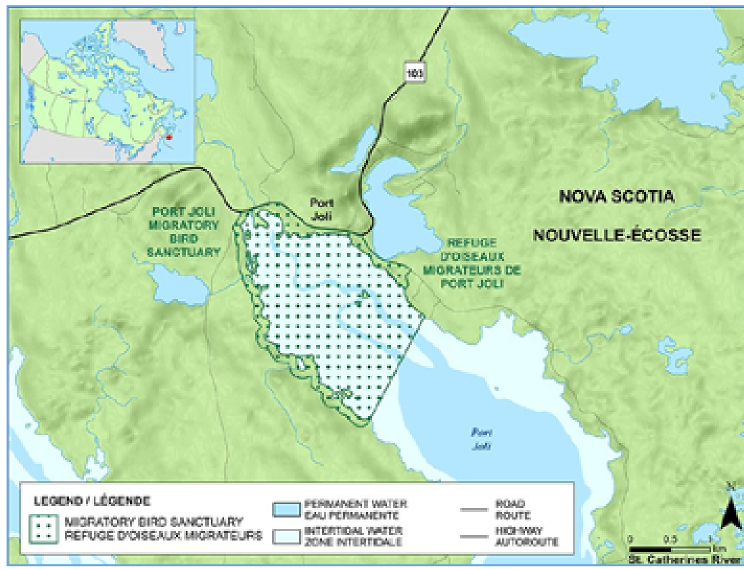

Figure 7: Port Joli migratory bird sanctuary (ECCC).

III. ECOSYSTEM SERVICES PROVIDED

- Creation of habitat for many fish species, including forage fish and some commercially harvested species, particularly for juvenile life stages[14]
  - Eelgrass meadows enhance foraging opportunities and provide refuge from predation compared with unvegetated coastal habitats
- Enhanced water quality through the filtering of sediments from the water column and stabilization on the sea bottom by roots and rhizomes[9]
- Creation of habitat for diverse invertebrate and algae species[9]
  - Structural complexity of eelgrass meadows results in higher densities and species compositions relative to unvegetated coastal habitats like mud flats
- Coastal buffering from storm surge and erosion via wave attenuation[15]
- Blue carbon sequestration[16,17,18]
  - Seagrasses, including eelgrass, trap and bury carbon-rich sediments at a rate comparable to salt marshes and mangroves

[14] Joseph et al. (2013). Use of eelgrass habitats by fish in eastern Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/138. ii + 12p.
[15] Barbier EB (2017). Primer: marine ecosystem services. Curr. Biol. 27: R431-R510.
[16] Fourqurean JW et al. (2012). Seagrass ecosystems as a globally significant carbon stock. Nat. Geosci. 5: 505-509.
[17] Mcleod E et al. (2011). A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. Front. Ecol. Environ. 9: 552-560.
[18] Röher ME et al. (2018). Blue carbon storage capacity of temperate eelgrass (Zostera marina) meadows. Glob. Biogeochem. Cycles 32:1457-1475.

IV. CONSERVATION AND PROTECTION OBJECTIVES

- Ensure no net loss of eelgrass habitat
- If eelgrass declines are known or suspected to have occurred based on historical records including local/traditional knowledge, address the underlying causes of decline and restore full areal coverage
- Ensure that ecosystem functions of eelgrass meadows are preserved

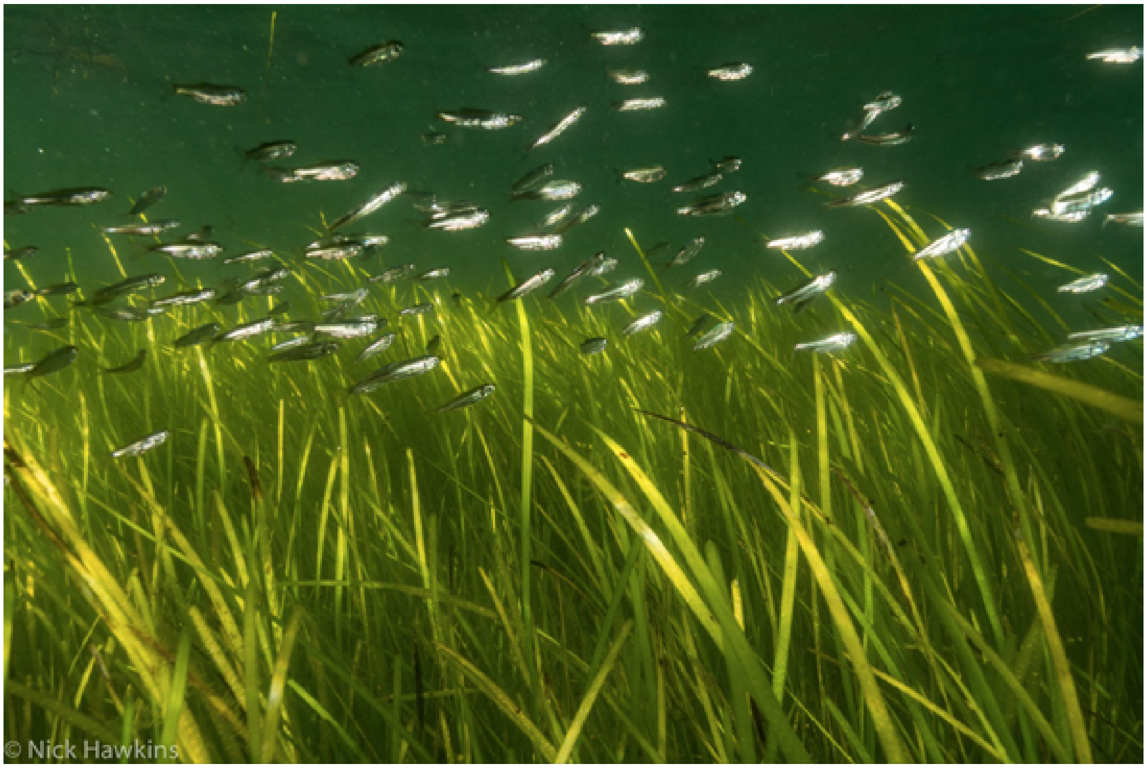

Figure 8: Eelgrass meadow (copyright Nick Hawkins).

V. THREATS/ACTIVITIES THAT IF PERMITTED WOULD UNDERMINE ACHIEVEMENT OF CONSERVATION OBJECTIVES

There are a variety of threats to eelgrass meadows in the Port Joli area that an ESA could mitigate. Unlike other parts of the province with greater impacts from coastal development and nutrient run-off, the land surrounding Port Joli is relatively undeveloped and well protected.[19] However, a key consideration for this site is the impact of European green crab, an invasive species that has been present in Nova Scotia for many decades and has been implicated in eelgrass declines in the province[20] as well as elsewhere in Atlantic Canada[21,22] and on the west coast.[23] Within Nova Scotia, the impacts of green crab are not consistent across sites, possibly reflecting differences in crab density.[24] Data are lacking on green crab impacts in Port Joli, specifically. A particular value of an

[19] Murphy GEP et al. (2019).
[20] https://www.pc.gc.ca/en/pn-np/ns/kejimkujik/nature/conservation/ecosystem-cotier-coastal
[21] Malyshev A and Quijón PA (2011). Disruption of essential habitat by a coastal invader: new evidence of the effects of green crabs on eelgrass beds. ICES J. Mar Sci. 68: 1852-1856
[22] Matheson K et al. (2016). Linking eelgrass decline and impacts on associated fish communities to European green crab Carcinus maenas invasion. Mar. Ecol. Prog. Ser. 548: 31-45
[23] Howard BR et al. (2019). Habitat alteration by invasive European green crab (Carcinus maenas) causes eelgrass in British Columbia, Canada. Biol. Invasions. 21: 3607-3618
[24] Wilson E and Garbary DJ (2020). Absence of recover in a degraded eelgrass (Zostera marina) bed in Nova Scotia, Canada: results from a transplant study. Proc. N. S. Inst. Sci. 50: 251-267

ESA in Port Joli would be to generate resources to monitor and evaluate green crab impacts at this site and, if necessary, conduct green crab control activities to help facilitate meadow restoration. This could be done in partnership with local fishermen, similar to the project by Parks Canada at Keji'mkujik Seaside Adjunct.[18]

In addition, any other work, undertaking or activity that could negatively impact eelgrass meadow health (e.g. through lower water quality or direct disturbance) should be considered for regulation under an ESA. For example, an ESA should prohibit open net-pen finfish aquaculture and require adequate setback for developments outside the boundary to ensure that nutrient inputs and waste do not lead to smothering of eelgrass and/or eutrophication.[25]

In addition, through the pathway of effects, an ESA should consider regulating any future shoreline or upstream developments that could reduce water quality through sedimentation or nutrient loading (e.g. hard shoreline structures, riparian development). In such cases, to effectively preserve the valued components of the ESA, proposals should require a heightened level of scrutiny under the *Fisheries Act*.

Other activities that should be evaluated for regulation under an ESA include mooring and anchoring practices, fishing activity although most activity in this area occurs in deeper water at the mouth of the bay) and marine plant harvesting.

JURISDICTIONAL ISSUES

- Upstream land-use patterns and activities/works/undertakings that contribute to nutrient loading or sedimentation (provincial/municipal)
- Open net-pen finfish aquaculture (provincial)
- Hard shoreline structures (provincial/municipal)

VI. RESTORATION OPPORTUNITIES

Restoration of seagrass meadows is possible but the track record of restoration projects around the world is mixed.[26] New methodologies (e.g. seed bag deployment) and ensuring that the underlying drivers of decline are effectively managed may be key to restoration success. In Port Joli, this means evaluating the impacts of localized stressors like green crab activity as well as other possible contributors like temperature changes and nutrient inputs. If eelgrass trends and drivers can be identified, and strategies put in place to address them, restoration at this site could enhance the value of the meadows to fish populations and could have many co-benefits for biodiversity and climate mitigation/adaptation.

VII. MONITORING & RESEARCH NEEDS

- Water quality monitoring (e.g. nutrient loads, sedimentation)
- Temperature, salinity monitoring
- Eelgrass extent, cover, condition and trends (building from existing data)
- Relationships between eelgrass and fish populations as well as flora and fauna
- Green crab density and impacts
- Assessment of need for restoration (i.e. have declines occurred that we should try and reverse?)

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25 Cullain N et al. (2019). Potential impacts of finfish aquaculture on eelgrass (Zostera marina) beds and possible monitoring metrics for management: a case study in Atlantic Canada. PeerJ 6: e5630.

26 Macreadie PI et al. (2021). Blue carbon as a natural climate solution. Nature Rev. Earth Environ. 2: 826-839.https://doi.org/10.1038/ s43017-021-00224-1