National Eelgrass Task (NET) Force: engagement in support of a dynamic map of eelgrass distribution in Canada to support monitoring, research and decision making

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NATIONAL EELGRASS TASK (NET) FORCE: ENGAGEMENT IN SUPPORT OF A DYNAMIC MAP OF EELGRASS DISTRIBUTION IN CANADA TO SUPPORT MONITORING, RESEARCH AND DECISION MAKING

by

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TABLE OF CONTENTS

ABSTRACT

Gomez C., Guijarro-Sabaniel J., Wong M. 2021. National Eelgrass Task (NET) Force: engagement in support of a dynamic map of eelgrass distribution in Canada to support monitoring, research and decision making. Can. Tech. Rep. Aquat. Sci. 3437: vi + 48 p.

The National Eelgrass Task (NET) Force is envisioned as an innovative, diverse and inclusive partnership of scientists, managers, and partners working towards a concrete common goal: a national map of eelgrass distribution in Canada that is publicly accessible, dynamic, and useful for monitoring and collective decision-making. Multiple partners are conducting independent initiatives to better map the distribution of eelgrass on Canada's coastlines at different spatial scales, using various approaches. Recognizing the ecological and socio-economic benefits that eelgrass beds provide in coastal ecosystems, there is national interest in combining efforts to achieve a comprehensive national eelgrass map. This map should be based on principles of open, reproducible, and participatory science tools to analyze, map, visualize, and update eelgrass data. NET Force is leveraging eelgrass initiatives and projects currently underway, as well as data already collected/available to facilitate coordination of efforts. Areas of focus include eelgrass data accessibility, integration, and use of open and reproducible tools for eelgrass data access. This initiative will be achieved by: 1) engaging and consulting with diverse partners to develop an overall plan and strategy for NET Force, 2) disseminating and implementing the plan and strategy by identifying and bringing together eelgrass partners and consolidating available data, data products and tools, 3) conducting research to appropriately integrate data and data products into a common format, and 4) creating a dynamic national map of eelgrass extent, with interactive material for educating the public. This document was assembled to formalize NET Force, and to summarize bilateral discussions, a national DFO forum, and a national multi-partner forum. This document summarizes the status of initiatives to support eelgrass monitoring and research, provides details relevant for management and science capacities, and recommends actions to achieve the goal of NET Force. This report also represents a call for other partners in Canada actively working on eelgrass monitoring and distribution to join NET Force.

RÉSUMÉ

Gomez C., Guijarro-Sabaniel J., Wong M. 2021. National Eelgrass Task (NET) Force: engagement in support of a dynamic map of eelgrass distribution in Canada to support monitoring, research and decision making. Can. Tech. Rep. Aquat. Sci. 3437: vi + 48 p.

Le groupe de travail national sur la zostère (NET Force) est considéré comme un partenariat innovateur, diversifié et inclusif de scientifiques, de gestionnaires et de partenaires travaillant à un objectif commun concret : la création d'une carte nationale de la répartition des zostères au Canada qui soit accessible au public, dynamique et utile pour la surveillance et la prise de décision collective. De multiples partenaires mènent des initiatives indépendantes pour mieux cartographier la répartition des zostères sur les côtes du Canada à différentes échelles spatiales, en utilisant diverses démarches. Reconnaissant les avantages écologiques et socio-économiques que les herbiers de zostères offrent aux écosystèmes côtiers, il y a un intérêt national pour combiner les efforts afin de réaliser une carte nationale complète des zostères. Cette carte devra être basée sur les principes des outils scientifiques ouverts, reproductibles et participatifs pour analyser, cartographier, visualiser et mettre à jour les données sur les zostères. Le NET Force tire parti des initiatives et des projets relatifs aux zostères actuellement en cours, ainsi que des données déjà recueillies et disponibles pour faciliter la coordination des efforts. Les domaines d'intérêt comprennent l'accessibilité et l'intégration des données sur les herbiers, ainsi que l'utilisation d'outils ouverts et reproductibles pour l'accès aux données sur les herbiers. Cette initiative sera réalisée : 1) en mobilisant et consultant divers partenaires afin d'établir un plan et une stratégie globaux pour le NET Force; 2) en diffusant et mettant en œuvre le plan et la stratégie en identifiant et en rassemblant les partenaires en matière de zostères ainsi qu'en consolidant les données, les produits de données et les outils disponibles; 3) en menant des recherches pour intégrer de manière appropriée les données et les produits de données dans un format commun; 4) en créant une carte nationale dynamique de l'étendue des zostères, avec du matériel interactif pour éduquer le public. Le présent document a été préparé pour officialiser le NET Force et pour résumer les discussions bilatérales, un forum national du MPO et un forum national à multiples partenaires. Il résume le statut des initiatives visant à soutenir la surveillance et la recherche sur les zostères, fournit des détails pertinents pour les capacités de gestion et de science, et recommande des mesures pour atteindre l'objectif du NET Force. Le rapport constitue également un appel aux autres partenaires canadiens qui travaillent activement à la surveillance et la distribution des zostères à devenir membres du NET Force.

INTRODUCTION

Eelgrass (*Zostera marina*) forms extensive underwater meadows along much of Canada's coastlines. These nearshore habitats provide valuable ecosystem services including carbon storage, biodiversity support, shoreline protection, water filtration, nursery, shelter, and feeding habitat for a large variety of species and commercially important stocks (DFO 2009, Joseph et al. 2013). Given their location in coastal, shallow waters between land and the open ocean, eelgrass beds are highly susceptible to human activities, and consequently, targeted management and conservation measures are required to ensure the continued provision of ecosystem services (e.g. Murphy et al. 2019). Marine spatial planning provides a mechanism to balance and manage the compatibility of multiple human activities that may take place in the coastal zone that interact with eelgrass ecosystems (Douvere 2008, Ehler and Douvere 2009). Such planning is highly dependent on maps of eelgrass distribution, yet comprehensive national maps of eelgrass coverage in Canada do not exist.

This reports summarizes a series of engagement sessions held during 2019 and 2020, including bilateral discussions, a national DFO forum, and a national multi-partner forum. This engagement sessions led towards the consolidation of the National Eelgrass Task (NET) Force, envisioned as an innovative, diverse and inclusive partnership of scientists, managers, and partners working towards a concrete common goal: a national dynamic map of eelgrass distribution in Canada that is publicly accessible, dynamic, and useful for monitoring and collective decision-making. This report provides detailed information of the topics presented and discussed, perspectives from participants, and activities in support of NET Force.

ENGAGEMENT: BILATERAL DISCUSSIONS

Multiple partners from governmental and non-governmental organizations are conducting independent initiatives to better map the distribution of eelgrass in Canada's coastlines at different spatial scales, using various approaches. For instance, a Nova Scotia eelgrass Working Group (WG), that includes participants from governmental and non-governmental, met in 2019 to share updates about their regional eelgrass initiatives and research. A session designed to identify gaps highlighted that the number one issue that is preventing a coordinated and more efficient approach to eelgrass research and monitoring in Nova Scotia is the lack of information about eelgrass distribution. Lack of comprehensive information on eelgrass distribution is not unique to Nova Scotia.

Subsequent internal DFO meetings further reiterated that to ensure their continued provision of ecosystem services, a comprehensive, publically accessible national map of Canada's eelgrass is necessary to facilitate and prioritize targeted monitoring and surveillance, as well as to develop and provide advice to support collective decision-making for aspects related to blue economy, aquaculture siting, marine spatial planning, *Fisheries Act* violations, environmental response, conservation planning, maintaining natural environment, and responding to environmental incidents.

NET Force engaged with several DFO sectors, programs, and regions regarding this project. Several meetings with DFO Science (Maritimes, Gulf), Aquaculture Management (Maritimes, Gulf) Oceans (Maritimes) and Integrated Planning Fish and Fish Habitat Protection Program (FFHPP, Maritimes) have been held. Participants indicated their support and have identified several uses of the proposed product. The Program for Integrated Environmental Response (PIER, Quebec, Maritimes) and marine spatial planning (Maritimes, Gulf, National) are supporting this proposal and are considering this as a case study for the national marine spatial plan atlas to contribute towards national consistency in data products. Policy and Economics in National Capital Region (NCR) will collaborate and intend to use project results to enhance their current blue carbon project, and to inform economic models and ecological accounts. Environment and Climate Change Canada (ECCC, NCR) provided the distribution of current and historical eelgrass sites in Canada, representing a snapshot of the locations where eelgrass has been studied, and used as an indicator map (Figure 1, Environment and Climate Change Canada, 2020). Scientists working in eelgrass research in DFO Maritimes, Pacific, Newfoundland and Labrador, Quebec, and Gulf have all indicated their interest and intention to contribute data.

These bilateral discussions led towards the consolidation of NET Force, a DFO-led initiative that will be achieved by:

- Successfully engaging and consulting with other partners to develop and implement data sharing agreements, a plan and a strategy for NET Force,
- Disseminating and implementing the plan and strategy by identifying and consolidating eelgrass partners, available data, data products and tools,
- Conducting research to appropriately integrate data and data products into a common format,
- Creating a dynamic national map of eelgrass extent to support decision making, including interactive material for educating the public.

NET Force will allow for innovation and application of emerging methods and technologies to improve understanding of eelgrass distribution. The challenge is in compiling diverse eelgrass data into a comprehensive product, when each method

carries its own assumptions and uncertainty. Novel stitching Geographic Information System (GIS) techniques will be collectively developed and transferred for various geospatial projects. Outcomes will represent the first comprehensive and accurate estimate of eelgrass extent on all three coasts: there is no similar product available in Europe or North America. NET Force is also expected to provide a platform for partners to advance their own research. For example, outcomes will be used to calculate the blue carbon storage potential of Canada's eelgrass beds (project conducted by DFO Science and Policy and Economics sectors).

Additional discussions with potential data holders indicated that spatial data of eelgrass coverage are available. A National data inventory survey was created to further assess eelgrass data availability and file size. Ongoing discussions and the data survey indicated that partners are willing to contribute the available data and/or data products. Furthermore, partnership with the Marine Spatial Data Infrastructure (MSDI) portal is expected to build on available expertise and infrastructure in support of this project (for more information about spatial interactive tools available at DFO, and MSDI, see Gomez et al. 2021). The NET Force GIS analyst (Javier Guijarro-Sabaniel) is leading the coordination with all regions to actively engage with data holders. Certain types of mapping data (benthic sonar, presence/absence, field transects) may be directly incorporated into the open database. All products will be hosted using existing infrastructure, and will be maintained as part of DFO's infrastructure, or through external partners.

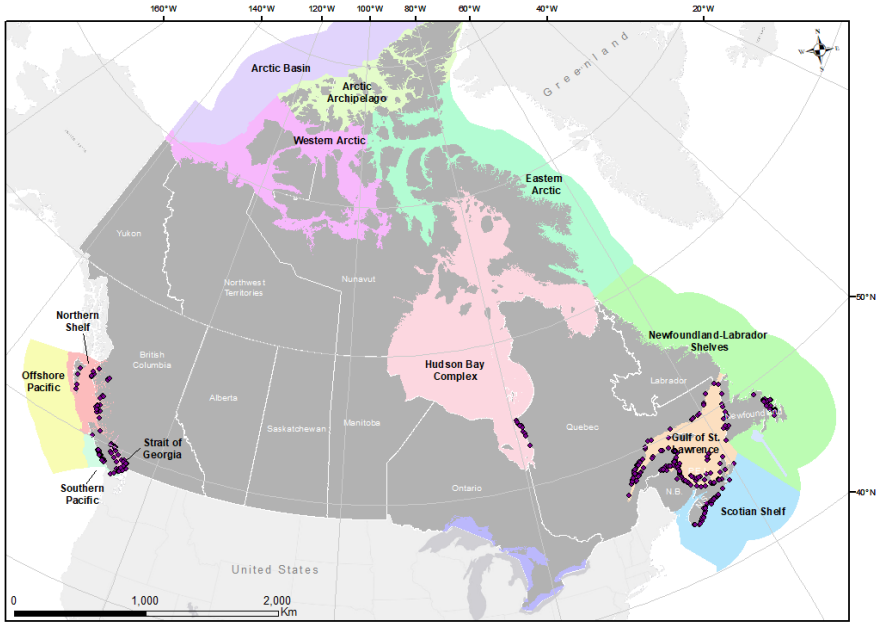

Figure 1. Eelgrass distribution in Canada including historical data consolidated by ECCC. Map courtesy of Brett Painter (Environment and Climate Change Canada, 2020).

ENGAGEMENT: NATIONAL DFO VIRTUAL FORUM

Session 1: Introduction and Context

Presenters: Tana Worcester, Melisa Wong, and Catalina Gomez

The goals of DFO's National virtual forum were mainly to:

- Connect with DFO regions to gauge interest and engage partners (prior to inviting external partners),
- Identify relevant DFO decisions that can be informed by NET Force, and required products and information,
- Start conversation about exchange of technical information and emergent methods for assessment and predictions,
- Develop a roadmap for a diverse, collaborative network of partners.

This forum took place as a virtual event on Microsoft Teams on September 21, 2020 (Table 1). Tana Worcester, Science management champion for marine spatial planning in the Maritimes Region, chaired the meeting, and began with an introduction and a virtual round table to better understand who was participating in this first national DFO engagement. Forty three participants attended the forum from different DFO sectors: Science, Marine Planning & Conservation, Policy & Economics, and Integrated Planning (Fish and Fish habitat Planning Program FFHPP). Participants included staff from Gulf, Quebec, Newfoundland and Labrador, Maritimes, Pacific Regions, and national headquarters (NHQ) (Appendix 1).

Table 1. Agenda of NET Force first virtual Forum, September 21, 2020.

AST	Items	
1:00 PM	Introductions and virtual round table	All
1:10 PM	Context	Tana Worcester, Melisa Wong & Catalina Gomez
1:25 PM	NET Force Terms of Reference	Melisa Wong; All
1:40 PM	Linkages with the blue economy	Lindsey Weber
2:00 PM	Legislative framework	Monica Boudreau; All
2:10 PM	Plenary Discussion: how eelgrass data products have been used, or will be used in the future, to inform decision making	All
2:45 PM	Break	All
3:00 PM	NET Force peer-review publication: Eelgrass distribution in Canada	Melisa Wong; All
	Diversity of eelgrass data and data products	Matt Christensen; All

	Technical Forum: stitching data & visualizing uncertainty (Winter 2020)	Catalina Gomez, All
	Engagement with external partners	Melisa Wong; All
	Final remarks	All
	Feedback, Q&A	

NET Force goals are also aligned with those of DFO's marine spatial planning program, which aims to bring together relevant people to better coordinate how marine space is used and managed to achieve ecological, economic and social objectives. While marine spatial planning is being led in DFO by the Marine Planning and Conservation Management sector, the Science sector is playing an important role in developing geospatial layers for a marine atlas. Science has engaged in the process of evaluating commonalities between spatial layers that should be developed to support this atlas, with eelgrass identified as a shared priority across the country. The NET Force initiative is conceived as a collaborative research and technical exchange to learn about diverse methods, modelling approaches, and sources of data used to represent eelgrass. Ultimately, the goal is to make information accessible and comparable across regions to support decision making and conservation of this important species, and apply lessons learned to other species and needs.

Even though eelgrass is a shared priority across the country, mapping eelgrass is being approached in different ways, with a diversity of tools, technologies, uses and applications. The presentations prepared for this forum showcased the various data sources, spatio-temporal scales, technologies, research questions and management applications, with many groups working on a great variety of projects. This siloed approach in some cases has limited opportunities to work together towards a common goal. We see this initiative as an opportunity to do just that:

- to provide a forum for diverse partners actively working on eelgrass mapping related projects and activities
- to leverage eelgrass initiatives and projects currently underway, as well as data already collected/available to facilitate coordination and participation,
- to create centralized research and data inventories that we can all access,
- to create and share tools and products beyond just the traditional peer-reviewed publications,
- to allow us to stitch together this mosaic of independent pieces into a patchwork of useful information, including the visualization of uncertainty.

NET Force is fundamentally a team effort, and its success will depend on members working cooperatively together. This requires some common operating principles proposed in Table 2. These principles represent our pledge and a challenge on how to

advance this initiative. In addition, there are other spatial data layers that could benefit from broader national coordination and cooperation so it is our hope to use NET Force as a pilot for broadly applicable techniques that can be developed collectively for enhanced spatial data products relevant for marine spatial planning and decision support.

Table 2. Pledge and challenge to approach the NET Force challenge courtesy of T. Worcester.

Operating principle	Examples of applications
Think rigorously	• We explore options • We learn from others • We challenge each other in a respectful manner • We value critical thinking and constructive feedback • We use structured decision-making
Be engaged	• We stay informed • We stay connected • We participate
Trust & amplify	• We build trust within the team • We build trust with partners and "clients" • We work to people's strengths
Service	• We serve the Canadian public • We constantly evaluate whether we are providing good value for money • We strive to make the planet and the lives of Canadians better
Work with purpose	• We are clear about why we're doing something, and we communicate this • We move forward with persistence and focus • We monitor and evaluate progress • We celebrate success
Optimism Prevails	• We believe that change for the better is possible and will happen if we work together
Excellence in Team Work	• We explore and adopt the best ideas • We celebrate teams and individuals

In support of this forum and NET Force engagement with external partners, a collection of tools were developed:

1. Microsoft Team virtual space to organize information for this network, to exchange information, post questions for the group as well as updates as they become available,

2. Draft Terms of Reference (see Session 2) to define the clear purpose of NET Force for the next 3 years,
3. An external platform to engage and exchange information with external partners: https://sites.google.com/view/nationaleelgrasstaskforce/home,
4. An evergreen gallery of recordings as a tool to share with the broader community approaches relevant to a variety of important eelgrass research questions and management applications.

Recordings were available to forum participants ahead of the virtual forum. Figure 2 represents a word cloud summary of the themes contained within the recordings. Presenters showcased the remarkable and diverse eelgrass work that is being led in each region, often in partnership with external partners. More presentations will be posted in this gallery as engagement and collaborations further expands. Appendix 2 provides abstracts for each recording made available for this forum.

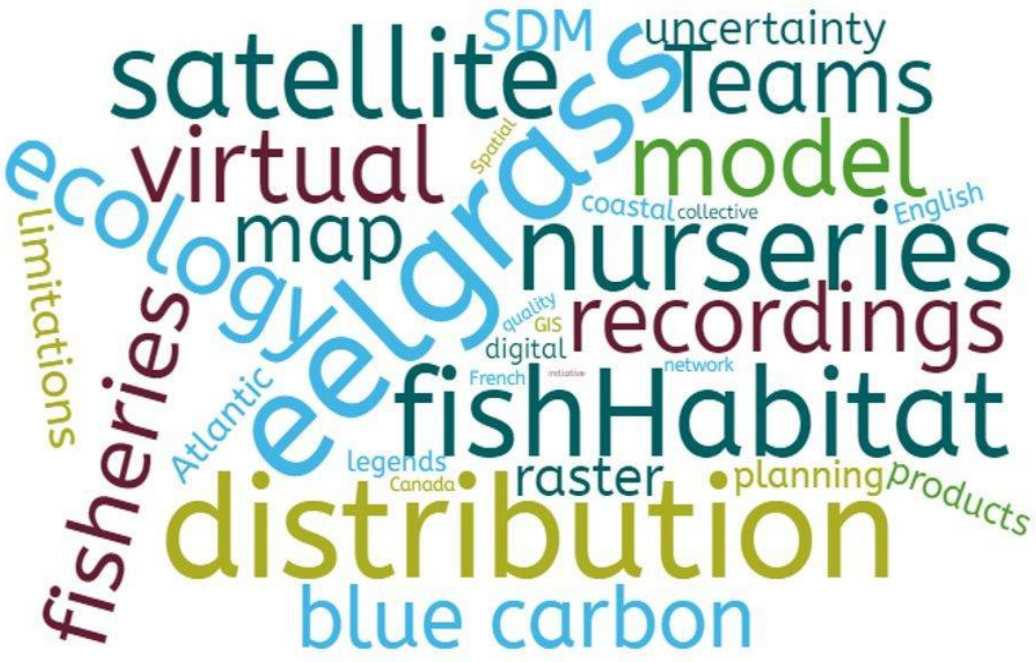

Figure 2. Word cloud summarizing themes summarized in the presentation prepared for the virtual forum.

Session 2: Terms of Reference and Membership

Presenter: Melisa Wong

The main goal of NET Force is to consolidate available eelgrass maps and mapping related data, compile these data into a common and accessible database, and map known eelgrass coverage on Canada's three coasts. This would create the building blocks for a dynamic national eelgrass map that could be continually updated, and be used to validate habitat model predictions and identify data-poor regions.

The specific activities of NET Force are to:

- Create a national map of eelgrass and the development of an accessible eelgrass database.
- Facilitate information and knowledge exchange by coordinating meetings, learning events and other capacity-building processes, and using existing information sharing mechanisms.
- Coordinate and collaborate with partners and regions in determining priority areas and issues of interest related to eelgrass mapping.
- Discuss analytical tools and approaches used to map eelgrass beds and approaches to stitch and amalgamate information (examples from DFO Maritimes Region conceptual model is here).
- Facilitate compilation of eelgrass mapping data into a national eelgrass map
- Identify opportunities for a permanent database of eelgrass mapping data associated with the national map.
- Ensure eelgrass mapping products developed adhere to nationally set standards and processes laid out by Open Data, Federal Geospatial Platform (FGP), and MSDI. Note that MSDI is only accessible to DFO employees and FGP is only accessible to federal employees.
- Develop an evergreen inventory of national and regional eelgrass projects and facilitate discussion and collaboration.
- Ensure that data products developed are relevant and useful for NET Force members and decision makers

NET Force is a National committee that is actively working on eelgrass related projects in Canada's coastline. Additional members and federal departments/agencies, governmental, non-governmental, and academic external partners may be invited to join as necessary. Working groups may be formed under NET Force to address other specific issues, data products, or analytical tools. A Working Group must have at least one member of NET Force and they shall meet independently. Members will report through their own organizations on matters raised during the conference calls/meetings

as needed. NET Force will be co-chaired by the following eelgrass National Representatives:

- Pacific Region: Emily Rubidge
- Gulf Region: Monica Boudreau
- Newfoundland and Labrador Region: Robert Gregory
- Maritimes Region: Melisa Wong

NET Force regional representatives based at DFO will support aspects of communication and dissemination of information, including sharing funding opportunities. Regional representatives will play an advisory role to help NET Force GIS analyst identify relevant eelgrass datasets and information, support engagement with new interested parties, and provide connections with the research community.

Secretariat functions will be carried out by either co-chair in collaboration within the MSP Science team in DFO Science, including the preparation of agendas, scheduling, and other tasks.

Session 3: Linkages with Blue economy

Presenter: Lindsey Weber

This presentation started with a reminder of the Minister of Fisheries, Oceans and the Canadian Coast Guard Mandate Letter:

"*Lead, with the support of the Minister of Transport, the Minister of Innovation, Science and Industry, the Minister of Economic Development and Official Languages and the Minister of Natural Resources, and in consultation with provinces and territories, Indigenous Peoples and business partners, in developing a comprehensive blue economy strategy to help guide future government actions and investments that enable Canada to grow its oceans economy to create good middle class jobs and opportunity for coastal communities while advancing our conservation objectives.*"

"Work with the Minister of Transport, the Minister of Natural Resources and the Minister of Environment and Climate Change to implement and further develop the Oceans Protection Plan. With the world's longest coastline, Canada must have a world-leading plan to protect it and marine species at risk. Pursue additional initiatives working with provinces, territories, Indigenous Peoples and all Canadians to better co-manage our three ocean coasts."

NET Force is funded currently by DFO's Deputy Minister's Results Reserve Fund (2020-2023), and is part of a broader Maritimes-led proposal titled "Innovative Approaches and Experimentation to Operationalize the Blue Economy in Maritimes Region". This will represent an opportunity to continue the conversation of capturing all pillars of

sustainability including ecological, social, economic, institutional and cultural considerations.

Session 4: DFO Legislative Framework

Monica Boudreau, Aimee Gromack, and plenary session

This session was assembled to spark discussion about management tools available within DFO, and to lead towards the discussion of how eelgrass data products have been used, or will be used in the future, to inform decision making.

At DFO, our legislative framework for the conservation and protection of species and habitats, such as eelgrass, includes:

- *Oceans Act* - Management of marine ecosystems through the principles of sustainable development, integrated management and precautionary approach (Section 30 on a National Strategy and Section 32 on Integrated Management Plans),
- *Fisheries Act* - Proper management and control of fisheries (Section 2.1a); Fish and fish habitat protection (Sections 34 to 42), and the Sensitive Benthic Area Policy (https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/benthi-eng.htm) under the Sustainable Fisheries Framework (https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/overview-cadre-eng.htm).
- *Species at Risk Act* - The purposes of this Act are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activities, and to manage species of special concern to prevent them from becoming endangered or threatened. This includes general prohibitions against killing, harming, harassing, capturing, or taking an individual of a wildlife species that is listed as extirpated, endangered, or threatened (Section 32); protection of residences (Section 33) and protection of critical habitat (Section 58).

the *Oceans Act*. The goal of the *Oceans Act* is to manage marine ecosystems through three principles which are sustainable development, integrated management and the precautionary approach. Integrated management plans need to have objectives on what to protect to achieve the sustainable development of our aquatic resources. For this, DFO has identified and designated Ecologically Significant Species (ESS), which are species considered important to maintain ecosystem structure and function, worth protecting. Because of the many ecosystem services eelgrass provides, this species was declared an ESS in 2009 for eastern Canada (DFO 2009). Effective mapping and monitoring of eelgrass ecosystems is recognized as a crucial component of the management and protection of coastal landscapes and the ecosystems they provide (Barrell et al. 2015).

Ecologically Significant Areas (ESA), “an area designated by regulations made under subsection 35.2(2)”, were an additional legislative tool identified under the *Fisheries Act*. Similar to Marine Protected Areas (MPA), ESAs are a Governor of Council regulation, aimed at regulating activities regulated by the Fish and Fish Habitat Protection Program (FFHPP, e.g. in or near-water construction activities that could impact fish or fish habitat such as dredging and infilling). ESAs can be designated in freshwater systems, intertidal, estuarine, and coastal systems or offshore, and are not meant to regulate activities related to fishing. Although there are currently no established ESAs, ESAs could play a role in protecting eelgrass beds.

The FFHP policy statement from August 2019 also refers to the consideration of cumulative effects to provide a “better understanding of the challenges to the aquatic ecosystem outside of the context of the reviews of specific works, undertakings, or activities”. The work led by Murphy et al. (2019), and also summarized in the recordings prepared for NET Force, is anticipated to contribute to future broader discussions on how to consider cumulative effects in decision making.

In the context of aquaculture management, lack of a comprehensive map of current and reliable eelgrass presence and distribution was highlighted as an important gap to better support decision making. Developing an eelgrass map will support future discussions about how best to monitor and investigate risk and potential effects of eelgrass from aquaculture sites, which is expected to be assessed on a case by case basis. This topic was proposed to be approached in a different, more technical discussion as risks, effects and thresholds are important considerations that have been acknowledged in previous processes (e.g. DFO 2009, 2012 where context was identified as playing a significant role, and consideration must take into account aquaculture type, location, currents, salinity regimes, community involvement, amongst other factors). Currently, something as simple as where eelgrass is distributed is a very difficult question to answer. Presence/absence may not always be enough information but in some cases it would be the best information available. NET Force aims at supporting questions related to eelgrass distribution, which is a key step to move the aquaculture discussion in the right direction, and to subsequently help future discussions in a different type of forum, process or working group.

In Pacific Region, eelgrass is a conservation priority in the MPA network design, and the region is in the process of scoping ecological significant species to further advance conservation goals. Eelgrass will most definitely make it to this list. In the context of conservation management, there are opportunities working with different jurisdictional groups such as Parks Canada, to identify other management tools outside DFO.

Session 5: How eelgrass data products have been used, or will be used in the future, to inform decision making

Plenary discussion

This discussion session was designed to encourage participants to share how data products and dynamic national maps from NET Force can better support decision making. NET Force is planning to stitch different data products together, to zoom into different areas of interest, and to explore what data and metadata is available for the different types of requests. This plenary session focused on understanding how decision makers will be using eelgrass information, identify some of the types of decisions that may be encountered, and identify how NET Force can support future decisions that managers may be facing in the next few years. This discussion and preliminary ideas highlighted below demonstrate the potential need to create a sub WG under NET Force to ensure that NET Force outputs will align with decision makers' needs. This is also a current and relevant topic for the marine spatial planning program as managers and scientists are working together to determine what spatial data products are needed and what products are feasible.

Eelgrass: dynamic system that requires a dynamic approach

Eelgrass is a fairly dynamic system. Managers would benefit greatly from a product that can be updated on a regular basis to provide the most up to date and relevant information. For example, efforts in the Quebec Region are largely focused on monitoring marine vegetation as the tools and technology available were easier to develop and apply compared to efforts that may be required to monitor fish and invertebrates. Although coastal ecosystem mapping in the Quebec region value the goal of generating updated and dynamic eelgrass data products, this is a very difficult task to achieve and further research in this realm may be required.

The Program for Integrated Environmental Response (PIER) supports environmental response planning across DFO regions. Realistically, it will not be possible to have the most up to date information on eelgrass for every location in Canada. However, for emergency response, we could take advantage of near real time information that may arrive from remote sensing for a particular area as well as the methods that members of these groups are rapidly developing, to ultimately provide near real time assessments of potential eelgrass habitat for environmental response. This type of near real time information is available and used for other needs (e.g. hurricane and weather related events). PIER is actively looking at field validation of eelgrass predictions and expert advice, with the latter being their main source of information.

Future discussions in this theme of dynamic spatial planning and information access will need to consider how current tools under development can be applied for other purposes, time scales, and management requirements to look at information in annual, seasonal or long-term cycles. For example, various pieces of data are available for different regions in Canada from different time periods, which provide snapshots in time. Based on the scoping exercise NET Force has conducted thus far, it is evident that few projects are planning to go beyond snapshots in time and to actually perform long term monitoring. In the process of creating a national map of eelgrass distribution, decisions will have to be made on what information may be presented, and what data products from different time periods are deemed appropriate. This type of decision will largely be informed and validated over time by research questions aiming at better understanding eelgrass ecology and resilience, variation over time, and time required for eelgrass beds to recover. Collectively, we can all work on the integration across scales which would be fundamental to truly make the desired map dynamic. There are teams working on the ground to understand the real local scale processes and metrics, which should then be linked and integrated with larger scale tools such as remote sensing. NET Force presents an opportunity to leverage this opportunity to improve site-specific information and explore solutions of different temporal and spatial scales. Through future engagement and discussion it would be important to keep track of what aspects will be site-specific and what aspects may be applicable across the board for eelgrass beds.

Supporting future research and cumulative impact assessments

Past research has documented the expansion of the invasive European green crab (*Carcinus maenas*) to southern and western waters of Newfoundland. The ecological impacts of these invasions can be severe, and have contributed to the degradation of some eelgrass beds (Matheson et al. 2016). The ecological devastation following Green crab expansion in some ecosystems has also been documented in terms of impacts to commercially important species (Zargarpour et al. 2020). In hindsight, information about eelgrass distribution before the green crab expansion would have provided an opportunity to quantify the extent of damage. It is the hope of NET Force to have this type of information available in the future to support the quantification of current and future extent of eelgrass beds and the impacts of cumulative stressors over time.

Compatibility of ecological and human activities over time will be addressed as part of other research initiatives underway (Serdynska et al in prep.). Vulnerability assessment, which is an important component of cumulative impact mapping, can largely benefit not only from information on eelgrass distribution but also quality and size of the eelgrass beds. This information could then be used to potentially develop and visualize a spatial health metric: relatively healthier eelgrass beds can potentially be more resilient and less vulnerable to cumulative impacts over time. Eelgrass health and condition is an

important component of the research focus in the Maritimes Region: what makes some beds more resilient than others, what are the environmental features that make some beds more resilient to change. As we build this initiative and make more connections we will be able to expand tools needed to answer these questions. For example, Species Distribution Modelling (SDM) in the Pacific and Maritimes Region can help answer questions related to ecosystem conditions that are important in the context of past, current and future predictions. This is another example of how this network is expected to provide a platform for partners to advance individual research to achieve a common goal. This discussion also provides potential future research priorities that may advance after current goals and objectives of NET Force are accomplished.

Identifying priority eelgrass areas

Environmental assessment and conservation planning can benefit from the process of identifying particular eelgrass beds that may require prioritization due to their vital ecological role in supporting the life cycle of important species or commercially important stocks (e.g. nursery, shelter, and feeding habitat). The question was posed to this initiative as to whether some effort may be allocated to explore criteria to potentially identify unique, resilient and particularly important eelgrass beds. This type of identification and prioritization could be useful also for PIER during an oil spill response, as well as considerations under reviews relevant to the *Fisheries Act* (e.g. ESA).

Data gaps

NET Force will continue to identify the many spatial data gaps associated with eelgrass information. Spatial gap areas worth mentioning include coastal Newfoundland and Labrador, northern British Columbia, the Arctic and Nova Scotia. NET Force is planning to use funds available to support large scale approaches to fill some of these spatial data gaps using satellite imagery and SDM. These two broad scale techniques will be integrated into a framework to make better predictions while minimizing satellite acquisitions and environmental data required. A more targeted conversation will follow to identify what locations may benefit from investment to better support decision making. There are several limitations on the data and data products available. The goal is to make best use of existing information and to document caveats and uncertainties properly.

Eelgrass within zones

The development of an eelgrass map will hopefully support other discussions related to distance of eelgrass to predicted exposure zones, and advice on susceptible eelgrass areas within those zones. The following are examples of exposure zones associated with different activities.

- Predicted exposure zones are determined by the aquaculture Science group with the site information provided by proponents (e.g., current meter data) to calculate exposure zone of aquaculture activities (e.g., depositional feed/feces, advective/dispersive fish health treatments).
- The predicted extent of an oil spill area is used by PIER to define an exposure zone/response area in support of response planning.
- The Ecosystems Management Regulatory Review Unit undertakes the review of project plans [works, undertakings and activities] to identify the potential risks of the project to the conservation and protection of fish and fish habitat (e.g., environmental and impact assessment data) to make regulatory decisions under the *Fisherie*s Act and the *Species at Risk Act*. Benthic information in the project footprint is often requested by the proponent and information related to the affected areas of activities is requested on a project-specific basis. If the data does not exist, then the Regulatory Reviews Unit requests that the proponent obtain the information. Historical eelgrass layers created for internal DFO purposes are then used to summarize information, including associated underwater video. There is no clear guidance on how far from the project footprint information should be collected and has ranged from 0 to 500 meters beyond the footprint depending on the environmental setting and scope of each individual project and/or the potential for cumulative effects. Biophysical and ecological overviews provide foundational information for site design and MPA network planning. Eelgrass within the boundaries of potential conservation areas would be key information to support potential conservation objectives

Session 6: Peer review publications – Eelgrass distribution in Canada

NET Force is planning to use traditional collaborative spaces for integration and data dissemination in the form of peer-review publications. These will be products of this group with a contribution to the scientific literature and the larger community.

Session 7: Diversity of eelgrass and eelgrass data products

Presenter: Matt Christensen

Eelgrass mapping data is diverse and includes many different data types that were collected for different purposes using different methodology. Data types may include species distribution models, presence/absence surveys, and extent polygons. Data may have been collected for environmental monitoring by academic institutions, government agencies, NGOs or for mitigation or impact assessments by consultants. These data may be collected using drones or planes, sonar, satellite imagery, underwater camera, diving, or foot-based mapping. Each dataset has varying spatial and temporal scales. The accessibility of eelgrass mapping data is often limited by either the data format or

available metadata and documentation. Data formats are mostly raster or vector but the degree to which the data has been processed and the availability of metadata for both collection and processing limits its usability. There are currently several simultaneous eelgrass mapping data collation efforts at varying scales and for different purposes. These efforts speaks to both the utility and complexity of collating eelgrass mapping data as well as the need for a centralized clearinghouse such as NET Force. Absences are as valuable as eelgrass presence. NET Force presents enough capacity and expertise to make this project succeed as long as tasks are organized and tackled in focused groups to define clear roles and avoid overstretching participants.

Session 8: Technical Forum - stitching data & visualizing uncertainty

Presenter: Catalina Gomez

Presentation and plenary discussion

This initiative has the difficult task of bringing together eelgrass expertise, data, data products and metadata to develop a national dynamic map of eelgrass distribution in Canada that is publicly accessible, dynamic, and useful for monitoring and collective decision-making. Early engagement and participation is key if we want to succeed with this endeavor and that is why we are proposing a very technical GIS workshop in the coming months. The plan is to convene in a virtual space and to use ArcGIS to start exploring the challenges and obstacles ahead in a very practical way. The GIS analyst will create maps on the fly using sample data from different regions. With input from everyone in the virtual room, the GIS analyst will visualize and examine how different data products may look like when being assembled in the same map.

The purpose of this initiative may need to be at the forefront of this exercise so there is clear direction on what activities, data and data products may need to be prioritized. This is because some of the eelgrass data available is outdated, interannual variability in an eelgrass bed can be extremely high, and therefore, there will be questions about the reliability of historical data that will need to be assessed. For example, if outputs are primarily for decision making we may want to decide what would be the oldest data source we can include in a dynamic map to support current and future decision making. Historical eelgrass, consequently, may be of interest at a later stage of NET Force (e.g. Nahirnick et al. 2020).

This workshop will also allow us to explore the concept of stitching data, a notion borrowed from Natural Resources Canada (Natural Resources Canada) when they document the process of amalgamating data from different surveys for mapping surficial geology. Once outputs are stitched, the not so trivial process of developing standardized legends begins. This workshop will allocate time to discuss developing legends so products in Canada's three coasts are comparable. During this upcoming

workshop we would also start examining how to visualize uncertainty by using, for example, color coding. Locations where we are confident that there is eelgrass (due to field work for example) may look bright in a map, and areas where we are less confident that there is eelgrass (models not yet validated) could have a darker transparency. This workshop will further explore how to represent spatial gaps that may direct future monitoring efforts, and how to properly acknowledge and highlight contributions that all different groups are spearheading in each region (Figure 3). One of the biggest challenges will be keeping this a simple yet informative mapping product.

Figure 3. Key concepts that will be explored during the GIS technical forum for internal and external partners.

Session 9: Roadmap for engagement with external partners

Plenary discussion

This forum was our first formal engagement with national DFO partners to better understand and align eelgrass information and products with research and management needs. There is a large group of external partners that are part of NET Force, including the Nova Scotia eelgrass WG where the idea of an eelgrass map first emerged. In this context, a similar forum with external partners was organized for the end of 2020.

The forum with external partners is summarized in sections below. It discussed similar issues as the ones discussed in the first forum, including what data products may be useful for their purposes, and partner's contribution to NET Force. Results of data surveys reflected interest and willingness of external partners to accomplish our goal of open and publicly accessible spatial data products, leveraging infrastructure and expertise available at DFO.

Session 9: Final remarks

Bob Gregory, Tana Worcester and Melisa Wong

The awareness about the importance of eelgrass habitat has dramatically increased in the past few decades. It is fundamental that we can continue to recognize their key role in providing vital ecosystem services including carbon storage, fisheries maintenance, biodiversity support, shoreline protection, water filtration, nursery, shelter, and feeding habitat for a large variety of species and commercially important stocks. The interest was reflected in this forum today and it is our hope that it will continue to grow and expand as we begin to collectively establish an innovative, diverse and inclusive partnership of scientists, managers, and partners working towards our concrete common goal of a national dynamic map of eelgrass distribution in Canada.

ENGAGEMENT: NATIONAL MULTI-PARTNER FORUM

This forum took place on Microsoft Teams on December 2, 2020 and it followed a similar layout as the DFO national virtual forum (Table 3):

- Context and introduction presented by the chairperson (Tana Worcester);
- Description of NET Force goals and terms of reference (Melisa Wong);
- Plenary discussion; including discussion of presentations about the diversity of eelgrass products;
- Platforms for sharing information, data agreements, and goals of the upcoming GIS technical workshop (Matt Christensen and Javier Guijarro-Sabaniel).

Forty seven participants joined this workshop (Appendix 3) from the Pacific and Atlantic coasts of Canada, representing academia, NGOs, the private sector, science institutions, Indigenous groups, community groups and different levels of government organizations (municipal, provincial and federal). This section of the report summarizes information that differed from DFO's national virtual forum, including an exchange of information about the diversity of eelgrass initiatives and current projects and research in Canada. Presentations from the forum are available at this link. Many participants expressed willingness to continue engagement with NET Force, by participating in technical sessions, developing a community of practice, and sharing data products for

inclusion in the national eelgrass map. Participants expressed a desire to have more workshops related to eelgrass and the consolidation of a community of practice to support more opportunities for exchange of information. These items require further resources to achieve, and consequently, follow-up discussion may be required to identify opportunities to consolidate initiatives different to the ones laid out in the Terms of Reference of NET Force.

Table 3. Agenda of NET Force first virtual Forum, December 2 2020.

Time (AST)	**Items**	
1:00 PM	Introduction and Context	Tana Worcester
1:30 PM	NET Force: Introduction, Terms of Reference, DFO Forum, Membership. Opportunity to ask questions and provide feedback for ToR and this initiative.	Melisa Wong; All
2:15 PM	Plenary Discussion: what eelgrass data is available, how eelgrass data products have been used, or will be used in the future, to inform decision making, and to better support your organizations, mandates, communities and institutions	All
3:00 - 3:15 PM	Break	All
3:15 - 4:00 PM	Eelgrass: diversity of data, sharing platform and data agreements	Matt Christensen, Javier Guijarro-Sabaniel; All
	Technical Forum: stitching data & visualizing uncertainty	Javier Guijarro-Sabaniel; All
	Final remarks	All
	Feedback, Q&A	

The plenary discussion allowed participants to explore key questions from the perspective of each organization, including: what eelgrass data are available, how eelgrass data products have been used or will be used in the future to inform decision making, and how to better support the various organizations, mandates, communities and institutions. It was evident that the one hour allocated for this exchange was not enough to provide a comprehensive understanding of all perspectives. Table 4 identifies platforms used, or planned to be used, to access eelgrass data; Table 5 summarizes

examples of participatory science activities highlighted in the plenary session in the context of eelgrass.

Table 4. Online platforms available that include eelgrass records in Canada.

Platform/Tool	Website	Type of eelgrass data
OBIS	https://obis.org/	Datasets
CIOOS	https://cioos.ca/	Datasets
GBIF	https://www.gbif.org/	Species occurrence records
SeagrassSpotter	https://seagrassspotter.org/	Species occurrence records
iNaturalist	https://www.inaturalist.org/search?q=eelgrass	Species occurrence records

Dataset: Structured collection of data
Species occurrence record: Evidence of the occurrence of a species (or other taxa) at a particular place on a specified date

Table 5. Summary of participatory science engagement related to eelgrass in Canada addressed during the forum.

Contact	Geographic scope	Examples of activities
Bruce Hatcher	Bras d'Or Lakes, Nova Scotia, Canada	UNESCO Man of the Biosphere, annual surveys
Margot Hessing-Lewis	British Columbia, Canada, and international	Standardized data management and data collection approaches, Global seagrass community, IUCN
Jordy Thompson	Nova Scotia, Canada	Ecology Action Center, mobilizing communities to collect information on eelgrass data to validate predictive models
Mary Kennedy	Nova Scotia, Canada, and international	Data management and standards, and use of open data platforms (Table 4).
Diane Sanford	British Columbia, Canada	Mapping manual was developed in 2002 for British Columbia with standardized methodology

Session 1: Remarks by forum participants

This section synthesizes some of the main remarks and recommendations by participants during this national virtual event.

- Bruce Hatcher (Cape Breton University) provided introductory remarks about the importance of identifying why this mapping exercise and national undertaking important, and how it may be used by different organizations, communities and institutions. This set the stage for the plenary discussion and an opportunity for

participants to provide examples of how they use, or could use, information related to eelgrass distribution.

- From a policy and coastal planning perspective, Leigh Howarth (Centre for Marine Applied Research, CMAR) described how the Province of Nova Scotia, in accordance with federal and provincial policies, aims at avoiding locating sewage plants, construction, and aquaculture sites, near eelgrass beds. This is difficult to achieve in Nova Scotia as there is limited information about the exact location and distribution of eelgrass. Consequently, a dynamic map of eelgrass distribution can be fundamental to support coastal planning activities by provincial regulators such as the Nova Scotia Department of Fisheries and Aquaculture.
- Aimee Gromack (DFO) pointed out that in order to apply regulatory tools to protect eelgrass, we need to understand the effects of climate change in different and representative environmental conditions, and therefore, eelgrass mapping products are a good start to subsequently explore questions related to eelgrass quality and its resiliency to climate change.
- Al Hanson (ECCC) identified that a map of eelgrass distribution can help identify and prioritize gaps, as well as potential funding envelops. This task force can be an avenue to support communication and linkages between related projects.
- Participants highlighted the importance of leveraging efforts from past and current initiatives to ultimately strengthen NET Force. This task force is aware of past initiatives and is aimed at bringing partners together to further develop an evergreen eelgrass mapping product, with associated metadata, and a data management plan. Important efforts being conducted over the years to map eelgrass include:
    - International efforts from Fred Short and collaborators to map global eelgrass beds (www.seagrassnet.org);
    - Efforts by Margot Hessing-Lewis (Hakai Institute and Natural Climate Solutions) for data collection associated with seagrass density, cover, and fish communities, aiming at supporting long-term monitoring frameworks in British Columbia. This includes the development of standardized data management and data collection approaches through the Global seagrass community of practice from the International Union for Conservation of Nature.
    - Efforts by Lynn Lee in Parks Canada (Pacific Region) to make 15 years of eelgrass data accessible. This includes handling obstacles related to data compatibility and structure of databases. She recommended the co-development of guiding practices to achieve common structure in data collection and management across the country in support of NET Force.

  - Eelgrass mapping efforts led by the Commission for Environmental Cooperation (CEC) (http://www.cec.org/);
  - Distribution of current and historical eelgrass sites in Canada (Figure 1, Environment and Climate Change Canada, 2020);
  - Blue economy project led by Mary O'Connor and Matt Christensen (UBC, see more information in the gallery of recordings).

- Christina Macdonald, engagement specialist with the Canadian Integrated Ocean Observing System (CIOOS) Atlantic, highlighted the potential for this platform to explore opportunities to house eelgrass data in their system. Hakai Institute, for example, is working with CIOSS to use this portal as a way to consolidate metadata, structure a pipeline to organize data acquisition, and develop data products. It would be critical to ensure that there is not duplication of efforts as there are many other systems already established, including MSDI. Thus, careful consideration as to what systems to use will be important to reduce barriers for participation (see also Table 4).
- Mary Kennedy (retired, DFO) supported and advocated for appropriate data management and standards to help the process of using and updating data. She also highlighted additional platforms already established such as Ocean Biodiversity Information System (OBIS) and Global Biodiversity Information Facility (GBIF). Other platforms highlighted by participants include SeagrassSpotter and iNaturalist. A discussion is warranted to clarify the role of the many different platforms (summarized in Table 4) to avoid duplication of efforts and leverage already existing systems.
- Jordy Thompson described the role of the Ecology Action Center (EAC) at mobilizing communities to collect information on eelgrass data to validate predictive models. In addition to this participatory science approach, the EAC is also supporting policy case studies internationally to ultimately apply lessons learned in the regional context. EAC is interested in understanding what eelgrass data products may be available to engage the community and continue to support field work activities for additional data collection.
- Jennifer Yakimishyn (Parks Canada – Pacific Region) described the role of Parks Canada Ecological Integrity unit in monitoring coastal eelgrass meadows and associated fish communities, in collaboration with Hakai Institute. Jennifer is also involved with the ECCC projects looking at blue carbon within eelgrass meadows in the region. Parks Canada mandate includes long-term monitoring and protection of important ecosystems, which include eelgrass, informing management decisions related to conservation, restoration, and climate adaptation. An additional component includes data sharing, and methods to develop products that are consistent across regions (work which is already

underway with the Hakai Institute). It was highlighted that the Pacific Region is well-organized with well established networks of collaboration.

- Sarah Yuckin (Parks Canada) from the Ecological Integrity division in National headquarters described her role in supporting field units collecting data, as well as publishing data in the Open Government portal.
- Alan Hanson (Environment Canada - Canadian Wildlife Services, CWS) primarily works on conservation of migratory birds. Eelgrass provides important habitat for several species of migratory birds. In the 1980's, CWS had an inventory of coastal habitats which included information on eelgrass distribution. Since that time, other mapping projects have expanded information on eelgrass and supported work for the conservation of waterfowl species. Eelgrass is classified as a ECCC wetland type that warrants protection under the Federal Policy on Wetland Conservation, whose objective is to "promote the conservation of Canada's wetlands to sustain their ecological and socioeconomic functions, now and in the future". This Federal Policy includes guidelines of no net loss of wetland functions on all federal lands and waters that applies to eelgrass. Through environmental assessments, ECCC is asked to evaluate the potential impacts of projects on valued ecosystem components. Information on eelgrass is important to support assessments and to bring focus on the Federal Policy on Wetland Conservation. For example, if a project or undertaking cannot avoid or minimize impacts, there is a requirement for compensation and offsetting. In the context of eelgrass being a wetland type, there are a number of internationally important Ramsar designated wetlands that have achieved their designations because of the presence of important eelgrass beds.
- Alan Hanson reiterated the importance of developing a community of practice around eelgrass, and continue to support different mandates shared by organizations. This community of practice may be valuable if it extends beyond mapping to include conservation actions and policy. This type of community of practice can also support information products being developed by CWS such as the Important Areas for Marine Birds for Eastern Canada. At the time of its development, the Important Areas project required time-consuming engagement with four different DFO regions. A centralized community of practice can support this work, avoid duplication of efforts, and maximize efficiency.
- Brigitte Leblon (University of New Brunswick) conveyed information about her role in developing and using remote sensing tools for eelgrass mapping, as well as training material that could be developed by her group to support the eelgrass community.
- Jennifer Sylliboy (The Unama'ki Institute of Natural Resources), described initiatives to map wetlands in the Bras d'Or Lakes to identify wetlands of special significance. Wetlands provide important habitat for culturally important species

such as American eel (*Anguilla rostrata*). Mapping conducted in the Bras d'Or Lakes by Herb Vandermeulen is being archived by DFO Maritimes region. Access to this information by the eelgrass community would be useful to identify eelgrass habitat that may have been lost, or expanded, in the Bras d'Or Lakes.

- Diane Sanford and Anuradha Rao, from Sea Change Marine Conservation Society, described their work conducting eelgrass monitoring, mapping and restoration in the southern region of British Columbia. Recognizing the important role of participatory science and citizen involvement, a mapping manual was developed in 2002 for British Columbia with standardized methodology (https://www.cmnbc.ca/wp-content/uploads/2018/11/Methods-for-Mapping-and-Monitoring-Eelgrass-Habitat-in-British-Columbia-2002.pdf). This is currently being updated. Sea Change Marine Conservation Society also works in partnerships with First Nations to incorporate traditional knowledge and past history of seagrass beds in terms of location and use, leading to fairly comprehensive mapping of eelgrass. Sea Change Marine Conservation Society is currently working on a federally funded project to continue incorporating traditional knowledge and supporting baseline data collection to fill data gaps. One of their goals is to guarantee that the information will be available for planning at the municipal, provincial or any level of government, to make sure that marine spatial planning decisions, including coastal real state planning, will include seagrass considerations. Current mechanisms to exchange eelgrass information includes a current collaboration with the Pacific Salmon Foundation. A site is being created to be used as a tool to provide eelgrass baseline information and mapping. Networking capacity in British Columbia is large, partners successfully reach out to support and push for local by-laws. Education has been a very critical important tool to move projects forward.
- As a general recommendation for NET Force, Anaradha Rao highlighted the importance of reaching out to First Nations. This will require targeted effort as there are many efforts already underway in Pacific Region towards contributing to the broader picture. It is the hope that DFO regional co-chairs will help to reach out to Indigenous groups as this task force continues to evolve, while being respectful of their time and already established commitments and projects. Davies Morgan (Parks Canada, Gulf Region) highlighted that in some cases there are privacy concerns in relation to eelgrass data collected in First Nation territories, and consequently, further engagement will be required with Indigenous groups.
- Charlene LeBlanc shared the work that the community of Argyle Municipality in Nova Scotia started in 2016 to evaluate an aquaculture development area. Drones are being used for eelgrass mapping, and there is interest in learning more about the GIS tools and techniques available to process information and

develop consistent mapping products. A spatial dynamic map of eelgrass can ultimately support the process of placing potential aquaculture sites by avoiding eelgrass beds and providing a buffer to allow them to expand. Alex d'Entremont noticed that residents are very interested in eelgrass, particularly hunters which have knowledge about changes in the current and historical distribution of eelgrass.

- Mary O'Connor (University of British Columbia, UBC) highlighted the importance of historical information on eelgrass, and the many challenges associated with data rescue. The Living Data project (NSERC program) is an initiative to preserve and rescue legacy datasets, as well as to train students in best practices in data management, reproducible research, synthesis statistics and scientific collaboration. This initiative organizes data archiving internships, student-dominated working groups, undergraduate hackathons, multi-university courses, and a national certificate program. This initiative could be leveraged to rescue historical eelgrass data to support future endeavors to understand historical distribution.
- Emily Geissinger, PhD student at Memorial University in Newfoundland and Labrador region, is conducting her graduate work on habitat use of juvenile fish and nursery areas. Her group is planning to expand research on aspects related with microbial and other fauna that inhabits eelgrass. A comprehensive dataset of eelgrass distribution is critical to advance eelgrass research in Canada.
- Fanny Noisette, professor in benthic ecology and ecophysiology in the University du Québec à Rimouski, is working on seagrass and seaweeds in boreal regions and their future in the context of climate change. Having a global map would help her group identify different meadows showing contrasted environmental conditions, to assess differences in eelgrass physiological responses. She also envisions NET Force as an important networking platform to develop collaborations with seagrass partners outside of the Quebec region.
- Brett Painter (ECCC) has contributed to the upcoming publication to report on the Canadian Environmental Sustainability Indicators program (CESI) which tracks long-term trends for issues of key concern to Canadians (Environment and Climate Change Canada, 2020). Eelgrass indicators are represented as a summary of sites that indicate eelgrass presence (Figure 1). NET Force provides an opportunity to expand upon this work, avoid duplication of efforts, and support updates in approximately 3 years.
- Davies Morgan (Parks Canada, Gulf Region) is working on tidal underwater video surveys and is looking for a community of practice that can provide advice on how improve eelgrass density measurements.
- Bruce Hatcher described his research in relation to the role that seagrass meadows play in the biochemical cycles and web structure. Future research will

focus on adaptation and resilience of eelgrass to climate change. His past role with the UNESCO Man of the Biosphere highlighted the important role of participatory science on seagrass monitoring, exemplified with an annual survey in a small area of the Bras d'Or Lakes. These initiatives require robust co-development of management plans to clarify different needs and data types.

- Bruce Hatcher reiterated the importance to continue to articulate and refine the type of decisions that can be informed by outputs of this task force, as well as the best mechanisms to make information accessible to different communities and organizations. One recommendation is to continue to identify policies and regulatory frameworks that require eelgrass information. NET Force represents an important yet a challenging task to bring together very diverse data, and to make it interoperable with the various partners that collect data in various ways. Consequently, data integration will require careful consideration on how data will be combined, with associated technical guidance. Furthermore, discussion on how to collect eelgrass data may be a worthwhile endeavour so future work conducted by different organizations is based on agreed best practices to ultimately strengthen future data products.

Session 2: Data, workflows and data agreements

Workflows for data sharing, accessibility and data agreements
Javier Guijarro-Sabaniel

Figure 4 represents the proposed workflow between eelgrass data contributors and NET Force, and provides examples of usage. Data providers have the following two options for data sharing:

1. *Eelgrass workflow with DFO support* - Data providers have the option to share eelgrass data with NET Force GIS analyst using a DFO cloud store. Eelgrass data submitted will only be visible and accessible by each individual data provider and the GIS analyst. Eelgrass datasets will be compiled into a standardized format, which will then be submitted to the Ocean Biodiversity Information System (OBIS) on behalf of data providers. OBIS is a global open-access data aggregate platform on marine biodiversity, which allows access to data that is connected to data providers.

2. *Alternative eelgrass workflow through OBIS* - Data providers can directly place their eelgrass data in OBIS if they prefer this platform instead of using the DFO cloud store. Data providers can communicate with the NET Force GIS analyst to coordinate work to access data that may have not been shared through the cloud, and avoid duplication of efforts.

All partners and the public will be able to access and download **standardized eelgrass data** through OBIS. OBIS uses the Darwin Core standard which is basically a structure of columns and rows. OBIS harvests occurrence records from thousands of datasets and makes them available as a single integrated dataset. There are several ways to access OBIS data and one of them is through a package that provides direct access to the OBIS database using the programming language R. Users and data providers will be able to access the standardized eelgrass data to ensure it contains all the appropriate information. Users can use R code to download the data or the GIS analyst can provide support to access it.

All partners and the public will be able to access and download **eelgrass derived data products** through the Open Government portal (https://open.canada.ca). Users will have the ability to visualize the data products using tools like the marine spatial planning atlas. The open portal will updated eelgrass data products as they become available.

A template of the data agreements designed to support NET force workflow are available in Appendix 4 and Figure 5. Additional technical information will be discussed during the technical forum that will be held in the Fall 2021. Information about this GIS technical forum is laid out in session 8 of this document in DFO's national forum.

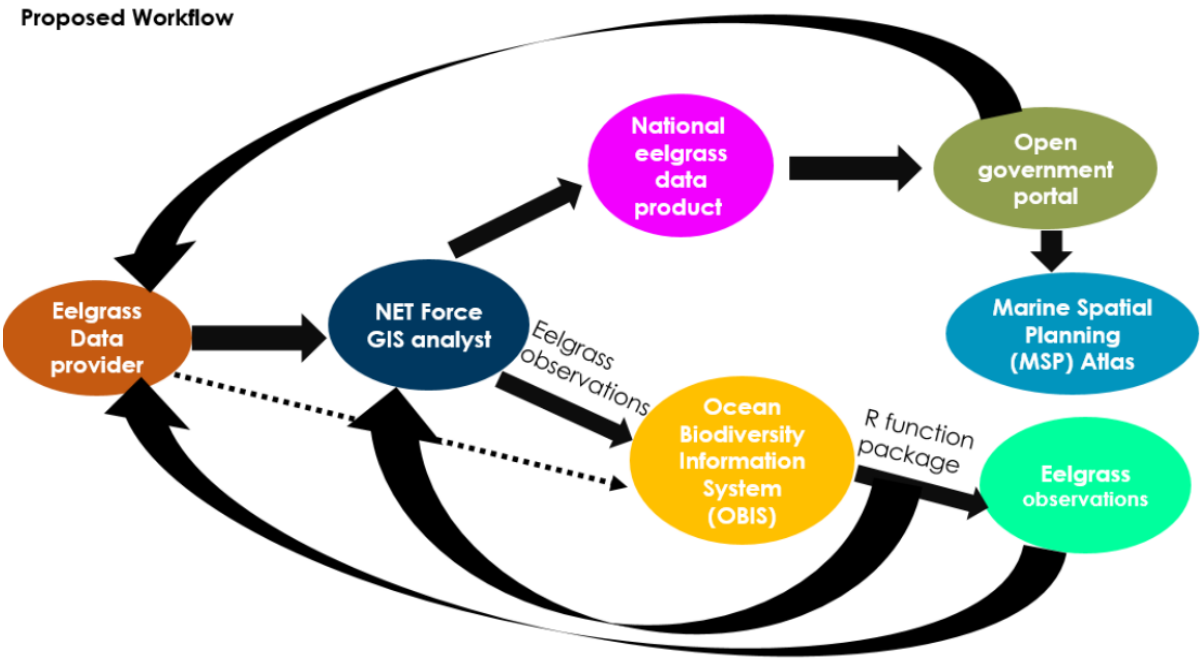

Figure 4. Diagram representing the proposed workflow between eelgrass data contributors, NET Force and examples of usage e.g. marine spatial planning atlas.

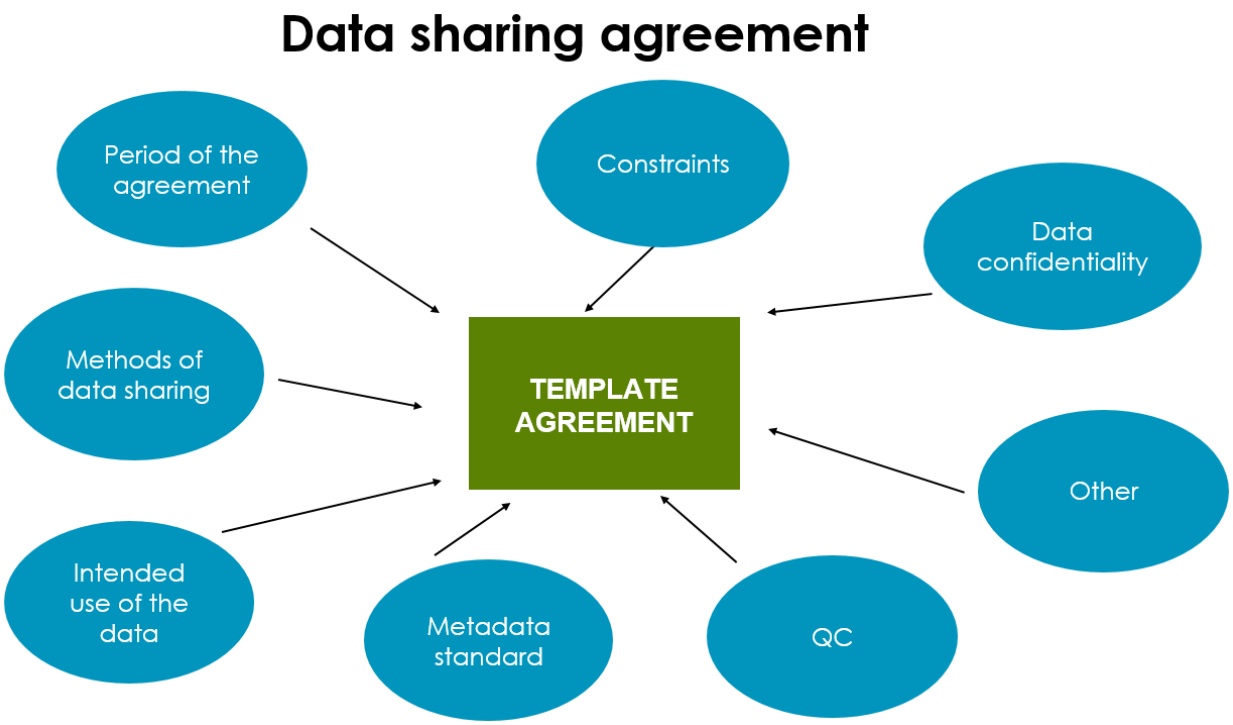

Figure 5. Diagram outlining the key aspects that would be included in data agreements between NET Force and data custodians, including information on quality control (QC) , data confidentiality if appropriate, constraints of data usage, period of the agreements, methods used to acquire eelgrass data and data sharing options, intended use of the data (national map of eelgrass), and metadata based on Open Government standards.

FINAL REMARKS

NET Force engagement has offered participants the opportunity to come together, learn, and exchange information in a collaborative setting to discuss eelgrass monitoring and research to support decision making. Engagement has been organized with the goal of supporting the NET Force endeavour of improving eelgrass spatial data products and improving communication of science advice to both internal decision-makers and external partners by bringing together relevant members currently working in eelgrass and pursuing the process of developing products in a transparent and participatory manner. These proceedings were assembled to maintain institutional knowledge by summarizing past and current eelgrass work, to receive feedback early in this initiative, and develop a roadmap to advance NET Force goals. Engagement and virtual initiatives have facilitated relationship building amongst partners, regions and sectors, and has facilitated the creation of an invaluable network to set the stage to collectively build a national, consistent eelgrass spatial data product. This report documents the beginning and an introduction to NET Force. We have secured three years of dedicated funding, and we are confident that collaboration will prevail.

ACKNOWLEDGMENTS

Special thanks to all workshop participants that have made possible the creation of the National Eelgrass Task Force. This endeavour would not be possible without their support and contributions. Many thanks to Jeffrey Barrell and Aimee Gromack for reviewing and providing feedback on this manuscript. The virtual forum would not have been possible without the interest and participation of all participants that contributed to this forum ad eelgrass research, monitoring and conservation. This initiative is being supported by DFO's Deputy Minister's Results Reserve Fund (2020-2023), and is part of a broader Maritimes-led proposal titled "Innovative Approaches and Experimentation to Operationalize the Blue Economy in Maritimes Region". Thank you to Phil Greyson, Gordana Lazin, and Lindsay Brager for taking notes during DFO's virtual forum. Thank you to Sheila Prall-Dillman and the DFO partnership hub for their support in designing the template for NET Force data agreements. DFO's forum organizing committee was composed of the following DFO Science staff: Melisa Wong, Tana Worcester and Catalina Gomez. Multi-partner forum organizing committee was composed of the following DFO Science staff: Melisa Wong, Javier Guijarro-Sabaniel, Matt Christensen, Tana Worcester and Catalina Gomez.

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APPENDIX 1. Attendee List (43) of the DFO virtual NET Force Forum, September 21 2020.

Participant	Sector	Region
Toby Balch	Science	Maritimes Region
Jeffrey Barrell	Science	Gulf Region
Tammy Blair	Science	Maritimes Region
Lindsay Brager	Science	Maritimes Region
Monica Boudreau	Marine Planning & Conservation	Gulf Region
Scott Coffen-Smout	Marine Planning & Conservation	Gulf Region
Michael Coffin		Gulf Region
Christine Desjardins	Science	Quebec Region
Emmanuel Devred	Science	Maritimes Region
Eva Dickson	Science	Gulf Region
Catalina Gomez	Science	Maritimes Region
Phil Greyson	Science	Maritimes Region
Robert Gregory	Science	Newfoundland & Labrador Region
Aimee Gromack	Integrated Planning FFHPP	Maritimes Region
Javier Guijarro-Sabaniel	Science	Maritimes Region
Adrian Hamer	Science	Maritimes Region
Cara Harvey	Science	Maritimes Region
Noreen Kelly	Science	Maritimes Region
Tanya Koropatnick	Marine Planning & Conservation	Maritimes Region
Gordana Lazin	Science	Maritimes Region
Caroline Longtine	Science	NHQ
Matt Christensen	Science	Pacific Region, University of British Columbia
Grace Murphy	Science	Maritimes Region
John O'Brien	Science	Maritimes Region
Ashley Park	Science	Pacific Region
Scott Pilcher	Science	NHQ
Sheila Prall-Dillman	Policy & Economics	Maritimes Region
Laurence Provencher-Nolet	Science	Quebec Region
Stacey Rehel	Marine Planning & Conservation	Gulf Region
Monik Richard	Marine Planning & Conservation	Gulf Region
Carrie Robb	Science	Pacific Region
Emily Rubidge	Science	Pacific Region
Anna Serdynska	Marine Planning & Conservation	Maritimes Region
Colleen Smith	Integrated Planning FFHPP	Maritimes Region

Candice St. Germain	Science	Pacific Region
Mike Sullivan	Science	Maritimes Region
Nadine Templeman	Science	NHQ
Sarah Tuziak	Integrated Planning FFHPP	Maritimes Region
Lindsey Weber	Policy & Economics	Maritimes Region
Maxine Westhead	Marine Planning & Conservation	Maritimes Region
Kristen Wilson	Science	Maritimes Region
Melisa Wong	Science	Maritimes Region
Tana Worcester	Science	Maritimes Region

APPENDIX *2. Abstracts of recordings made available for NET Force forum.*

Coastal Ecosystem Mapping, DFO, Quebec Region
Christine Desjardins

The mapping of coastal ecosystems is a project initiated jointly by Fisheries and Oceans Canada (DFO) and the University of Quebec at Rimouski (UQAR) in 2017. The objective is to carry out a surface mapping of intertidal and subtidal coastal marine ecosystems shallow water throughout Quebec. DFO is participating in this project as part of the Federal Planning for Integrated Environmental Response (PIER) initiative, which aims to support planning and response to environmental incidents by identifying environmental sensitivities. The project will generate maps of vegetated habitats considered vulnerable such as eelgrass, marshes and kelp beds for which the available data are obsolete or non-existent (Desjardins et al. 2018). The mapping uses aerial photos acquired by DFO (2015- 2020) at a spatial resolution of 30 cm and including 3 visible bands, red, blue, green and the infrared band. From these photos, mosaics are created and then an automatic segmentation is performed using PCI Geomatica. The generated segments, or polygons, are imported into a geodatabase (ArcGIS software from ESRI) to allow manual editing and their characterization. The minimum size of the mapped elements has been arbitrarily set at 1000 m^2. A review of the literature, photo-interpretation using oblique photos taken by UQAR, as well as field campaigns provided input for the characterization. To date, nearly 2,600 field validation points in the intertidal have been visited by UQAR and approximately 2,000 underwater video observation points have been visited by the DFO team. For each of the polygons, the characteristics concerning the presence / absence of eelgrass, the layering, the substrates, the vegetation cover, the dominant types of vegetation (algae and plants), the geomorphological system as well as the anthropogenic elements of the coast are interpreted and integrated into the characterization. The final product will not only update the mapping of eelgrass beds, but also those of other important coastal habitats such as marshes and kelp beds.

Eelgrass Mapping & Monitoring in the Southern Gulf of St. Lawrence, DFO, Gulf Region
Monica Boudreau, Jeff Barrell and Eva Dickson

Under the *Oceans Act*, Fisheries and Oceans Canada (DFO) is responsible for managing, in collaboration with partners and partners, estuarine, coastal and marine ecosystems through three principles: sustainable development, integrated management and the precautionary approach. Integrated management plans require objectives to protect ecosystems. These objectives may include, amongst others, enhanced protection of species considered important to maintain ecosystem structure and function

which may be designated as Ecologically Significant Species (ESS). Within coastal systems of eastern Canada eelgrass has been designated an ESS due to its many ecosystem services. Effective mapping and monitoring of eelgrass ecosystems is recognized as a crucial component of the management and protection of coastal landscapes and the ecosystem services they provide. In the Gulf Region, the Marine Spatial Planning initiative has provided an opportunity to develop and implement a framework to map the current distribution of eelgrass and initiate the long-term regional monitoring of this ESS in bays and estuaries of the southern Gulf of St. Lawrence. Working collaboratively with DFO-Science, efforts are currently focused on producing distribution maps from Wordview-2 and 3 satellite imagery. These maps will be updated on a cycle to assess changes in distribution. Research will be conducted to attempt to distinguish natural temporal and spatial variability from changes caused by anthropogenic pressures. If declines due to anthropogenic pressures are suspected, strategies will be developed to increase eelgrass mapping resolution, at local and bay scales, using a tiered approach to investigate potential causes. Once identified, appropriate management measures can be implemented to address these pressures to maintain or restore eelgrass ecosystems within the Gulf Region.

Eutrophication in the Southern Gulf of St. Lawrence, Gulf region
Michael Coffin

Intensity and frequency of nutrient impacts to coastal systems is increasing concomitant with increases to human population and land-use all around the world. Estuaries and bays in the Southern Gulf of St. Lawrence are no exception, though nutrient impacts are mostly associated with agricultural activity, particularly on Prince Edward Island. Nitrogen is the primary nutrient of consequence to marine systems, if not taken up on land, nitrogen leaches into groundwater and eventually makes its way through the watershed and into the estuary. Increased nitrogen availability leads to a well-established ecosystem response, whereby primary production and overall biomass of the system increases but it also become dominated by fewer species. Eutrophic systems are also characterized by large fluctuations of dissolved oxygen concentrations, higher during the day when oxygen is produced through photosynthesis and lower at night as respiration rate increases. We developed a monitoring program to capture these dissolved oxygen fluctuations with the intent to infer the trophic status of estuaries. High frequency dissolved oxygen data was collected in the upper estuary of 15 sites across the Southern Gulf of St. Lawrence. The dissolved oxygen time series were divided into biologically relevant metrics, representing dissolved oxygen variability, hypoxia and oxygen supersaturation which were then analyzed with multivariate statistics. Ultimately we found that these metrics predicted habitat type (eelgrass or macroalgae) and were predicted by nitrogen loading and water residence time. When we expanded dissolved oxygen monitoring throughout the estuary there was a clear

increase in dissolved oxygen extending downstream of the upper estuary. Thus the hypothesis that nutrient impacts are greatest where they are first available within the system was supported. When we tested the same hypothesis using eelgrass health metrics, the same pattern was found, i.e., eelgrass condition improved with distance from freshwater. However, and like in many estuaries around the world, we noticed that eelgrass was often absent from otherwise suitable habitat, likely having been displaced by macroalgae or sediments. Overall, the results of this work demonstrate that nutrient impacts occur along a gradient starting where nutrient availability is highest. Further, nutrient impacts can be quantified using high-frequency dissolved oxygen data. Finally, reduced eelgrass coverage also reflects nutrient impacts and that its absence from suitable habitat should be incorporated into impact assessments.

Blue Carbon: storage potential in Canada's eelgrass beds, DFO Pacific & Maritimes Region, University of British Columbia

Matt Christensen, Melisa Wong, Mary O'Connor

Coastal marine habitats are crucial for emission reductions through carbon sequestration, where carbon is captured from the atmosphere and oceans and stored in the sediments. 'Blue carbon' refers to the carbon sequestered by coastal marine habitats. In Canada, seagrass beds and salt marshes are major blue carbon habitats, capturing carbon through photosynthesis and particle trapping and storing it in the sediments over millenary time scales. Seagrasses are particularly efficient at storing carbon, responsible for 20% of global carbon sequestration in marine sediments despite only occupying 0.1% of the ocean surface. Canada has the longest coastline of any country in the world (202, 080 km), much of which supports blue carbon habitats. Despite this, our operational knowledge of blue carbon potential on Canada's shorelines is limited, particularly for the dominant seagrass *Zostera marina* (eelgrass). Canada has relatively few measurements of carbon storage in eelgrass beds and spatial extent of eelgrass on Canada's coasts remains unknown, making national estimates of blue carbon storage potential difficult. It is challenging to integrate key environmental and ecosystem service data into economic analyses for policy decision making. Canada has committed to overcoming through its role in the Global Ocean Accounts Partnership, an international collaborative approach to recognizing and valuing oceans for their social, economic and environmental benefits. Ultimately this is realized through Marine Spatial Planning and Ocean Accounting. Marine Spatial planning refers to a framework for integrative management and structured, evidence-based decision making. And Ocean Accounting provides a method of standardizing this information and evaluating overall performance. To map and quantify Canada's blue carbon potential in seagrass, all existing mapping data and blue carbon core data will be collated. Eelgrass mapping data is not available for Canada's entire coastline and the data that does exist is derived from many different methods and is stored in many different formats. There is a very

limited number of blue carbon core data for Canada. This will be supplemented by data from nearby areas. Additional cores will be collected in the field and modelling will be used to explore C drivers in Canada's eelgrass beds. Mapping and quantifying blue carbon in seagrass habitats are one piece of the blue economy puzzle.

Eelgrass data compilation to support Marine Protected Area Network Planning in the Pacific, DFO Pacific, University of British Columbia
Matt Christensen, Carrie Robb, Emily Rubbidge

Canada has committed to establishing marine spatial plans (MSP) in four marine bioregions. On the Pacific coast (100,000 km^2), MSP planning is underway in the Northern Shelf Bioregion, also known as the Pacific North Coast Integrated Management Area (PNCIMA), and the Strait of Georgia, known as the Salish Sea Integrated Management Area (SASIMA). Part of the MSP program will involve the development of interactive bioregional marine atlas that identify the location of current activities, ecologically and biologically significant areas, ecologically significant species (eelgrass is 1 of 195 ecological significant species) and community properties, degraded areas, depleted species and important habitats. Further, regional marine use plans will be developed to identify suitable areas for where marine activities can occur and areas which need to be avoided or have special measures put in place for conservation or protection. The pacific coast has a long history of marine spatial planning exercises. Over 100 marine protected areas (MPAs) exist on the pacific coast, but most were done in an ad hoc or opportunistic manner; existing and future MPAs can be improved through a network planning approach. In BC, the Marine Protected Areas Technical Team (MPATT) consists is a trilateral approach to marine spatial planning that includes the federal and provincial governments and 16 different first nations. The core goals are to protect and maintain biodiversity and special ecological features such as eelgrass. Several recent updates to pacific eelgrass spatial data have happened in recent history including the BC Marine Conservation atlas, MPATT technical dataset and the marine spatial planning initiative. This project examines the available spatial information and known data gaps on the distribution of seagrasses in BC to help ensure that current, comprehensive spatial data on this important habitat are available to inform MSP in PNCIMA and SASIMA. This includes a review of existing spatial datasets for seagrass (with a focus on *Zostera* species) on the BC coast. More specifically, the objectives are to 1) compile available spatial data on seagrass and integrate the new information into a new dataset representing the best available information on seagrass beds for the BC coast; and 2) develop accompanying metadata using a standard metadata format.

Eelgrass studies in Newfoundland: coastal nurseries for fishes, DFO, Newfoundland and Labrador Region
Bob Gregory

I described substantive results of 25 years of research studies from coastal Newfoundland, on the function of eelgrass ecosystems as fish nurseries. The presentation represented the collective results of investigations presented in 47 graduate student theses and 60 related science papers and reports, for the most part on age 0 juvenile Atlantic cod, in Newman Sound, Bonavista Bay. The contextual backdrop to my discussion is that the northern population of this species remained below 2% of historical levels in the offshore until ca. 2010, when a modest recovery commenced. Coincidently, eelgrass percent cover in the primary monitoring sites in Newman Sound began increasing as early as 2004, even establishing meadows where the plant had hitherto been absent. Similar increases in eelgrass were also observed during the past decade elsewhere along the northeast Newfoundland coast during this same period. Even though correlative evidence is almost never to be considered scientifically conclusive, the potential link between these observations is at least strongly suggestive. Additionally, causal links between nursery function and survival of juvenile cod were being investigated in several of these Newman Sound research studies.

Experimental studies in the sound have shown that 0- and 1-year old cod abundance increases locally when eelgrass increases in an area. For example, experimental removal of eelgrass cover leads to a decline in age 0 cod abundance; in contrast, when percent cover of eelgrass is either naturally or experimentally enhanced, age 0 cod abundance increases. Several studies have demonstrated that piscivorous fish use eelgrass patch edges and the size of patches make some eelgrass habitats riskier for smaller juvenile cod, than others. One study showed that over time, eelgrass habitat has had a stabilizing effect on the nearshore fish community in coastal Newfoundland.

The plant occupies only a small proportion of the Newfoundland coast (probably <2%), yet survival of young cod throughout their nearshore residency period in eelgrass habitats beds can be ~17,000 times higher than unvegetated habitat in the same general area. The ratio more than compensates for the plant's limited suitable growing area along the Newfoundland coast. The potential value of eelgrass habitat as a fish nursery is extremely high, relative to unvegetated substrates.

Seagrass Ecology Programs in DFO Maritimes Region: Status, Functioning, Resilience

Melisa Wong

I presented an overview of our research on seagrass ecology, including its status, functioning, and resilience. Our initial work focussed on faunal biodiversity, connections with production, and how it changes across seagrass landscapes. We then moved to studying the plants themselves to understand their condition and distribution. Current mapping initiatives with colleagues include species distribution modelling, satellite

mapping, and data compilation to create a national-scale map. Maps of eelgrass extent will facilitate our Blue Carbon project, which aims to quantify carbon storage capacity of Canada's eelgrass beds. We also have several projects exploring the ecological dynamics of eelgrass beds, including its growth, phenology, and reproductive ecology. Emphasis is placed on understanding how the physical environment shapes eelgrass condition (i.e., its productivity and resilience). Impacts from human activities (i.e., dredging, marine construction) and climate change (i.e., temperature and light stress) have been explored using manipulative field and lab experiments. We will synthesis our work using an ecosystem growth model for eelgrass, to model growth dynamics under current and future conditions.

Eelgrass Species Distribution Modeling in Nova Scotia's Eastern Shore
John O'Brien, Melisa Wong, Ryan Stanley

Protection of habitat-forming eelgrass is a key conservation priority for the Eastern Shore Islands (ESI); an Area of Interest for a coastal Marine Protected Area on Nova Scotia's Atlantic coast. However, baseline data on the distribution and condition of eelgrass in the area required for conservation planning is limited. To address these gaps, we conducted a stratified random drop camera survey of ESI in fall 2019. We are using survey data and species distribution modelling (SDM) techniques to develop predictive relationships between eelgrass occurrence and various environmental correlates and map the potential distribution of eelgrass in ESI. In a preliminary model derived through Random Forest Classification with limited available environmental data, we identified substrate type and depth as important environmental correlates with eelgrass distribution and we are assembling additional relevant GIS predictor layers. Follow up work will include applying an ensemble modelling framework in which a performance-weighted average prediction from many SDM model types is derived to improve accuracy and validating model performance in areas outside ESI. We also will develop methods for combining species distribution modelling techniques with remote sensing approaches in a framework that leverages the strengths of both approaches to fill gaps and refine our current picture of the distribution of eelgrass along the Atlantic coast of Nova Scotia.

Coastal Vegetated Habitat Mapping with Sentinel-2 and Worldview-2/3 Satellite Imagery, DFO, Maritimes Region
Kristen Wilson, Melisa Wong, Emmanuel Devred

Satellite remote sensing has been used to map the distribution of eelgrass and other seagrass species in the clear coastal waters of the world. To do so, the satellite measures the reflectance of sunlight of the seafloor over several wavelengths, which, after correction of the interactions with the atmosphere, water column, and sea surface,

are used to map coastal vegetated habitat. This process is most readily applicable in regions with very clear waters, but its use in optically complex waters with low water transparency is increasing. Our SPERA funded project aims at mapping eelgrass habitat in the optically complex waters of the Maritimes Region using two different satellite sensors: Sentinel-2 and Worldview 2/3. The first sensor, Sentinel-2, provides freely available imagery which is acquired every 2/3 days over the Maritimes coastal regions with four spectral bands in the visible spectrum (three of which are of use for bottom habitat mapping) at a 10-m pixel resolution. Our classification approach used simple band ratios and machine learning classifiers to map submerged aquatic vegetated habitat to a maximum depth of 10 m with comparable accuracy metrics as other studies performed in very clear waters. These habitat maps cannot differentiate between vegetated habitat types, for instance eelgrass from kelp habitat, but our methods can be used in a systematic manner to classify the large-scale distribution of coastal vegetated habitat throughout the Maritimes Region. The second sensor, Worldview-2/3, is a commercial satellite which must be tasked at a substantial price, but provides eight visible spectral bands (six of which can be used for bottom habitat mapping) at a 2-m pixel resolution. We have acquired Worldview-2/3 imagery at several locations throughout the Maritimes region and will produce bottom habitat maps for each image. Our study additionally aims to compare the differences in predicted vegetated habitat maps between Worldview-2/3 and Sentinel-2 satellite imagery to leverage the full range of benefits of each satellite sensor at effective cost. The resulting coastal vegetated habitat maps from both Sentinel-2 and Worldview-2/3 provide essential data layers for marine spatial planning which can be used to monitor vegetated habitat extent, and inform management decisions throughout the Maritimes region.

Cumulative effects of human activities on seagrass beds in Atlantic Canada, DFO, Maritimes Region and Dalhousie University

Grace Murphy, Melisa Wong, Heike K. Lotze, Noreen Kelly

Eelgrass habitats are particularly vulnerable to human activities as they are subject to threats from both the terrestrial and marine realms. This presentation covers two aspects of my work on anthropogenic stressors to eelgrass ecosystems. First is the development of a standardized multi-scale human impact metric that we applied to 180 eelgrass beds in 52 bays across Atlantic Canada. And second, I discuss how we are currently expanding this impact metric to assess cumulative effects to eelgrass in the region. The standard human impact metric consists of 5 bay-scale and 4 local-scale impacts expected to influence eelgrass ecosystems, including watershed land alteration, human population density, nitrogen loading, invasion extent, fishing activity, shellfish aquaculture activity, water quality, overwater structures, and riparian land alteration. Our results show that eelgrass beds in Atlantic Canada exist across a wide

gradient of human impacts with considerable differences in the strengths of impacts between regions and at different spatial scales. The human impact metric can be used to estimate the number of eelgrass beds that may be at risk from specific stressors. For example, 64% of the eelgrass beds we assessed are considered at risk of degradation from anthropogenic nitrogen loading. We are now assessing the cumulative effect of these human activities on eelgrass by combining the intensity of the individual impact scores with vulnerability weights to take into account that some impacts will be more detrimental to eelgrass than others. In the future we will be validating the cumulative effect scores with eelgrass condition data to assess how well the cumulative effect scores relate to eelgrass health. We are also assessing thresholds for cumulative effect scores that could indicate a level above which eelgrass would be more at risk of degradation.

APPENDIX 3. Attendee List (47) of the virtual NET Force Forum, December 2 2020

Baccardax Westcott, Alexi (Dalhousie University)
D'Entremont, Alix (Argyle Municipality)
Anuradha, Rao (Ekalogical Connections / SeaChange Marine Conservation Society)
Aruna (Guest)
Leblon, Brigitte (University of New Brunswick)
Hatcher, Bruce G. (Cape Breton University)
LeBlanc, Charlene (Argyle Municipality)
Karbowski, Chelsey (Environment and Climate Change Canada)
Macdonald, Christina (Dalhousie University)
Douglas, Angela (Coalition SGSL)
Sanford, Dianne (Moonstone Enterprises)
Van Hemessen, Doug (Nature Conservancy)
Geissinger, Emilie (Memorial University of Newfoundland)
Adamczyk, Emily (University of British Columbia)
Meyer, Friedrich (Parks Canada)
Gomez, Catalina (Department of Fisheries and Oceans)
Gromack, Aimee (Department of Fisheries and Oceans)
Guijarro-Sabaniel, Javier (Department of Fisheries and Oceans)
MacDonald, Haley (Nature Conservancy)
Hanson, Alan (Environment and Climate Change Canada)
Burton, Jake (Gwaii Haanas - Parks Canada)
Sylliboy, Jennifer (Unama'ki Institute of Natural Resources)
Yakimishyn, Jennifer (Parks Canada)
Dunic, Jillian (Simon Fraser University)
Cristiani, John (University of British Columbia)
Kennedy, Mary (retired DFO)

Thomson, Jordy (Ecology Action Center)
Laliberté, Julien (Department of Fisheries and Oceans)
Howarth, Leigh (Centre for Marine Applied Research)
Ogston, Lindsey (Tsleil-Waututh Nation)
Lynn, Lee (Parks Canada)
Hessing-Lewis, Margot (Hakai Institute)
O'Connor, Mary (University of British Columbia)
Christensen, Matt (University of British Columbia)
Bordt, Michael (Department of Fisheries and Oceans
Davis, Morgan (Gulf Islands NPR, Parks Canada)
Noisette, Fanny (Université du Québec à Rimouski)
Painter, Brett (Environment and Climate Change Canada)
Green, Randy (New Brunswick Community College)
Yuckin, Sarah (Parks Canada)
Smith, Colleen A (Department of Fisheries and Oceans)
Keyla Miller (Souris & Area Wildlife)
Jaegler, Thomas (Université du Québec à Rimouski)
Pretzlaw,Troy (Parks Canada)
Wong, Melisa C (Department of Fisheries and Oceans)
Worcester, Tana (Department of Fisheries and Oceans)
Zachary, Davie (Spiri Robotics)

APPENDIX 4. NET Force data agreement

Data Sharing Agreement

BETWEEN

Her Majesty the Queen in Right of Canada, as represented by the Minister of Fisheries, Oceans and the Canadian Coast Guard

AND

XXXXXXXXXX

May, 2021

1. NAME OF PARTICIPANTS

- HER MAJESTY THE QUEEN IN RIGHT OF CANADA as represented by the Minister of Fisheries, Oceans and the Canadian Coast Guard (hereinafter referred to as “DFO”)
- XXX as represented by XXX, (hereinafter referred to as “XXX”)

2. INTRODUCTION

- XXX and DFO have a shared interest in eelgrass conservation and are collaborating in the National Eelgrass Task Force (NET Force).
- NET Force is an innovative, diverse and inclusive partnership of scientists, managers, and partners led DFO. The NET Force is working towards the common goal of a national map of eelgrass distribution in Canada. The map is intended to be publicly accessible, dynamic, and useful for monitoring and collective decision-making, for example, in relation to Marine Spatial Planning, aquaculture siting, Marine Conservation Targets, and the Blue Economy Strategy.
- Multiple partners are conducting independent initiatives to better map the distribution of eelgrass in Canada’s coastlines at different spatial scales, using various approaches. Recognizing the ecological and socio-economic benefits that eelgrass beds provide in coastal ecosystems, there is a national interest in combining efforts to achieve a comprehensive national eelgrass map. The goal of the NET Force is to leverage eelgrass data already collected and initiatives and projects currently underway to facilitate coordination of efforts. This work is guided by the principles of open, reproducible, and collaborative science.
- XXX and DFO have agreed to an arrangement whereby XXX’s spatial data for the XXX will be used by DFO to contribute to the NET Force national eelgrass distribution map.

3. EXPECTED OUTCOMES

- This Agreement will facilitate an efficient, consistent and collaborative approach to the compilation of reliable, quality-controlled data to contribute to a national map of eelgrass distribution.

4. DEFINITIONS

- "**Agreement**" means the recitals, definitions, terms and conditions stipulated herein.
- "**Project Authority**" means the person designated by each Participant organization to manage and oversee the execution of this Agreement on its behalf.
- **“Data”** refers to all spatial data provided by XXX to DFO in support of the NET Force map of eelgrass distribution, including the metadata.
- **“Open data”** is defined as structured data that is machine-readable, freely shared, used and built on without restrictions.

5. **SCOPE**

- This Agreement applies to XXX sharing spatial data with DFO that depicts the geographic occurrences and boundaries of eelgrass beds. Initially, this involves data from XXX.

6. ROLES AND RESPONSIBILITIES

- The Participants intend for data to be shared as follows:
    - XXX's project authority, will provide the data to DFO's project authority.
    - The data provided by XXX to DFO will include spatial data (.shp, .dbf) that depicts the geographic occurrences and/or boundaries of eelgrass beds from XXX.
    - XXX will ensure that the data provided to DFO has undergone quality control.
    - XXX will provide the data to DFO with metadata, as agreed upon between the project authorities.
    - XXX will provide the data through a cloud storage provided by DFO.
    - Only the project authorities at XXX and DFO will have access to the data in the cloud storage for the purpose of making changes or to include updated data.
    - DFO will integrate the XXX data into the NET Force map of eelgrass distribution. This map will be available in various open platforms that will make the data accessible to the public.
    - XXX will be given an opportunity to review the portion of the NET Force eelgrass map that integrates the XXX data prior to it being submitted to the open data portals such as the Open Data Portal and the Ocean Biodiversity Information System (OBIS). The data will be used to populate the Marine Spatial Planning Atlas. DFO will not share XXX's data with other organizations before it is published in the portals without the prior written consent of the XXX.
    - DFO will ensure that XXX's data includes a credit to the XXX in each of open data platforms.
    - DFO's project authority will be identified as the contact for public enquiries about the NET Force map but he will refer any questions specifically related to the XXX data to the XXX project authority for response.
    - During the term of this Agreement, XXX will share with DFO any updates to the spatial data of the XXX, if there are corrections or new methods of analysis are applied.
    - During the term of this Agreement, if XXX conducts field work or uses other methodologies to collect eelgrass data in new areas, XXX agrees to share the data to the NET Force project.

- Once the data is integrated into open data portals, it will remain publically available beyond the expiration of this Agreement on March 31, 2023.

7. MANAGEMENT PROVISIONS

- The Participants will meet as required to fulfil the objectives set out in section 3.

8. SHARING OF INFORMATION

- While this Agreement is in effect and at all times thereafter, DFO and XXX and any officers, employees or agents of each of them shall treat all information, data, documents, reports and materials acquired or to which access have been given in the course of, or incidental to, the performance of this Agreement in accordance with the *Access to Information Act* (Canada) and the *Privacy Act* (Canada). The Participants shall not disclose or permit to be disclosed such information, data, documents, reports and materials, unless:

  a. the Participants agree to the disclosure;

  b. the disclosure is required by law;

  c. the information was obtained from the public; or

  d. the information is available to the public.

- The data provided by XXX to DFO pursuant to this Agreement will not include any personal or private information, for example, it will not include aerial imagery.

9. DIFFERENCES IN INTERPRETATION AND APPLICATION

- The Participants will endeavour to resolve issues regarding the implementation of this Agreement in a timely manner using mechanisms available at the staff and senior executive level and through the NET Force. Where an issue remains unresolved, the pre-eminent jurisdiction responsible for the matter under consideration will make the final determination.

10. REVIEW

- DFO's project authority will submit a report on the effectiveness of all data sharing agreements related to the NET Force to the Regional Director, Science, Maritimes Region, as soon as practicable after the conclusion of the fiscal year or the end of the NET Force project, whichever is sooner. A year will be considered to run from April 1 to March 31.

11. AMENDMENT

- This Agreement may be amended by the Participants at any time. An amendment will be confirmed by an exchange of letters by the Participants setting out the amendment and its effective date.

12. FINANCIAL ARRANGEMENTS

- This Agreement will not impose any financial responsibilities on its Participants, except that each participant will be responsible for the staff and funding costs it incurs in its own interest, related to the support of the agreement.

13. DURATION, WITHDRAWAL AND TERMINATION

- The Agreement will come into effect on the date it is signed by both Participants and will expire on March 31, 2023, unless it is extended through a written amendment. Either Participant may terminate this Agreement forthwith by providing written notice to the other Participant at any time prior to the data being integrated in an open data portal.

14. LEGAL DISCLAIMER

- This Agreement is an expression of the mutual intentions of the Participants and is not legally binding on them or enforceable against them.

15. PROJECT AUTORITIES

- The Project Authority for DFO is:

XXX

- The Project Authority for XXX is:

XXX

- Either Participant may by written notice to the other designate a new Project Authority.

16. EFFECTIVE DATE AND SIGNATURE

- This Agreement has been signed by the Regional Director of Science, Maritimes Region, on behalf of the Minister of Fisheries, Oceans and the Canadian Coast Guard on behalf of Her Majesty the Queen in Right of Canada, and by XXX on behalf of the XXX on the dates noted below.

SIGNED IN THE PRESENCE OF:

FOR HER MAJESTY THE QUEEN IN RIGHT OF CANADA

_____ _____

XXX	Date

FOR THE XXX

XXX	Date

This Agreement comes into effect on the latest date noted above.