Status and Conservation of Eelgrass (*Zostera marina*) in Eastern Canada

Alan R. Hanson

Atlantic Region 2004
Canadian Wildlife Service
Environmental Conservation Branch

Technical Report Series Number 412

Environment Canada | Environnement Canada
Canadian Wildlife Service | Service canadien de la faune

Canada

TECHNICAL REPORT SERIES
CANADIAN WILDLIFE SERVICE

This series of reports, established in 1986, contains technical and scientific information from projects of the Canadian Wildlife Service. The reports are intended to make available material that either is of interest to a limited audience or is too extensive to be accommodated in scientific journals or in existing CWS series.

Demand for these Technical Reports is usually confined to specialists in the fields concerned. Consequently, they are produced regionally and in small quantities; they can be obtained only from the address given on the title page. However, they are numbered nationally. The recommended citation appears on the title page.

Technical Reports are available in CWS libraries and are listed in the catalogue of the National Library of Canada in scientific libraries across Canada. They are printed in the official language chosen by the author to meet the language preference of the likely audience, with a résumé in the second official language. **To determine whether there is significant demand for making the reports available in the second official language, CWS invites users to specify their official language preference. Requests for Technical Reports in the second official language should be sent to the address on the title page.**

SÉRIE DE RAPPORTS TECHNIQUES DU SERVICE CANADIEN DE LA FAUNE

Cette série de rapports donnant des informations scientifiques et techniques sur les projets du Service canadien de la faune (SCF) a démarré en 1986. L'objet de ces rapports est de promouvoir la diffusion d'études s'adressant à un public restreint ou trop volumineuses pour paraître dans une revue scientifique ou l'une des séries du SCF.

Ordinairement, seuls les spécialistes des sujets traités demandent ces rapports techniques. Ces documents ne sont donc produits qu'à l'échelon régional et en quantités limitées; ils ne peuvent être obtenus qu'à l'adresse figurant au dos de la page titre. Cependant, leur numérotage est effectué à l'échelle nationale. La citation recommandée apparaît à la page titre.

Ces rapports se trouvent dans les bibliothèques du SCF et figurent aussi dans la liste de la Bibliothèque nationale du Canada utilisée dans les principales bibliothèques scientifiques du Canada. Ils sont publiés dans la langue officielle choisie par l'auteur en fonction du public visé, avec un résumé dans la deuxième langue officielle. **En vue de déterminer si la demande est suffisamment importante pour produire ces rapports dans la deuxième langue officielle, le SCF invite les usagers à lui indiquer leur langue officielle préférée. Il faut envoyer les demandes de rapports techniques dans la deuxième langue officielle à l'adresse indiquée sur la page titre.**

STATUS AND CONSERVATION OF EELGRASS (*Zostera marina*)
IN EASTERN CANADA

Summary from a Workshop held:
17 – 18 December, 2003
Sackville, New Brunswick, Canada

ALAN R. HANSON
Canadian Wildlife Service, P.O. Box 6227, Sackville, New Brunswick, Canada E4L 1G6

Canadian Wildlife Service Technical Report 412

This report may be cited as:

Hanson, A.R. (ed.) 2004. Status and conservation of eelgrass (*Zostera marina*) in Eastern Canada. Technical Report Series No. 412. Canadian Wildlife Service, Atlantic Region. viii. + 40 pp.

Published by the authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-5/412E
ISBN: 0-662-36629-8

Copies may be obtained from:

Alan R. Hanson
Canadian Wildlife Service
P.O. Box 6227
Sackville, NB, Canada E4L 1G6

Phone: (506) 364-5061
Fax: (506) 364-5062
e-mail: al.hanson@ec.gc.ca

Summary

Although eelgrass (*Zostera marina*) has been widely recognized as an important component of coastal ecosystems in Eastern Canada, the workshop held 17-18 December 2003, in Sackville, New Brunswick, was the first meeting of its kind to bring together people interested in the status and conservation of eelgrass in this region. The workshop had three main themes: mapping and monitoring changes in eelgrass distribution and abundance; the importance of eelgrass to coastal ecosystems; and causes of eelgrass declines.

Regional surveys to monitor changes in eelgrass distribution and abundance do not yet exist for Eastern Canada. Presentations by Hanson, Forbes *et al.*, Duggan, and Pinsent on mapping wetlands, coastal morphology, significant coastal habitat, and eelgrass donor sites, respectively, indicated that tools and procedures exist to undertake a comprehensive regional mapping and trend analysis program. However, it would require additional resources and coordination to undertake such a program on a regional scale.

Collectively, the information presented by the various researchers from specific study areas (summarized below) provided consistent evidence of a wide spread decline in eelgrass distribution and abundance in the Maritime Provinces.

Sharp and Semple analysed a series of 1:10,000 colour air photos from 1978, 1989 and 2000 for two areas in Lobster Bay, Yarmouth County, Nova Scotia. They estimated a loss of 30% and 44% in the area covered by eelgrass in these two areas during the period 1978-2000.

Chapman and Smith calculated the total intertidal area occupied by eelgrass in four inlets along the Atlantic Coast of Nova Scotia (Cole Harbour, Chezzetcook, Petpeswick and Musquodoboit Harbour) in 1992 and 2002. They estimated that the average decline of intertidal eelgrass beds over 10 years was 79.5 % ± 20.8 % (SD), with Petpeswick having the greatest loss (96%) and Cole Harbour the least (49%).

Locke and Hanson sampled above-ground eelgrass biomass in 13 southern Gulf of St. Lawrence estuaries in 2001 and 2002. In 2001, eelgrass biomass was reduced in the eastern part of the study area, coinciding with the area invaded by green crabs (*Carcinus maenus*). By 2002, biomass was reduced throughout the study area irrespective of the distribution of green crabs or other invasive species. The mean reduction between years was about 40%. The most dramatic reduction (88%) was in Rustico, Prince Edward Island.

Garbary *et al.* documented a 95% decline in Antigonish Harbour, Nova Scotia in 2001 compared to 2000. They subsequently asked Harbour Masters throughout Nova Scotia to comment on the status of eelgrass beds and changes in the biology of their harbour. Within the geographic area that included all reported sites of eelgrass decline, 31 out of a total of 40 sites reported a decline in eelgrass. All sites where eelgrass declines were reported also reported abundant or increasing numbers of green crabs.

Presentations documented the importance of eelgrass to waterfowl (Hanson), mobile epifaunal communities of estuaries in the southern Gulf of St. Lawrence (Joseph *et. al.*) and juvenile cod in Newfoundland (Gregory).

Reasons suggested for declines in eelgrass distribution may be geographically specific, or may reflect synergistic interactions among several factors. These include eutrophication (Lotze *et al.*), disturbance by green crab (Garbary *et. al*), and environmental changes (Hanson and Locke). Protocols for restoring eelgrass beds by replanting root stock have been tested in Newfoundland (Pinsent) and hold promise for future management action.

Recommendations from the working groups on mapping and monitoring (Milton and Methven), ecosystem importance of eelgrass (Gregory and Locke) and causal mechanisms (Garbary and Munro) had two common themes. They confirmed the ecosystem level importance of eelgrass in estuaries of Eastern Canada and that this role is being compromised by severe and continuing declines in the Maritime Provinces. They also emphasized that increased integrated efforts will be required to build the collective knowledge necessary to conserve eelgrass in Eastern Canada.

RÉSUMÉ

Bien que la zostère (*Zostera marina*) soit une composante importante des écosystèmes côtiers de l'Est du Canada, l'atelier des 17 et 18 décembre 2004 à Sackville, Nouveau Brunswick, a été le premier en son genre à réunir plusieurs gens préoccupés par son statut et sa conservation dans la région. Trois thèmes différents ont été abordés durant l'atelier : la cartographie et le suivi des tendances régissant la distribution et l'abondance de la zostère; le rôle de la zostère au sein des écosystèmes côtiers; et les causes du déclin de la zostère.

L'Est du Canada ne possède pas encore de programmes régionaux de suivi des changements en cours dans la distribution et l'abondance de la zostère. Or, tel que l'ont démontré Hanson, Forbes *et al.*, Duggan et Pinsent dans leurs présentations respectives sur la cartographie des terres humides, la morphologie des côtes, les habitats côtiers d'importance et les milieux donneurs, la mise sur pied d'un tel programme est plausible puisque existent bel et bien les outils et les procédures nécessaires pour effectuer un suivi cartographique et analytique à l'échelle de la région. Il va de soit cependant que l'instauration d'un programme de cette importance nécessiterait des ressources financières et administratives supplémentaires.

L'ensemble des informations présentées par les chercheurs lors de l'atelier et concernant des régions d'études variées (résumées ci-dessous) mettent en évidence un déclin de la distribution et de l'abondance de la zostère dans l'ensemble des Provinces maritimes.

Sharp et Semple ont comparé des séries de photos aériennes en couleur à une échelle de 1 :10 000 prises en 1978, 1989 et 2000, et couvrant deux zones de Lobster Bay dans le comté de Yarmouth en Nouvelle Écosse. Les résultats font état d'une diminution respective dans ces deux endroits de 30 % et de 44% de la superficie de zostère entre 1978 et 2000.

Chapman et Smith ont calculé la superficie totale occupée par la zostère dans la zone intertidale de quatre bras de mer situés sur la côte atlantique de la Nouvelle-Écosse (Cole Harbour, Chezzetcook, Petpeswick et Musquodoboit Harbour) pour les années 1992 et 2002. Ils ont ainsi pu estimer à 79.5 % ± 20.8 % (É.-T.) la diminution moyenne des bancs intertidaux de zostère durant ces 10 années. Le déclin le plus important s'est produit à Petpeswick (96%), tandis que le plus faible à Cole Harbour (49%).

Locke et Hanson ont échantillonné la biomasse superficielle de zostère dans 13 estuaires du Golfe du Saint-Laurent en 2001 et 2002. En 2001, la biomasse de zostère avait diminué dans la partie est de la région d'étude, ce qui correspond à peu près à la zone envahie par le Crabe vert (*Carcinus maenus*). En 2002, l'ensemble de la région d'étude avait connu un recul de la zostère et ce, indépendamment de la distribution du Crabe vert. Cette réduction a été de l'ordre de 40 % en moyenne. Rustico, à l'Ile-du- Prince-Édouard a connu le déclin le plus important (88%).

Garbary *et al.* ont documenté un déclin de l'ordre de 95% entre 2000 et 2001 à Antigonish Harbour, Nouvelle-Écosse. Ils ont par la suite fait appel à des maîtres de port de partout en Nouvelle-Écosse qu'ils ont questionné sur le statut des bancs de zostère et les changements biologiques survenus dans leurs ports respectifs. Sur l'ensemble des 40 sites pour lesquels des informations concernant la zostère ont été obtenues, 31 connaissent un déclin de la zostère. De plus, tous les sites affectés par cette diminution abritent également des populations importantes de Crabe vert ou connaissant une croissance de sa population.

Les communications ont présenté l'importance de la zostère marine pour la sauvagine (Hanson), pour les communautés épifauniques mobiles de l'estuaire du golfe du Saint-Laurent (Joseph et al.) et pour la morue juvénile à Terre-Neuve (Gregory).

Les causes du déclin de la zostère marine peuvent être spécifiques géographiquement parlant ou refléter une interaction synergique entre plusieurs facteurs. Elles incluent l'eutrophisation (Lotze *et al.*), les perturbations dues au crabe vert (Garbary *et al*) et les changements environnementaux (Hanson et Locke). Le protocole de restauration des lits de zostère à l'aide de souches a été testé à Terre-Neuve (Pinsent) et semble prometteur pour les futures initiatives de gestion.

Les recommandations des groupes de travail sur la cartographie et la surveillance (Milton et Methven), l'importance écosystémique de la zostère (Gregory et Locke) et les mécanismes de causalité (Garbary et Munro) avaient deux thèmes en commun. Elles ont confirmé l'importance du rôle de la zostère dans les estuaires de l'Est du Canada et la fragilisation dans les Provinces maritimes de ce rôle en raison du déclin important et continu de la zostère. Elles ont également réitéré le besoin accru d'intégration des efforts d'acquisition des connaissances nécessaires à la conservation de la zostère.

TABLE OF CONTENTS

TABLE OF CONTENTS

INTRODUCTION

This document summarizes presentations and discussions from a workshop on the status and conservation of eelgrass (*Zostera marina*) in Eastern Canada which was held 17 – 18 December 2003 in Sackville, New Brunswick, Canada. Attendees from Quebec and the Atlantic provinces represented universities, community environmental groups, provincial agencies, as well as three federal departments (Fisheries and Oceans Canada, Natural Resources Canada and Environment Canada). This diverse participation was indicative of the concern for, and importance of, eelgrass in Eastern Canada. Moreover, it allowed for a broad synthesis of the state of knowledge on eelgrass in Eastern Canada and future actions required to ensure the sustainable management of this important coastal marine resource.

The first day of the Workshop included invited presentations on: monitoring and mapping the distribution and abundance of eelgrass; the importance of eelgrass to marine ecosystems and migratory birds; potential causative mechanisms for changes in eelgrass distribution and abundance; and eelgrass restoration techniques. The second day of the workshop allowed for discussion among workshop participants on issues related to mapping and monitoring eelgrass, the ecosystem function of eelgrass and causal mechanisms for changes in eelgrass distribution and abundance.

It is hoped that this report will act as a catalyst for future collaborative work among those concerned with eelgrass and estuaries in Eastern Canada.

SECTION 1 – INVITED PAPERS

Wetland mapping in Atlantic Canada

Alan R. Hanson
Canadian Wildlife Service, Environment Canada
P.O. Box 6227
Sackville, NB E4L 1G6

Information is required for larger spatial areas to understand the significance of reported declines of eelgrass in Nova Scotia. Identifying sources of information on eelgrass density and abundance collected in previous years is critical to any retrospective analysis of trends. Small research projects which mapped eelgrass beds during 1970-1995 may collectively be a source of historical information from which trend analyses could be undertaken.

The Maritime Wetland Inventory (Hanson & Calkins 1996) identified and classified freshwater wetlands and coastal habitat. This inventory was based on colour air photos from 1974-1978 for Nova Scotia, 1974 for Prince Edward Island, and 1980-1985 for New Brunswick. Salt marshes were classified according to the ratio of high to low marsh and the number of ponds per hectare. Inter-tidal, subtidal marine and estuarine wetlands were classified along with their substrate type, including the presence of eelgrass beds. This information exists as 1:50 000 scale paper maps.

The province of Nova Scotia created a provincial wetland inventory based on colour air photos taken during 1990-1996. This inventory also recorded the extent of eelgrass beds. These wetland inventories could potentially be used for retrospective analyses of eelgrass beds. These air photos were not taken to maximize their suitability for identifying inter-tidal and subtidal habitat and hence there are limitations with these data for mapping eelgrass.

Currently the National Wetland Inventory Program is evaluating the feasibility of using LandSat7 and Radarsat data to identify and map wetlands in Canada. One of the main reasons for this project is to develop the capacity to cost-effectively determine changes in land cover, such as wetlands, over time at large spatial scales. The pilot projects in Atlantic Canada include coastal wetlands and eelgrass beds. A newly developed pattern recognition image analysis software (E-Cognition) is being used in these pilot projects. A pilot project in British Columbia is also evaluating the merits of Landsat7 and Radarsat data to map eelgrass beds as compared to air photo or CASI information.

Our ability to monitor changes in eelgrass beds hopefully will improve in the future. Retrospective analyses of trends in eelgrass will be influenced by the nature of the available data. To use existing wetland inventory data as part of a retrospective analysis, a first step would be to validate the inventory data with air photos from that time period.

Mapping eelgrass and tracking change in estuaries

Donald L. Forbes, Steven M. Solomon, Gavin K. Manson
Geological Survey of Canada, Natural Resources Canada
Bedford Institute of Oceanography, 1 Challenger Drive
Dartmouth, NS B2Y 4A2

The Geological Survey of Canada (GSC) is involved in the mapping of coastal and marine geology, including seabed morphology and sediments, as well as in understanding the processes that lead to erosion, sedimentation, and geomorphic change in the coastal zone. Over the past few years we have demonstrated the close link between seabed substrate conditions and marine habitats in collaboration with DFO, industry, and other partners. This work has been most advanced on the continental shelf but has also proceeded in coastal waters, including experimental mapping of eelgrass beds. From 1997 to 2000 the GSC was involved in an integrated series of coastal mapping projects along the north shore of Prince Edward Island (Forbes *et. al.*, 1997, 1998; Forbes and Manson, 2002). We are currently undertaking extensive mapping of the coastal zone in south-east New Brunswick as part of an interdisciplinary study on the coastal impacts of climate change and sea-level rise in that area.

Along the north shore of PEI, we mapped coastal morphology and seabed characteristics using a wide range of tools. These included: single-beam echosounding, three different systems for multibeam sounding, multibeam backscatter, digital sidescan sonar, high-resolution seismic reflection, ROV video, airborne video, vertical aerial photography, multi- and hyperspectral airborne and spaceborne imaging, airborne laser altimetry (LiDAR), Radarsat-1 fine-mode SAR, and airborne polarimetric SAR simulating Radarsat-2 imagery.

In the course of a detailed bathymetric survey for estuarine circulation and tidal inlet migration studies in Rustico Bay, PEI in 1997 (Forbes and Solomon, 1999), we discovered that the sweep multibeam system being used for very shallow water could not distinguish the bottom in areas with eelgrass growth. As a result, we were obliged to undertake mapping within the estuary using an inflatable boat and outboard motor, differential GPS navigation, and a Knudsen 320M single-beam sounding system operating at 200 kHz. In this way, we were able to acquire bathymetric data in depths as shallow as 0.5 m. Using a Unix-based digital post-processing system, we were able to assign individual soundings to two classes: estuary bottom or top of vegetation (generally eelgrass). Areas of eelgrass growth were verified by visual observation and a GIS layer was developed to display areas where eelgrass was detected. Although we did not pursue this further, the technique could be readily adapted to measure the height of eelgrass growth.

References

Forbes, D.L. and Manson, G.K. 2002. Coastal geology and shore-zone processes. In Coastal impacts of climate change and sea-level rise on Prince Edward Island (Forbes, D.L. and Shaw, R.W., editors). Geological Survey of Canada, Open File 4261, Supporting Document 9, 85 p. (on CD-ROM).

Forbes, D.L. and Solomon, S.M. 1999. Inlet division and coastal instability following tidal prism diversion. Proceedings, Coastal Sediments '99 (Long Island, NY). American Society of Civil Engineers, Reston VA, p. 1418-1433.

Forbes, D.L., Sherin, A.G., Beaver, D., Frobel, D. and Covill, R. 1999. Multibeam bathymetric surveys, inner shelf off northern Prince Edward Island. Cruise report BIO 97093 & IML 98043C, NGCC/CCGS Frederick G. Creed. Geological Survey of Canada, Open File 3816, iv+25 p & 6 appendices.

Forbes, D.L., Solomon, S.M., Frobel, D., Goguen, M., Sherin, A.G., Parrott, R. and Covill, R. 1998. Bathymetry, bottom conditions, and tidal inlet stability, Rustico Bay and vicinity, Prince Edward Island. Geological Survey of Canada, Open File 3766, iv+38 p. & 22 figs.

Significant Habitats Atlantic Coast Initiative (SHACI)

Dave Duggan
Coastal Management Section, Oceans & Environment Branch
Fisheries and Oceans Canada
Bedford Institute of Oceanograhy, 1 Challenger Drive
Dartmouth, NS B2Y 4A2

The Atlantic coast of Nova Scotia is a very diverse ecosystem with a complex distribution of fish, invertebrates, birds and mammals. The coastal communities in this region depend heavily on many valuable marine resources. The region's productive salt marshes, mud flats, sand beaches, bays/inlets and offshore islands provide significant wildlife habitat. As well, these habitats may provide new economic opportunities for residents of these communities.

The Oceans Act, passed in 1997, mandates the development and implementation of a national strategy for oceans management. The Department of Fisheries and Oceans (DFO) is the lead federal department for the conservation, management and sustainable development of renewable marine resources. Although much literature exists about specific Atlantic coast marine species and habitats, there is no current and comprehensive mapping initiative or document that has combined this information for the purpose of identifying significant marine habitats.

Coastal areas including estuaries, bays and continental shelves constitute roughly 7.4% of the sea's area (Sharp 1988). They are among the most biologically significant yet heavily altered marine ecosystems, and thus warrant special consideration and protection. In this light, the Significant Habitats Atlantic Coast Initiative (SHACI) is a project aimed at identifying, mapping and documenting significant coastal habitats along the Atlantic Coast of Nova Scotia. The coastal areas included in SHACI extend from Yarmouth on the southwest shore to Cape North on the northern coast of Cape Breton Island, including the Bras d'Or Lakes, and from the high tide mark to the 12 nautical mile offshore limit of Canada's Territorial Sea. The Oceans and Coastal Management Division, Maritimes Region, Fisheries and Oceans Canada is undertaking this initiative primarily to contribute to programs and initiatives being developed under the Oceans Act for the near-shore Atlantic coast region.

For the purposes of SHACI, a Significant Habitat is defined as:

> Any area of land or water within the territorial sea and internal marine waters of Canada, large or small, under private or public control that has desirable ecological and/or cultural and recreational attributes. These ecological attributes contribute to the functioning and sustainability of the coastal ecosystem, the conservation and protection of genetic, species, population and/or habitat diversity, and/or other similar vital ecological functions. The cultural and recreational attributes contribute to the health and well being of coastal communities, the conservation of historical and traditional cultures, and other components valued by coastal communities.

SHACI is relevant to several initiatives under the Oceans Act and will serve as a knowledge base for the creation and development of new initiatives. Generally, SHACI will:

- Provide an assessment of what is known about Atlantic coast habitats and help to identify information gaps;
- Be an information source for the Marine Protected Areas (MPA) and Integrated Management (IM) programs by identifying significant areas along the coast that may require a higher level of protection and incorporation into IM plans;
- Support DFO's work on the identification of appropriate standards and measures for marine environmental quality (MEQ); and
- Assist in identifying appropriate indicators and reference points for monitoring ecosystem health.

The maps and reports produced through SHACI are also intended for use by a general audience including ocean planners, fisheries managers, non-government organizations, consultants, industry and the public, for purposes such as public education, coastal planning, resource management and environmental assessments.

Boat-based eelgrass inventories and mapping of Newfoundland's north-east coast and Avalon Peninsula

David Pinsent
Jacques Whitford
607 Torbay Road
St. John's, NL A1A 4Y6

As a part of Husky Energy's Habitat Compensation Program for habitat disturbance at the White Rose Oil Field, Jacques Whitford was hired to find areas to transplant eelgrass around the island of Newfoundland. The premise was to increase the productive capacity of a habitat by transplanting eelgrass to an area where there was none.
Information from aerial photographs, marine charts, local fisheries officers, fishermen and field biologists was initially collected to identify potential transplant areas. The criteria used to identify a potential transplant site were based on an Eelgrass Site Selection Model (Short *et al.* 2002). Parameters of the model were adapted based on known eelgrass habitat associations in Newfoundland. The model identified 19 potential transplant sites in five bays around the island of Newfoundland.

During the summer and fall of 2002 and 2003, field surveys were conducted to ground-truth the model results. The eelgrass distribution along 370 km of coastline was mapped in Notre Dame Bay, Bonavista Bay, Trinity Bay, St. Mary's Bay and Placentia Bay. The eelgrass distribution in each area was delineated by direct observation. Using an aquascope from a Zodiac inflatable boat, an observer classified eelgrass densities in categories to the nearest 20%. Eelgrass densities were classified according to the amount of seabed covered by plant material. A data recorder noted densities directly onto a marine chart and geo-referenced all entries with a handheld GPS. A third person operated the boat, following the coastline at a speed of 1 to 2 knots.

We found eelgrass was present at all locations *a priori* deemed suitable for eelgrass growth. If the Eelgrass Site Selection Model determined the site to be a suitable transplant location, eelgrass was already present in densities from 20–100% cover.

References

Short, F.T., Davis, R.C., Kopp, B.S., Short, C.A., Burdick, D. M. 2002. Site-selection model for optimal transplantation of eelgrass *Zostera marina* in the northeastern US. Mar. Ecol. Prog. Ser. 227: 253-267.

Status of eelgrass beds in south-western Nova Scotia

Glyn Sharp and Robert Semple
Fisheries and Oceans Canada - Invertebrate Fisheries Division
Bedford Institute of Oceanography, 1 Challenger Dr.
Dartmouth, NS B2Y 4A2

There has been no comprehensive survey of eelgrass (*Zostera marina)* beds in south-western Nova Scotia. To provide an assessment of this habitat, we used observations from 25 years of intertidal research activities and from persons whose work and recreational activities has brought them into daily contact with intertidal mud flats. Sometimes the chronology and location of these reports were imprecise but these individuals generally are very experienced with their part of the coastline. Finally we analysed air photos from the standard Nova Scotia Department of Natural Resources air photo inventory.

Twenty-five years ago, healthy eelgrass populations occupied all suitable intertidal mud flat areas. By 2000, anecdotal reports from Cape Sable to Yarmouth described the denuded state of mud flats. More recent observations in 2003 confirmed this status. Present day observations describe many intertidal flats without vegetation and with glutinous mud substrate. Exceptions to this condition are reports of recruitment in the form of cohorts of year one eelgrass germlings from five widely separated sites in Lobster Bay, near Pubnico. There are also some areas where adult plants exist in isolated sites. These may be populations in transition to barren mud flats or a sign of recovering populations.

Estimates were made of total eelgrass biomass and production loss from the Tuskets to Pubnico Point, based on the assumption of total eelgrass coverage of mud flats in 1978. Above ground biomass loss is estimated at 441-3920 t dry weight and production loss is estimated at 3.6 to 25.2 t dry weight per year. Biomass and production figures were based on surveys from New England populations. Detailed analysis of 1978, 1989 and 2000 series 1:10,000 colour air photos for two mud flats in Lobster Bay recorded a loss of 30 % and 44% eelgrass cover. These figures should be considered with the variable restrictions of tide level, light angle, and development affecting the interpretation of air photos. The list of possible causes for the loss of eelgrass cover in south-west Nova Scotia includes disease, pollution, eutrophication, direct disturbance and changes in substrate. However, none of these issues alone could be confirmed to be the cause of such a wide scale and relatively sudden loss of intertidal eelgrass populations.

Quantifying the rapid decline of eelgrass beds on the eastern shore of Nova Scotia between 1992 and 2002

Annelise Chapman and Jennifer Smith
Biology Department, Dalhousie University
Halifax, NS Canada B3H 4J1

In several large tidal inlets on the eastern shore of Nova Scotia, eelgrass (*Zostera marina*) occurs in extensive beds, both intertidally and subtidally. Throughout the 20th century, eelgrass was harvested commercially in the region, and mass mortalities have been documented repeatedly in the past. During the 1990s, eelgrass beds on the Eastern Shore were dense and extensive, but anecdotal evidence indicated a rapid and massive decline of populations between 1999 and 2002.

The goal of our study was to quantify this decline by measuring the distribution changes of intertidal eelgrass populations in four large tidal inlets in eastern Nova Scotia. We compared existing aerial photographs, published by the province of Nova Scotia in 1992 and taken at low tide, with new aerial images taken during this study in 2002. Through a process of (i) image registration to a topographical grid, (ii) colour signature selection of eelgrass, manually adjusted and (iii) quantification of grid cells occupied by eelgrass signatures, we were able to calculate the total intertidal area occupied by eelgrass in four inlets (Cole Harbour, Chezzetcook, Petpeswick and Musquodoboit Harbour) in 1992 and in 2002.

We ground-truthed the 2002 eelgrass signatures identified from aerial photographs by visiting 103 GPS-registered stations in three of the inlets by canoe, identifying sediment types and benthic vegetation. This allowed us to distinguish eelgrass beds from other benthic vegetation, such as green algal mats.

The average decline of intertidal eelgrass beds in the four inlets was 79.5 % ± 20.8 % (SD) over the ten years, with Petpeswick having the greatest loss (96%) and Cole Harbour the smallest (49%). We did not find any consistent pattern of eelgrass disappearance, in that sediment type, exposure, location within the inlet, or population features could not explain the decline of some beds and persistence of others. We also did not find symptoms of the wasting disease, which devastated eelgrass populations across North Atlantic coasts in the past.

We conclude that aerial photography is an extremely powerful tool to map the distribution of intertidal eelgrass on scales of tens of kilometres, but should not be used to draw conclusions about population parameters at smaller scales, such as surface cover, shoot density and shoot length.

Changes in eelgrass in southern Gulf of St. Lawrence estuaries

Andrea Locke and J. Mark Hanson
Fisheries and Oceans Canada, Gulf Fisheries Centre
P.O. Box 5030
Moncton, NB E1C 9B6

During a series of surveys for invasive species, we collected data on the above-ground biomass and percent cover of eelgrass (*Zostera marina*) in estuaries along the Northumberland Strait shores of New Brunswick, Nova Scotia and Prince Edward Island, and along the north shore of Prince Edward Island. We focussed on looking for invasive species in eelgrass beds which we considered a habitat that would be particularly attractive to invading green crabs (*Carcinus maenas*), rather than sampling randomly among habitats in estuaries. Thus, our data do not provide an estimate of mean eelgrass biomass in the entire estuary, but rather represent the mean biomass of eelgrass within beds.

Samples were collected from 13 estuaries during synoptic surveys in 2001 and 2002 (in New Brunswick: Kouchibouguac, Richibucto, Cocagne and Baie Verte; in Nova Scotia: Tatamagouche, Merigomish, Caribou, and Pomquet; in Prince Edward Island: St. Mary's Bay system, Hillsborough, Bedeque, Cascumpec and Rustico). These surveys were conducted between late June and mid-August, and three sites per estuary were sampled. Using a scuba mask or glass-bottomed bucket, the percent cover of eelgrass, algae, and other grasses such as *Ruppia* were visually estimated on a 70 cm x 70 cm quadrat, haphazardly tossed in the direction of the eelgrass bed. Above-ground biomass was then collected by hand from the quadrat. In the laboratory, eelgrass was separated from other components (algae, epibionts, etc.), dried at 60° C for 24 hr, and weighed. Only biomass will be discussed in detail in this presentation. A preliminary comparison of biomass and percent cover indicated that conclusions should be similar for both methodologies.

Eelgrass was sampled and mapped during a detailed survey of three estuarine systems in 2002 and 2003. Sampling was conducted using the same methodologies as the synoptic work. The estuaries, selected on the basis of their species invasion history, included the St. Mary's (PEI) system (consisting of St. Mary's Bay, and the Cardigan, Montague and Brudenell rivers), Caribou (NS), and the Kouchibouguac (NB) system (Kouchibouguac Lagoon, and Kouchibouguac and Black rivers). Up to 32 eelgrass samples were collected in each location from mid July to late August. Mapping of coastal habitat types, activities and structures was conducted from a boat using a GPS and navigational charts.

An additional time series may be constructed for the Kouchibouguac system by combining our data with the above-ground biomasses collected in 1999-2000 by Venitia Joseph (M.Sc. thesis), or the percent cover estimates obtained by Greg Klassen (Index of Biotic Integrity project) from 1996 to 2002.

In the synoptic survey of 2001, we observed that eelgrass biomass was lower in the eastern part of the southern Gulf of St. Lawrence than in the western part of our study area. We tested the hypothesis that eelgrass biomass was lower in estuaries with green crab than in uninvaded estuaries, and the result was significant at $P = 0.04$. However, this result was confounded by the spatial trends, leading us to conclude that we could not separate the effects of green crab from an east-west environmental (or other) factor.

Our synoptic survey of 2002 showed a reduction of eelgrass biomass across all 13 estuaries with the exception of Hillsborough (PEI) (Table 1). The most dramatic reduction (88%) was in Rustico (PEI). There were no differences attributable to presence of green crab or the green alga *Codium fragile* ssp. *tomentosoides*.

The synoptic survey was not repeated in 2003, but comparison of the detailed surveys of 2002 and incomplete data from 2003 revealed a further reduction of biomass in all estuaries sampled in 2003. Comparison of our biomass data from 2001-2003 to V. Joseph's data in Kouchibouguac estuary in 1999-2000 indicated a consistent decline in eelgrass biomass, starting about 2001.

Our preliminary conclusions are:

1. Our data are consistent with a decline in eelgrass biomass in the southern Gulf of St. Lawrence, during the period 2001-2003.
2. This decline seems to have started in the eastern portion of the study area in 2001, spreading to the west by 2002.
3. There was no relationship to the distribution of recent species invasions, except in 2001, when the apparent trend was confounded by spatial relationships.

These conclusions should be considered with several caveats. First, the analyses are preliminary and laboratory analyses of 2003 data have not been completed. The data were not collected specifically in order to study eelgrass, and thus the sites were not randomly sampled. However, we selected our sites based on the presence of eelgrass and sampled the same sites the following year. Consequently, our conclusion of a decline in biomass is statistically valid but it likely overestimates the loss in biomass for entire estuaries (the biomass estimates can not be extrapolated to the entire estuary). Seasonality and interannual differences in survey timing may affect the data, although we made an effort to limit our sampling to the period when eelgrass biomass should be maximal.

Although the evidence, including anecdotal accounts by local residents, suggests a widespread loss of eelgrass throughout the southern Gulf of St. Lawrence in recent years, it is important to remember that our time series of data is very limited. We do not know the "normal" range of eelgrass biomass in this area. In other words, is this a real and worrisome decline in eelgrass biomass, or part of a normal cycle? A related question is whether there is a lower threshold of eelgrass biomass, which would result in catastrophic effects on the organisms which depend on eelgrass. At present, a method does not exist to quantify these effects at the ecosystem level, which is the appropriate level, given the multiple biotic communities as well as physico-chemical characteristics that are affected by eelgrass within an estuary. One promising approach, capable of being applied at a variety of organizational levels, is the Index of Biotic Integrity currently under development for Kouchibouguac National Park.

Table 1. Changes in the above-ground dry biomass of eelgrass in 13 estuaries in the southern Gulf of St. Lawrence. The percent change estimates for 2003 are preliminary.

Province and Estuary	Percent change from previous year 2002	2003
NEW BRUNSWICK		
Baie Verte	-72.3	
Cocagne	-65.0	
Kouchibouguac	-39.3	-9.8
Richibucto	-49.7	
NOVA SCOTIA		
Caribou	-8.7	-23.6
Merigomish	-37.8	
Pomquet	-22.6	
Tatamagouche	-61.1	
PRINCE EDWARD ISLAND		
Bedeque	-61.0	
Cascumpec	-29.7	
Hillsborough	+64.7	
Rustico	-87.7	
St. Mary's	-50.4	-46.1
MEAN CHANGE	-40.1	

Destruction of eelgrass beds in Nova Scotia by the invasive green crab

David J. Garbary, Anthony G. Miller, Norm Seymour and Jim Williams
Department of Biology, St. Francis Xavier University
Antigonish, NS B2G 2W5

As we reported in Seymour *et al.* (2002), mean number of migrant Canada Geese (*Branta canadensis*) present in Antigonish Harbour in the southern Gulf of St. Lawrence during October to December 1998-2000 were similar (450-500 birds). These numbers are comparable to those observed since the 1970s. During this period Canada Geese primarily used two foraging sites. However, in 2001, the average number of birds declined by half and primary foraging sites were used only rarely. This change coincided with a decline of 95% between October 2000 and October 2001 in the biomass of roots and rhizomes of eelgrass (*Zostera marina*), the principal food of geese in this estuary. In addition, there was a reduction of about 50% in the number of Common Goldeneye (*Bucephala clangula*), which feed on invertebrates associated with eelgrass. This decline in weekly abundance of Canada Geese and Common Goldeneye was probably the result of unusually short residence times in the estuary, rather than a decline in the total number of migrants. We attribute these changes in the distribution and abundance of geese and goldeneyes to the dramatic decline in eelgrass, which we in turn attribute to increased numbers of green crabs (*Carcinus maenas*) in the estuary.

In recent years, we have attempted to collect information on how widespread these declines in eelgrass were across Nova Scotia. We distributed a survey questionnaire to 140 Harbour Masters along the Atlantic shoreline from Yarmouth to Merigomish, asking them to comment on:

1. How extensive the eelgrass beds are or have been historically
2. Changes in eelgrass abundance in recent years
3. Changes in the biology of the harbour

Seventy Harbour Masters responded to the survey. Within the geographic area that included all reported sites of eelgrass decline, 31 out of 40 respondents reported a decline in eelgrass. All Harbour Masters in the 31 sites where eelgrass declines were reported also responded that there was an abundance or increasing number of green crabs.

In order to better understand the causal mechanisms between green crab and decline of eelgrass we initiated additional studies in Tracadie Harbour, Nova Scotia. We used enclosures to study green crabs *in situ*. We estimate that green crabs in Tracadie Harbour remove 87,000 eelgrass shoots per day, representing a loss of biomass of 890 kg/day. Green crabs removed eelgrass shoots by excavating burrows in their search for benthic bivalves, as well as shredding and cutting shoots that obstruct their digging activities.

We are also investigating another mechanism by which activities of green crabs may contribute to the removal of eelgrass. Empirical data have shown increased epiphyte loading in areas of high green crab abundance. In Tracadie Harbour this was 0.54 ± 0.38 g dw per g dw of shoot. This increase epiphyte load leads to increase buoyancy of eelgrass shoots, which could potentially increase the tendency for the rhizomes to float away from the substrate when disturbed by the digging activity of crabs.

In conclusion our work to date indicates that:

1. a major decline has occurred in eelgrass distribution in Nova Scotia over the last 3-6 years,
2. green crabs are the major cause of this decline,
3. although overall impacts of the decline on waterfowl are unclear, we have noted a decline of about 50% in the number of migrating Canada Geese at one site, with apparent impacts on waterfowl in other locations, and
4. there may be similar negative impact on detritus-based food chains, and on estuarine biodiversity in coastal waters of Nova Scotia.

References

Seymour N.R., Miller A.G., Garbary D.J. 2002. Decline of Canada geese (*Branta canadensis*) and common goldeneye (*Bucephala clangula*) associated with a collapse of eelgrass (*Zostera marina*) in a Nova Scotia estuary. Helgol. Mar. Res. 56:198-202.

The importance of eelgrass to waterfowl in Atlantic Canada

Alan R. Hanson,
Canadian Wildlife Service, Environment Canada
P.O. Box 6227
Sackville, NB E4L 1G6

The importance of eelgrass (*Zostera marina*) to waterfowl has long been recognized. In eastern North America, the Atlantic Brant (*Branta bernicula hrota*) was known to feed almost exclusively on eelgrass. Along the mid-Atlantic United States, the Atlantic Brant, because they foraged on eelgrass, was said to make better table fare than the Canada Goose (*Branta canadensis*). Coastal lagoons such as Tabusintac, New Brunswick were well known spots for hunting Atlantic Brant, where local foundries made cast-iron decoys for the wings of sink boxes, local carvers made wooden decoys, and local hunt clubs guided rich sportsmen.

The importance of eelgrass to waterfowl, was demonstrated during 1930-1932 when thousands of hectares of eelgrass disappeared in eastern North America (Cottam and Addy 1947). The decline was attributed to wasting disease caused by the slime mold *Lybrinthula*, although climatic conditions may also have played a role (Martin 1954). During the winter of 1933-1934, the eastern North American population of Atlantic Brant was estimated at only 10% of that present in 1930-31. During this period of low eelgrass availability, the surviving birds changed their diet to include sea lettuce (*Ulva* spp.) and upland foods. This switch in diet was quickly noticed by hunters who complained that the Atlantic Brant's culinary qualities were negatively impacted (Barry 1964). A significant consequence of the decline in eelgrass is that their fall migration pattern no longer includes a route along the coast of New Brunswick and Nova Scotia. Fall migration now is focused on a direct route overland from James Bay along the Hudson Valley to the Atlantic Coast near New York City, with a large overwintering population near Atlantic City, New Jersey (Bellrose 1980).

Eelgrass recovered slowly in the northeast (Cottam and Addy 1947; Cottam and Munro 1954). In Atlantic Canada, estuaries with eelgrass are used by migrating Canada Geese, American Black Ducks (*Anas rubripes*), Common Goldeneye (*Bucephala clangula*) and Barrow's Goldeneye (*Bucephala islandica*). In south-western Nova Scotia, over-wintering Canada Geese rely on eelgrass (Martell 1969, Newman-Smith 1983). In recent years, local residents have reported starving Canada Geese in southwestern Nova Scotia and a lack of eelgrass. This situation gathered considerable media attention, with the public demanding a government sponsored feeding program. Eelgrass declines have also been reported along the eastern shore, and were again reported in December 2003. Along the Nova Scotian Northumberland Strait, there was a documented loss of eelgrass from the Antigonish Estuary, and concomitant decline in fall staging Canada Geese and Common Goldeneye during 1998-2000 (Seymour *et al.* 2002). Historical evidence suggests that if eelgrass declines were to become widespread there would be major impacts on waterfowl feeding behaviour, migration patterns and over-winter survival.

References

Bellrose F.C. 1980. Ducks, Geese and Swans of North America. Harrisburg, PA. Stackpole Books. 539 p.

Cottam C., Addy C.E. 1947. Present eelgrass condition and problems on the Atlantic Coast of North America. Trans. N. Amer. Wildl. Conf. 12:387-398.

Cottam C., Munro D.A. 1954. Eelgrass status and environmental relations. J. Wildl.Manage. 18:449-460.

Martell A.M. 1969. A study of winter waterfowl ecology at Port Joli, Nova Scotia. M.Sc. Thesis. Acadia University, Wolfville, Nova Scotia. 275 p.

Martin A.C. 1954. A clue to the eelgrass mystery. Trans. N. Amer. Wildl. Conf. 19:440-449.

Newman-Smith G. 1983. The utilization of Port Joli and Port L'Hebert and Sable River by migrating and overwintering Canada Geese. M.Sc. Thesis. Acadia University Wolfville, Nova Scotia. 60 ++ p.

Seymour N.R., Miller A.G., Garbary D.J. 2002. Decline of Canada geese (*Branta canadensis*) and common goldeneye (*Bucephala clangula*) associated with a collapse of eelgrass (*Zostera marina*) in a Nova Scotia estuary. Helgol. Mar. Res. 56:198-202.

Characterization and habitat use of eelgrass in Kouchibouguac Estuary, New Brunswick

Venitia Joseph[1], Andrea Locke and Jean-Guy Godin
[1]Presenter and contact: Fisheries and Oceans Canada, Gulf Fisheries Centre
P.O. Box 5030
Moncton, NB E1C 9B6.

We investigated spatial distribution of fish and decapods over two summers in eelgrass (*Zostera marina.*) beds and nearby non-vegetated sandy habitats in the lower Kouchibouguac Estuary, New Brunswick. During the ice-free season in 1999 and 2000, mobile epifauna were sampled using fyke nets, minnow traps and an epibenthic sled. Eelgrass biomass, sediment, and physico-chemical data were also collected.

During summer months, peak biomass in the lagoon was ~ 300 g/m². Sediments were finer and the percent organic content higher in eelgrass habitats than in sandy habitats. Eelgrass habitats contained a higher species richness and abundance of mobile fish and decapods than nearby sandy habitats, although differences in abundance were significant only for fish. Abundance was generally greater at night than during daylight hours for most species.

Atlantic tomcod (*Microgadus tomcod*), winter flounder (*Pleuronectes americanus*) and sand shrimp (*Crangon septemspinosa*) dominated night/crepuscular catches, whereas threespine stickleback (*Gasterosteus aculeatus*) and cunner (*Tautogolabrus adspersus*) predominated in diurnal periods. The nursery function of eelgrass habitat was most evident for juvenile white hake (*Urophycis tenuis*) and small cunners (< 3 cm in length), which were found only in such habitat.

Water depth did not significantly affect the spatial distribution of fishes and decapods,in shallow (<1 m) versus deep (>1 m) sites, although larger cunners (>3 cm) were generally found to occupy deep sites. This study is one of the few to have investigated the ecological importance of eelgrass habitats for mobile epifaunal communities in eastern Canada.

Eelgrass as nursery habitat for juvenile fish in the coastal marine environment

Robert S. Gregory
DFO - Northwest Atlantic Fisheries Centre
St. John's, NL A1C 5X1

Juvenile Atlantic cod densities in Newfoundland are highest in eelgrass (*Zostera marina*) beds (Ings *et a*l. 2004). During the period 1995-2003, research has focused on examining if juvenile cod use eelgrass beds as habitat because of increased food availability or because of reduced predation risk (Linehan *et al.* 2001; Laurel *et al.* 2003a, 2003b, 2004). The majority of this research has occurred in Newman Sound in Terra Nova National Park, Newfoundland.

The vast majority of juvenile cod are found near the bottom in coastal areas less than 10 m deep. Highest densities of age 0 cod are observed in eelgrass sites (Ings *et al.* 2004). These findings were supplemented with an eelgrass removal-enhancement experiment (Laurel *et al.* 2003b) which conclusively demonstrated that juvenile cod select eelgrass areas as nursery habitat. Using a 'Before-After Control-Impact' (BACI) experimental design we found that densities of age 0 Atlantic cod and piscivorous fish declined in areas where eelgrass was removed and increased in areas where eelgrass was added.

In these studies, predation risk was lower in larger eelgrass patches (Laurel *et al.* 2003a), although predation rate is highest at the edge of individual patches (Gorman in prep.). These results suggest that there is an optimum size of individual eelgrass beds, to minimize predation risk. This prediction was borne out in a study where the highest juvenile cod densities were observed at intermediate habitat complexity (Wells 2002), suggesting an optimum blend of habitat area and degree of fragmentation.

In 1999, compact airborne spectrographic imagery (CASI) was used to map eelgrass in inner Newman Sound. CASI provided good spatial resolution of eelgrass distribution (4m x 4m) including subtidal eelgrass as deep as 6 m. Habitat complexity (*i.e.*, perimeter to area ratio) of eelgrass patches was predictable across spatial scales within spatial resolutions of 256 m^2 to 25,600 m^2 (O 2002). It was thus similar to aerial photography and satellite imagery. To be effective, CASI required calm surface water conditions, low tide conditions, and high solar azimuth, reducing time windows where it was effective.

References

Gorman, A.M. MSc thesis In Prep. Memorial University of Newfoundland. St. John's.

Ings, D.W., D.C. Schneider, R.S. Gregory, V. Gotceitas. 2004. Vegetation and shoreline complexity determines the density of juvenile fishes in the coastal marine environment. Mar. Ecol. Progr. Ser. 00:000-000. In Revision.

Laurel, B.J., R.S. Gregory, J.A. Brown, J. Hancock, D.C.Schneider. 2004. Behavioural consequences of density-dependent habitat use in marine fish. Mar. Ecol. Progr. Ser. 00:000-000. In Press.

Laurel, B.J., R.S. Gregory, J.A. Brown. 2003a. Predator distribution and habitat patch area determine predation rates on age 0 juvenile cod (*Gadus morhua*). Mar. Ecol. Progr. Ser. 251:245-254.

Laurel, B.J., R.S. Gregory, J.A. Brown. 2003b. Settlement and distribution of age 0 juvenile cod, *Gadus morhua* and *Gadus ogac*, following a large-scale habitat manipulation. Mar. Ecol. Progr. Ser. 262:241-252.

Linehan, J.E., R.S. Gregory, D.C. Schneider. 2001. Predation risk of age 0 cod (*Gadus*) relative to depth and substrate in coastal waters. J. Exp. Mar. Biol. Ecol. 263:25-44.

O, M. 2002. Multi-scale analysis of eelgrass habitat (*Zostera marina*) in Newman Sound, Newfoundland. MSc thesis, Memorial University of Newfoundland, St. John's.

Wells, N.J. 2002. Scaling eelgrass complexity in Newman Sound, Newfoundland and applications to fish ecology. MSc thesis, Memorial University of Newfoundland, St. John's.

An eutrophication survey of eelgrass beds in estuaries and coastal bays in northern and eastern New Brunswick.

Lotze, H.K. Inka Milewski[1], B. Worm and Z. Koller.

[1] Presenter and contact: Conservation Council of New Brunswick
254 Douglasfield Road,
Miramichi, NB E1N 4S5

Seagrasses are underwater flowering plants, uniquely adapted to colonize sandy and muddy seafloors in shallow coastal waters worldwide. Once established, they typically form dense meadows, not unlike fertile pastures on land, which grow up to two meters high and cover many acres of the coastal ocean. In sandy regions such as the Gulf of St. Lawrence, eelgrass (*Zostera marina*) forms the dominant underwater vegetation and builds essential habitat for many fish and invertebrates.

The Conservation Council of New Brunswick conducted a field survey in July 2002 because it was concerned about the health of coastal habitats in northern and eastern New Brunswick. We were interested in the consequences of high nutrient loading on the structure of eelgrass beds and their associated plant and animal communities. Altogether, ten bays and estuaries were selected. The survey sites had similar physical and biological characteristics according to scientific and anecdotal information. The bays also had similar marine resource extraction histories, such as shellfish harvesting (*e.g.*, oysters, clams, mussels) and finfish fisheries (*e.g.*, tomcod, gaspereau, smelt, eels). On the other hand, the bays had differing histories of human-induced nutrient loading (nitrogen, phosphorus) through land clearing, housing development, agricultural run-off, fish plant discharges, and other point- and non-point sources of nutrient releases.

All bays were visited within a one week period and one representative study site was selected to assess: 1) the structure of eelgrass beds (shoot density, canopy height, total cover); 2) the abundance and diversity of annual algae (epiphytes, free-floating and bottom-growing macroalgae); 3) the abundance and diversity of associated animals (filter feeders, epiphytic animals, herbivores, detritivores, predators); 4) the abundance of phytoplankton in the water column (chlorophyll *a* concentration); and 5) water characteristics (temperature, salinity). The study sites were grouped into low- and high-impacted sites on the basis of nutrient loading.

Low- and high-impacted sites showed similar eelgrass bed structure (shoot density, canopy height). At high-impacted sites (Cocagne, Bouctouche, Baie Sainte-Anne, and Lamèque) the meadows were more patchy and not as homogeneous as compared to low-impacted sites (Kouchibouguac, Kouchibouguacis, and Tabusintac) resulting in lower overall eelgrass cover. Epiphyte load, bottom-growing or drifting algae, and phytoplankton concentration were about twice as high in high-impacted sites compared to low-impacted sites. These high epiphyte and phytoplankton loads decrease light penetration to the eelgrass. Since eelgrass is dependent on high water quality, reduced light penetration is likely to reduce eelgrass productivity. Annual drifting or bottom-growing algae have a short life-span and decompose during summer and fall. High loads of decomposing annual algae contribute to low-oxygen or anoxic conditions, which have negative effects on eelgrass health and survival. During our survey, all high-impacted sites showed signs of anoxic conditions and resulting emissions of toxic hydrogen sulfide. The fauna associated with eelgrass beds also showed clear differences between low- and high-impacted sites. Although high-impacted sites had similar filter feeder abundances, the number of detritivores was six times higher, the number of herbivores was three times lower, and the number of predators was ten times lower compared to low-impacted sites. These differences in the animal community show a clear shift from a herbivorous to a detritivorous food chain that utilizes the overabundance of decomposing organic matter. Overall species richness and diversity of the entire community did not differ between low- and high-impacted sites. However, there were significant differences in the species composition within the community. At sites with high nutrient loading, red algae and epiphytic animals were replaced by green and brown algae, and herbivores were replaced by detritivores.

The results from our field survey indicate clear signs of eutrophication, with strong shifts in the plant and animal communities between sites of low- and high- nutrient loading. We recommend that mitigation efforts should concentrate on the reduction of point- and non-point source nutrient loading. Discharges from large point-source operations such as municipal wastewater treatment facilities, fish processing plants and pulp and paper mills need to be a priority area for regulation. Restoration of coastal wetlands and the establishment of adequate buffers around agriculture operations and septic systems should also be priorities for action. Wetlands serve as natural filters and buffers between land and sea, and they store and recycle nutrients thereby reducing the impact of non-point nutrient loading.

Eelgrass restoration in Bonne Bay, Gros Morne National Park, Newfoundland

David Pinsent
Jacques Whitford
607 Torbay Rd
St. John's, NL A1A 4Y6

A diesel fuel spill on a coastal road in 1999 and associated containment berm construction along a shoreline in East Arm, Bonne Bay, destroyed an eelgrass bed. Although Husky Energy was not involved in the spill, they volunteered to restore the eelgrass bed as part of their Habitat Compensation Program for habitat disturbance at the White Rose Oil Field.

Eelgrass was harvested from a large bed near the spill site and transplanted using the Transplant Eelgrass Remotely with Frames System or TERFS method (Short *et al.* 2002). Harvesting was done by pinching plants from the rhizome mat at low tide. SCUBA diving gear was not required. Twenty-five pairs of plants were attached to each wire frame using biodegradable paper ties. The frames are weighted and placed by lowering from a boat. 3600 frames and 180,000 eelgrass plants were placed over an area of 8750 m^2. Frames were left in place for 11 to 13 weeks until all the paper ties had dissolved.

Frames were removed in mid-October 2003 and a survey was conducted to determine the success of the transplant project. Divers estimated the percent survival of eelgrass in 539 frames, randomly selected over 2 water depth strata, 4-6 m and 7-9 m. Survival ranged from 0-100% in both depth classes. On average, survival was 19.4% in 7-9 m of water and 7.7% in 4-6 m of water. The area of 19.4% survival covered approximately 5351 m^2 and the area of 7.7% survival was approximately 3398 m^2. The overall average survival for the 8749 m^2 transplant site was 13.6%, which translates into 24,390 plants. The average density over the entire site therefore was 2.78 plants per m^2.

References

Short, F.T., Kopp, B.S., Gaeckle, J.L., Tamaki, H. 2002. Seagrass ecology and estuarine mitigation: a low-cost method for eelgrass restoration. Japan Fisheries Science Journal 68:1759-1762.

SECTION 2 - RESULTS FROM DISCUSSION GROUPS

Eelgrass Decline: Reality and Causation

Discussion Group Leaders: David Garbary[1] & Jean Munro[2]
[1]Department of Biology, St. Francis Xavier University, Antigonish, NS B2G 2W5
[2]DFO-MPO, C.P. 1000, Mont Joli, QC G5H 3Z4

Evidence for Eelgrass Decline

Prior to a discussion of causal mechanisms, the panel agreed that evidence suggests that a decline in eelgrass (*Zostera marina*) has and continues to occur. This decline is an issue at large or small scales in all the Maritime Provinces. The 95% decline of eelgrass in Antigonish Harbour between 2000 and 2001 may be the most dramatic example, especially because of the suddenness of the decline in what was apparently a healthy and pristine estuary (Seymour *et al.* 2002). Only Newfoundland and Labrador, and the coast of Quebec, have been without conspicuous decline in eelgrass beds, except for that associated with point sources of pollution or nutrient input. In light of the widespread decline at sites from the lower reaches of the Bay of Fundy through to the Southern Gulf of St. Lawrence (see various contributions to this Workshop), it is not surprising that a single causal factor has not been identified to explain the regional decline. Overall, there is a consensus that a regional decline is occurring, and that this may have important implications for estuarine and soft bottom benthic communities in general.

One general issue in all of eastern Canada is that there are insufficient baseline studies to establish the nature of healthy eelgrass beds against which changes can be accurately determined. A second general issue is that while eelgrass decline may have been observed through both detailed studies and more sporadic observations, these declines may be attributable to a suite of different causal factors. Thus, while embarking on major research programs to establish the causes for decline, several important questions need to be investigated:

1) What is the nature of healthy eelgrass beds in the various hydrographic and ecological situations in eastern Canada? What might be considered normal production levels and biodiversity?
2) To what extent is there loss of area of established beds, and is this being compensated for by growth of other beds?
3) To what extent are those eelgrass beds that are not changing in area suffering from reduced biomass or productivity?
4) How does one distinguish between background, year-to-year or seasonal fluctuations and those induced by anthropogenic eutrophication, invasive organisms or other causes?

The above four issues can be addressed by selecting eelgrass beds that are considered to be in pristine condition and are unlikely to be affected by pollution, and maintaining a long-term monitoring program. Regardless of the extent to which monitoring occurs, these sites should be protected to minimize human disturbance, to the extent possible. These sites will provide a reference standard against which the status of other beds in each province or habitat can be evaluated. Monitoring of eelgrass in eastern Canada should follow standardized protocols developed by Short (2000).

Known Causes or Potential Causes of Eelgrass Decline in Eastern Canada

Many of the factors impacting eelgrass beds globally are affecting eelgrass beds in eastern Canada, at least on a local scale. However, the vast increase in the number of sites in Nova Scotia where decline has been observed (without apparent wasting disease) suggests that a new phenomenon is impacting eelgrass beds. The known or potential causes of eelgrass decline in the region were summarized by presenters at the workshop. These are outlined below.

Eutrophication

This is a major problem facing estuaries and nearshore waters globally and eutrophication may be caused by point sources of nutrient inflow (*e.g.*, sewage or drainage pipes) or generalized sources (*e.g.*, inflow from rivers and streams impacted by farms or communities). This was considered to be a generalized problem in Prince Edward Island where agriculture dominates the landscape. Elsewhere, inputs from fish processing plants and dumping of human sewage provide major point sources of pollution that are affecting eelgrass beds.

An important point raised at this meeting was that there were considerable regional differences in the importance of eutrophication as a negative impact factor. The northern Gulf of St. Lawrence was considered to be the least impacted, and the southern Gulf of St. Lawrence most impacted. These effects are correlated with human population density in coastal areas and relative intensity of agriculture. It was apparent that considerable data on nutrient inflow and water quality is already available though various provincial, federal, and university sources, and that there was a need to assemble these data. A meta-analysis of this information might be extremely informative in providing a history of impacts at different scales. A general concern about the impact of deposition of pollutants from atmospheric sources was also raised.

Invasive species

Two invasive species: the green seaweed (*Codium fragile*), and the green crab (*Carcinus maenus*), occur in eastern Canada. These species have already become widely distributed and can be expected to become more abundant in eelgrass beds in the southern Gulf of St. Lawrence. Although both species have become locally abundant along the Atlantic coast of Nova Scotia, interactions with eelgrass have not been well documented. There is considerable evidence that high numbers of green crab can have a negative effect on eelgrass abundance as a consequence of their foraging activity. Although production of *C. fragile* can be locally abundant, and may have dramatic impacts on shellfish in estuarine conditions, the competitive interactions with eelgrass are unclear. For both of these exotic species there is no clear understanding of the negative impacts that they might have with respect to eelgrass. Given the localized abundance of the two invasive species, and the importance of eelgrass in estuarine systems, understanding the interactions of the invaders to eelgrass may be critical in evaluating not only long term ecological changes in the habitat, but also the implications for economic utilization of estuarine resources.

The issues associated with both of these species require that monitoring sites be established to determine the stability of eelgrass populations in relation to these invasive species. Sites without the invasive species are needed as controls to sites where the invading species are (or have) becoming established. Three potential sites for long term monitoring include Lennox Island (Prince Edward Island), Caribou Harbour (Nova Scotia) and Magdalen Islands (Quebec). At least one site is needed along the Atlantic coast of Nova Scotia and on the Gulf shores of New Brunswick.

Canada Geese

Canada geese (*Branta canadensis*) have large populations in northern Nova Scotia during fall migration and on the wintering grounds in southern Nova Scotia. These birds forage extensively on eelgrass roots and rhizomes. With the collapse of eelgrass in Antigonish Harbour in 2001, the number of fall staging birds was reduced by about 50 %. This decline was co-incident with the collapse of eelgrass on the wintering grounds and for several winters, Canada geese have been starving in their wintering grounds in southern Nova Scotia. Although poor bird health is most likely a consequence of reduced food availability, it may also be possible that the foraging activity of goose populations has exacerbated the problems in already reduced eelgrass beds. The relationships between Canada geese and eelgrass decline should be thoroughly investigated at the wintering grounds in Port l' Hebert and Port Joli in southern Nova Scotia.

Worm and Clam Harvesting

Although 'worming' and 'clamming' do not typically occur in eelgrass beds, these sediment-dwelling organisms often occur on adjacent mud flats. Trampling of eelgrass beds by harvesters, shading as a result of increased sediment loads in the water, and growth of microalgae from increased nutrient loading, may all have negative impacts on eelgrass growth and survival. Although this may be locally important for some eelgrass populations, this is not likely to be important on a regional basis. Nevertheless, the impacts of invertebrate harvesting on eelgrass populations need to be evaluated and the management implications considered.

Mussel and Oyster Harvesting and Aquaculture

Mussel cultivation and harvesting of natural or farmed populations of oysters takes place in many estuaries, often where there are natural populations of eelgrass. The impact on eelgrass is unknown; however, shading from suspended mussel socks and nutrient loading from animal waste may have major impacts, particularly in small estuaries where significant portions of the surface area are utilized.

In Malpeque Bay, PEI where oyster harvesting occurs, the presence of eelgrass is regarded as a nuisance because it makes the oysters more difficult to harvest. Although harvesting efficiency may improve with eelgrass decline, the long term health of the habitat (and commercial oyster numbers) may be dependent upon a productive eelgrass community. Requests for eelgrass removal as a means of improving commercial harvests of other species should be evaluated and avoided where possible, based on a whole ecosystem precautionary approach.

Eelgrass wasting disease

During the 1930s, there was a collapse of eelgrass populations in eastern North America, including the Maritime Provinces. This decline was subsequently attributed to a pathology induced by the slime mould *Labyrinthula zosterae*. It is now known that the causative agent forms systematic populations in eelgrass habitats, but it only causes disease outbreaks sporadically. None of the researchers attending this workshop provided evidence that *L. zosterae* was causing or contributing to declines currently being observed. In northern Nova Scotia, wasting disease was observed in older leaves in living shoots and in drift shoots after they had been dislodged from the substratum, but not at a level likely to impact populations.

Weather Events and Climate Change

The effects of regional or global climate change on eelgrass populations have not been determined. There are major potential indirect impacts such as sea level rise (30 cm per century) and increased storm activity (*e.g.*, Hurricane Juan), which may have resulted in increased erosion or increased nutrients in the water column. Given the wide geographic range of eelgrass (warm temperate to subarctic climates), and the extreme seasonal fluctuations in eastern Canada (water temperatures from -1°C to > 25°C), it would seem unlikely that even several degrees of rise in ocean temperature would seriously impact eelgrass populations.

Summary

There is a need for permanent monitoring stations in relatively pristine eelgrass communities to track natural and human induced changes in eelgrass populations. Eelgrass declines have been noted in the southern Gulf of St. Lawrence and the Atlantic coast of Nova Scotia, although there is no consensus that the decline can be attributed to one or even a few causal factors. The importance of eelgrass habitat to ocean biodiversity and productivity suggests that understanding the causes of decline is an environmental priority in the region. Once the factors contributing to the decline are better understood, it may be possible to manage these systems to minimize the extent of the declines and its biological and human impacts.

Eelgrass: Mapping and Monitoring

Discussion Group Leaders: Randy Milton[1] and David Methven[2]
[1]Nova Scotia Department of Natural Resources, Kentville, NS B4N 4E5
[2]Department of Biology, University of New Brunswick, Saint John, NB E2E 5L7

Points for discussion as suggested by Workshop Organizers:

1. Identify key issues;
2. Review the technical considerations of how to accomplish tasks;
3. Provide sample size and sample location considerations;
4. Provide cost estimates;
5. Identify planned initiatives;
6. Discuss possible collaborations and synergies;
7. Discuss potential inter-disciplinary funding proposals

The group discussed and summarized ideas on criteria they believe need to be captured within an eelgrass monitoring program. The criteria discussed were general in nature because they would need to be applied to a diversity of situations and research topics. Discussion was lively and ideas were captured as points and subsequently organized within headings of distribution, abundance, change detection, and approaches or who should undertake the work.

The group combined these elements to conceptualize a monitoring program that would provide information on changes in eelgrass distribution and abundance (Figure 1). A critical need is for synoptic regional coverage of the current distribution and abundance that includes both intertidal and subtidal beds. A second need is to undertake trend analyses of past changes in eelgrass distribution using historical imagery or survey data.

A basic question in developing a monitoring program is: why is it necessary? Presentations at the Workshop made reference to recent changes (positive and negative) in the regional and local distribution and abundance of eelgrass. The causes, or drivers of change, are subject to debate (see Garbary and Munro) but likely include effects due to climate change, invasive species, disease, and point and non-point sources of pollution.

Field investigations usually focus on understanding local effects and secondarily whether this pattern and process applies over larger regional scales. A monitoring program needs to be designed applying appropriate criteria and standard methodologies in order to facilitate the building of a systems evaluation as opposed to solely monitoring local effects. Communication among researchers is critical to ensure that the various local studies can collectively provide information at the regional scale. To this purpose, the individual protocol components can be broadly grouped into: W*hat*, W*hen,* and *Where* to measure and W*ho* will do the measuring.

The *What* to measure will be influenced by the identification of the problem, its extent and likely effects on eelgrass locally or regionally. The variables to be measured (*e.g.* biomass, density, patchiness) should function as an early warning indicator prior to serious environmental harm.

The frequency of measurement (the *When*) will be determined by the characteristics of the problem.

The variables will be used to evaluate change in ecological character of the system which can be defined as "... *the impairment or imbalance in any biological, physical, or chemical components of the wetland ecosystem, or in their interactions, which maintain the wetland and its products, functions and attributes*" (Source: *Wetland Risk Assessment Framework* adopted by Ramsar Resolution VII.10 at the 7th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971), San José, Costa Rica, 10-18 May 1999). Change in ecological character can be simply defined as the type of change as opposed to the cause of change.

Variables being measured should occur in multiple sites (the *Where*) both locally and regionally (Figure 2). Three target areas have been tentatively identified, which include the Atlantic coast of Nova Scotia extending into the Gulf of Maine (Lobster Bay), the Lower Bay of Fundy, and regions of the Gulf of St. Lawrence. This work should build upon current research and inventory programs undertaken by government agencies, universities, and community groups (the *Who*) individually or in partnership. Communication among parties is highly desired and can be undertaken through regular workshops, electronic communication, and networks such as list serves.

The participants emphasized the need to standardize methodologies (the *How*) among projects and to measure the same variables locally and regionally. Numerous approaches can be used depending upon the variable and the spatial scale, and may include ground or on-site studies, the use of remote sensing, combinations of technologies, and multiple scales (e.g. m^2 intensive plot surveys, or low resolution (km^2) satellite remote sensing for synoptic distribution). It is important that data from all studies can be pooled to increase our understanding of the regional significance of issues.

The monitoring program should also collect information to verify data gathered during synoptic regional surveys of eelgrass distribution and abundance.

Next steps include expanding the network of individuals and organizations involved in work on eelgrass, identification of current and historical information on distribution and abundance, and establishing priorities for cooperative work.

Figure 1 - A conceptualized monitoring program for eelgrass in Eastern Canada.

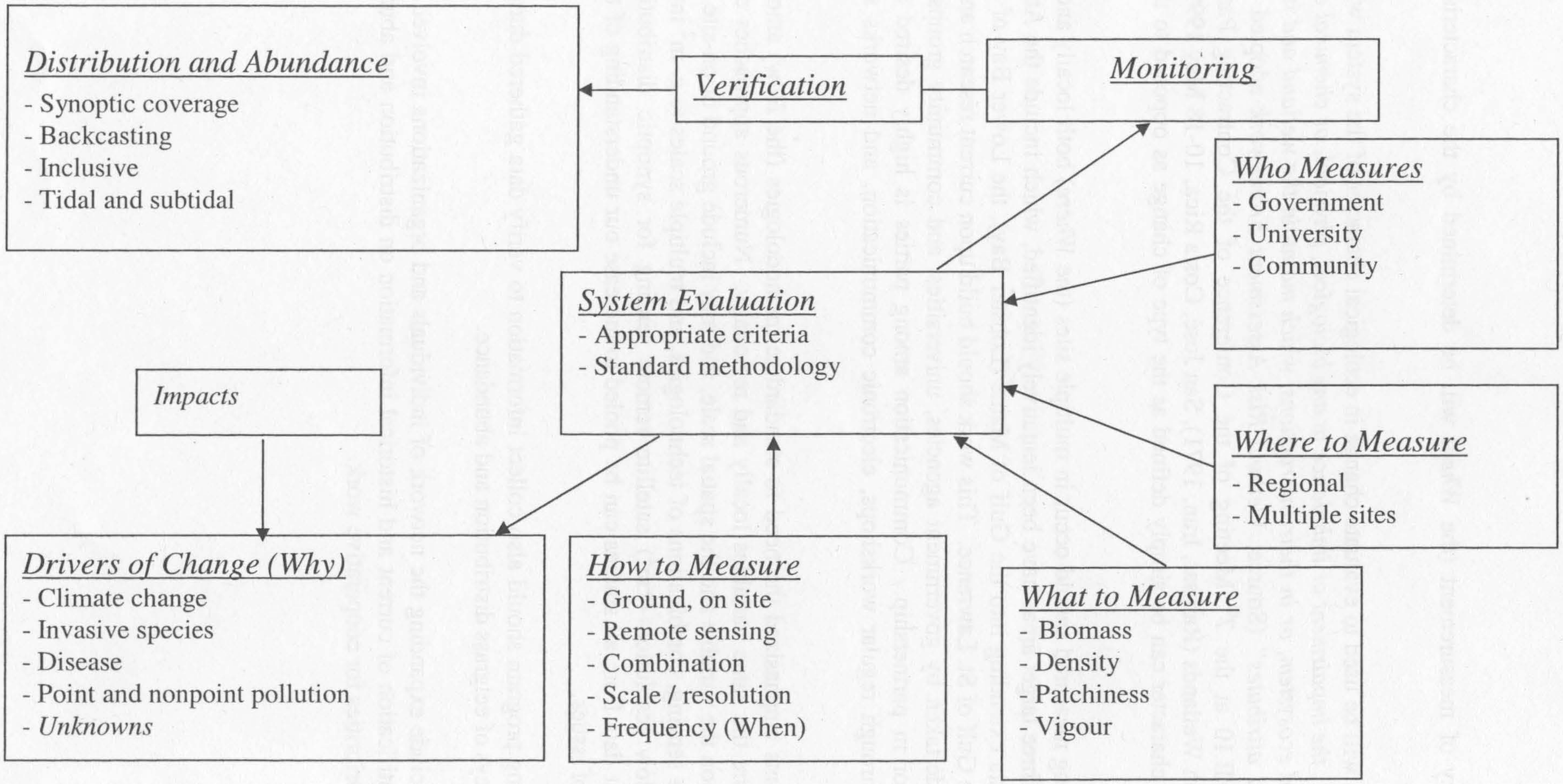
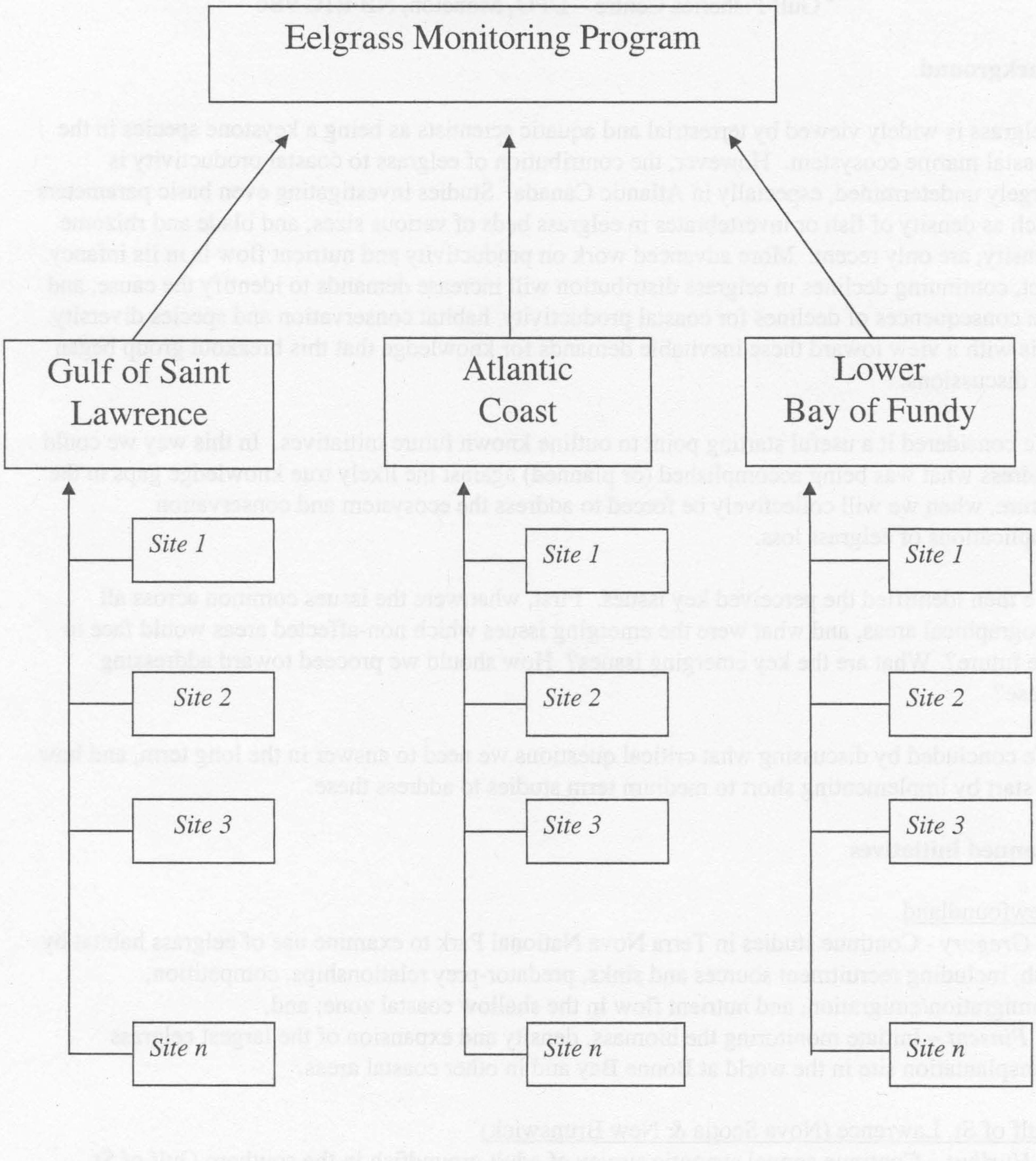


Figure 2 - Conceptual spatial framework for eelgrass monitoring program for Eastern Canada. It must be spatially and statistically robust, and include major ecological regions, have multiple sites per region, and have appropriate sample size within sites.



Eelgrass: Ecosystem Importance

Discussion Group Leaders: Robert Gregory[1] and Andrea Locke[2]
[1] Northwest Atlantic Fisheries Centre - DFO, St. John's, NL A1C 5X1
[2] Gulf Fisheries Centre – DFO, Moncton, NB E1C 9B6

Background

Eelgrass is widely viewed by terrestrial and aquatic scientists as being a keystone species in the coastal marine ecosystem. However, the contribution of eelgrass to coastal productivity is largely undetermined, especially in Atlantic Canada. Studies investigating even basic parameters such as density of fish or invertebrates in eelgrass beds of various sizes, and blade and rhizome density, are only recent. More advanced work on productivity and nutrient flow is in its infancy. Yet, continuing declines in eelgrass distribution will increase demands to identify the cause, and the consequences of declines for coastal productivity, habitat conservation and species diversity. It is with a view toward these inevitable demands for knowledge that this breakout group began its discussions.

We considered it a useful starting point to outline known future initiatives. In this way we could address what was being accomplished (or planned) against the likely true knowledge gaps in the future, when we will collectively be forced to address the ecosystem and conservation implications of eelgrass loss.

We then identified the perceived key issues. First, what were the issues common across all geographical areas, and what were the emerging issues which non-affected areas would face in the future? What are the key emerging issues? How should we proceed toward addressing these?

We concluded by discussing what critical questions we need to answer in the long term, and how to start by implementing short to medium term studies to address these.

Planned initiatives

<u>Newfoundland</u>
R. Gregory - Continue studies in Terra Nova National Park to examine use of eelgrass habitat by fish, including recruitment sources and sinks, predator-prey relationships, competition, immigration/emigration, and nutrient flow in the shallow coastal zone; and,
D. Pinsent – Initiate monitoring the biomass, density and expansion of the largest eelgrass transplantation site in the world at Bonne Bay and in other coastal areas.

<u>Gulf of St. Lawrence (Nova Scotia & New Brunswick)</u>
T. Hurlbut – Continue annual synoptic survey of adult groundfish in the southern Gulf of St. Lawrence and possible increased effort to focus on SARA (Species At Risk Act) initiatives (e.g. hake, and cod);

V. Joseph – Publish results of previous investigations of fish and decapod habitat use in Kouchibouguac River estuary, one of the first such studies in Canadian eelgrass habitats;
H. Collins and I. Milewski (MREAC/CCNB) – Investigate the impact of the fish plant in Baie Ste. Anne on the local environment, including nearby eelgrass beds;
A. Locke- Publish and finish lab work on collected data from the southern Gulf of St. Lawrence including the Kouchibouguac River estuary;
L. LeBlanc (Kouchibouguac National Park) - Estuaries were mapped in 2003 with DFO collaborators. Investigate Index of Biotic Integrity (IBI) on eelgrass beds pending funding in 2004-05 (with G. Klassen and E. Trembay);
K. Morrisey – Augment existing Shediac Bay Wetlands Atlas with additional material on eelgrass distribution information and pursue eutrophication issues;
M. Breau, V. Joseph, D. Keen – Explore the use of available and future data collected for Environmental Assessments to determine if eelgrass beds are "significant" or VECs (valued ecosystem components); and
D. Garbary – Continue monitoring efforts in Antigonish Harbour, regarding eelgrass dieoff and green crab distribution.

<u>Bay of Fundy and southwest Nova Scotia</u>
K. McAloney – Continue surveys of over-wintering waterfowl in eastern and south-western Nova Scotia, Minas Basin, Passamaquoddy and Grand Manan, focusing on areas of recurring problems; input data into Environmental Assessment databases; update databases on overwintering birds; and enhance monitoring of eelgrass distribution;
G. Sharp and A. Chapman – Continue eelgrass monitoring in southwestern Nova Scotia

<u>Quebec (Magdalen Islands)</u>
C. McKindsey – Conduct opportunistic baseline studies associated with other ongoing non-eelgrass projects.

Key Issues:
1. The degree of degradation of eelgrass beds in the Maritime Provinces is alarming – 50-90% loss in widespread geographic locations. Eelgrass die-offs have not yet been experienced in the coastal waters of Newfoundland and are, therefore, not yet an issue there. However, there are two issues of importance to investigators and habitat managers:
   i. Is the Maritime experience a harbinger of things to come in Newfoundland?;
   ii. Newfoundland has the valuable scientific contribution of being able to study unaffected beds (*e.g.*, before problems occur, or as a control environment for affected areas elsewhere).
2. There is a recognized lack of understanding of the overall status of eelgrass in Atlantic Canada – *e.g.*, what are the effects of eelgrass loss?; what were the historical densities, distributions, and fluctuation magnitudes and frequencies?; could Traditional Ecological Knowledge (TEK) be used such as input from fishermen and hunters?
3. There is little standardization of monitoring methods for censusing eelgrass and associated biotic communities, even within individual areas. In order to compare across different geographic areas and time and space scales, standardization of core protocols will become increasingly important. It is important to use methods consistent with the global seagrass

monitoring program developed by Fred Short at the University of New Hampshire. The protocol may require SCUBA diving in the Maritimes, and will require SCUBA diving in Newfoundland. However, the techniques may be modified to suit growing conditions in Canadian coastal waters, while remaining valuable in the global context. Such prospects should be explored.

4. What are the effects of extreme weather events including storms, climate change, inter-annual temperature fluctuations, floods, and turbidity.
5. What are the ecological roles of intertidal and subtidal eelgrass populations, in a relative and absolute sense? Are there similar declines in both?
6. How effective are various aerial photography and satellite remote sensing techniques? Is it important to standardize around low tide time, wind conditions and seasonality (affect on density and extent)? Currently, there is a large degree of compromise, including issues of expense, interpretation and ground truthing);
7. Is *Zostera marina* a species at risk, and does it warrant consideration as a possible candidate for COSEWIC listing? Investigation would be necessary to quantify the level of endangerment, which could be difficult over broad areas as there is a general lack of baseline census work. What is "critical habitat" for this aquatic species?
8. There was general consensus that more focus needs to be placed on understanding the ecology of eelgrass in eastern Canada.

Technical Issues:

1. Existing research programs, although some have only recently been implemented, can collectively be used to address ecosystem impacts. Currently we have the conceptual and analytical tools to address broad ecosystem level impacts such as Index of Biological Integrity (IBI) and related approaches, investigations of individual ecosystem components, and studies sites located throughout the region (southern Gulf of St. Lawrence, Bay of Fundy, Atlantic coast, and Newfoundland). These activities should enable us collectively to examine the big picture, both similarities and differences, and the importance of eelgrass habitat throughout the region.
2. It was recognized that there is little, to no information, available from Quebec on eelgrass status – densities, declines, and distributions.
3. It was discussed with concern that eelgrass "control" (*i.e.*, removal) is still practiced within the aquaculture industry in some parts of eastern Canada.

Conclusions

Reviewing the data on animal use of eelgrass beds in eastern Canada allowed us to state with some confidence that eelgrass beds are:

1. Used as nursery habitat for fish and invertebrates;
2. Used directly and indirectly as feeding habitat for geese and ducks;
3. Biological filters, removing toxins in waterways, estuaries, and coastal areas;
4. Important stabilizers of fine grained sediments; and
5. Areas of enhanced biological productivity and biodiversity.

Our breakout group recommended that Fisheries and Oceans Canada, Environment Canada and Parks Canada, and similar provincial agencies, carefully consider eelgrass in the Environmental Assessment process. For example, presently, DFO guidelines under the HADD process allow for eelgrass loss to be compensated by other habitat types, even when eelgrass may be the most valuable habitat in the coastal zone.

We also recommended several topic areas for short-and medium- term scientific studies, given the paucity of investigations in these areas, and the importance of eelgrass to a healthy ecosystem and consider the following to be of high priority:

1. Nutrient fluxes to/from eelgrass beds.
2. What proportion of estuarine/coastal productivity is due to eelgrass?
3. What is the quantitative and qualitative significance of the detrital pathways driven by eelgrass?
4. What is the monetary value of eelgrass on a unit area basis, derived perhaps through links to commercial fisheries, waterfowl hunters, etc.

Table 1 – Mailing Address of Workshop Participants

Last Name	First Name	Organization	Address	City	Prov.	Country	Postal Code
Bateman	Myrtle	Canadian Wildlife Service	P.O. Box 6227	Sackville	NB	Canada	E4L 1G6
Beck	Gerald	Richibucto River Association	3 River Street	Rexton	NB	Canada	E4W 2C9
Boyd	Paul	Department of Fisheries and Oceans	133 Church St.	Antigonish	NS	Canada	B2G 2E3
Chapman	Annelise	Dalhousie University	Biology Dept.	Halifax	NS	Canada	B3H 4J1
Collins	Harry	Miramichi River Environmental Assessment Committee	133 Newcastle Blvd.	Miramichi	NB	Canada	E1V 2L9
Connor	Kevin	New Brunswick Department of Natural Resources	P.O. Box 6000	Fredericton	NB	Canada	E3B 5H1
Dibblee	Randy	PEI Fish and Wildlife Division	P.O. Box 2000	Charlottetown	PE	Canada	C1A 7N8
Duggan	Dave	Coastal Management Section DFO	1 Challenger Dr.	Dartmouth	NS	Canada	B2Y 4A2
Forbes	Donald L.	Geological Survey of Canada	BIO P.O. Box 1006	Dartmouth	NS	Canada	B2Y 4A2
Frenette	Isabelle	Fisheries and Oceans Canada	343 University Avenue	Moncton	NB	Canada	E1C 9B6
Garbary	David	St. Francis Xavier University	Dept. of Biology	Antigonish	NS	Canada	B2G 2W5
Gallant	Richard	PEI Dept. Agriculture, Fish, Aquaculture and Forestry	P.O. Box 2000	Charlottetown	PE	Canada	C1A 7N8
Gauvin	Jocelyne	Pays de Cocagne Sustainable Development Group	176 ch. Cormier Cross	Cocagne	NB	Canada	E4L 2J5
Godin	Carole	Fisheries and Oceans Canada	343 Universite Ave., P.O. Box 5030	Moncton	NB	Canada	E1C 9B6
Gregory	Robert S.	Department of Fisheries and Oceans	Northwest Atlantic Fisheries Centre	St. John's	NL	Canada	A1C 5X1
Hanson	Alan	Canadian Wildlife Service	P.O. Box 6227	Sackville	NB	Canada	E4L 1G6
Hazel	François	Maurice-Lamontagne Institute Department of Fisheries and Oceans	850 route de la mer P.O. Box 1000	Mont Joli	QC	Canada	G5H 3Z4
Hiltz	Darren	Department of Fisheries and Oceans	1 Challenger Drive	Dartmouth	NS	Canada	B2Y 4A2
Hurlbut	Tom	Department of Fisheries and Oceans	343 University Avenue.	Moncton	NB	Canada	E1C 9B6

Table 1 (continued) – Mailing Address of Workshop Participants

Last Name	First Name	Organization	Address	City	Prov	Country	Postal Code
Joseph	Venitia	Department of Fisheries and Oceans	343 Universite Ave.	Moncton	NB	Canada	E1C 9B6
Julien	Brigitte	Southeastern Anglers Association	65 Irving Blvd., unit 3	Bouctouche	NB	Canada	E4S 3J7
Keen	Delly	Department of Fisheries and Oceans	P.O. Box 1236	Charlottetown	PE	Canada	C1A 7M8
Kim	Kwang-Young	Dept. of Oceanography Chonnam National University		Kwangju		Korea	500-757
LeBlanc	Leophane	Parks Canada Kouchibouquac National Park	186 Route 117	Kouchibouquac National Park	NB	Canada	E4X 2P1
Locke	Andrea	Department of Fisheries and Oceans	P.O. Box 5030	Moncton	NB	Canada	E1C 9B6
Marcoux	Olivier	Conseil regional de l'environment Gaspésie Îles-de-la-Madeleine	106A avenue Port-Royal Suite 103	Bonaventure	QC	Canada	GOC 1EO
McAloney	Keith	Canadian Wildlife Service	P.O. Box 6227	Sackville	NB	Canada	E4L 1G6
McKindsey	Chris	Department of Fisheries and Oceans	850 route de la Mer	Mont Joli	QC	Canada	G5H 3Z4
Methven	David	University of New Brunswick – St. John	P.O. Box 5050	St. John	NB	Canada	E2E 5L7
Milewski	Inka	Conservation Council of NB	254 Douglasfield Rd.	Miramichi	NB	Canada	EIN 4S5
Milton	Randy	Nova Scotia Department of Natural Resources	136 Exhibition St.	Kentville	NS	Canada	B4N 4E5
Morrissey	Krista	Shediac Bay Watershed Association	164 Pleasant St., Suite A	Shediac	NB	Canada	E4P 2L8
Munro	Jean	Maurice-Lamontagne Institute Department of Fisheries and Oceans	850 route de la Mer C.P. 1000	Mont-Joli	QC	Canada	G0L 1B0
Murphy	Lea	Department of Fisheries and Oceans	P.O. Box 1236	Charlottetown	PE	Canada	C1A 7M8

Table 1 (continued) – Mailing Address of Workshop Participants

Last Name	First Name	Organization	Address	City	Prov	Country	Postal Code
Ollerhead	Jeff	Mount Allison University	144 Main St.	Sackville	NB	Canada	E4L 1A7
Pinks	Clinton	CBCL Ltd.	1489 Hollis St.	Halifax	NS	Canada	B3J 2R7
Pinsent	David	Jacques Whitford Ltd.	607 Torbay Rd.	St. John's	NL	Canada	A1A 4Y6
LeBlanc Poirier	Nathalie	Richibucto River Association	3 River Street	Rexton	NB	Canada	E4W 2C9
Provencher	Lizon	Maurice-Lamontagne Institute Department of Fisheries and Oceans	850 route de la Mer	Mont Joli	QC	Canada	G5H 3Z4
Sharp	Glyn	Department of Fisheries and Oceans	1 Challenger Drive	Dartmouth	NS	Canada	B2Y 4A2
Tremblay	Eric	Parks Canada Kouchibouquac National Park	186 Route 117	Kouchibouquac National Park	NB	Canada	E4X 2P1
Thomson	Lewis	Canadian Wildlife Service	7th Floor Alderney Drive.	Dartmouth	NS	Canada	B2Y 2N6
Vandermeulen	Herb	Department of Fisheries and Oceans	1 Challenger Drive	Dartmouth	NS	Canada	B2Y 4A2
Wile	John	Ducks Unlimited Canada	P.O. Box 430	Amherst	NS	Canada	B4H 3Z5

Table 2 – Phone Number, Fax and E-mail Address of Workshop Participants

Last Name	First Name	Phone	Fax	E-Mail
Bateman	Myrtle	506-364-5041	506-364-5062	myrtle.bateman@ec.gc.ca
Beck	Gerald	506-523-8884	506-523-8885	rrassoc@nbnet.nb.ca
Boyd	Paul	902-863-5670	902-863-5818	boydp@dfo_mpo.gc.ca
Chapman	Annelise	902-494-2349	902-494-3736	Anne.Lise.Chapman@dal.ca
Collins	Harry	506-778-8591	506-773-9755	mreac@nbnet.nb.ca
Connor	Kevin	506-453-2440	506-453-6699	kevin.connor@gnb.ca
Dibblee	Randy	902-368-4666	902-368-5830	rldibblee@gov.pe.ca
Duggan	Dave	902-426-6183	902-426-3855	duggand@mar.dfo-mpo.gc.ca
Forbes	Donald L.	902-426-7737	902-426-6152	dforbes@nrcan.gc.ca
Frenette	Isabelle	506-851-6979	506-851-3027	frenettei@dfo-mpo.gc.ca
Garbary	David	902-867-2164	902-867-2389	dgarbary@stfx.ca
Gallant	Richard	902-368-5524	902-368-5542	rkgallant@gov.pe.ca
Gauvin	Jocelyne	506-576-8247	506-576-7480	gddpc@nb.aibn.com
Godin	Carole	506-851-2485	506-851-6579	godinc@dfo-mpo.gc.ca
Gregory	Robert S.	709-772-4491	709-772-5315	GregoryR@dfo-mpo.gc.ca
Hanson	Alan	506-364-5028	506-364-5062	al.hanson@ec.gc.ca
Hazel	François	418-775-0630	418-775-0718	HazelF@dfo-mpo.gc.ca
Hiltz	Darren	902-426-3622	902-426-1489	hiltzd@mar.dfo-mpo.gc.ca
Hurlbut	Tom	506-851-6216	506-851-2620	hurlbutt@ dfo-mpo.gc.ca
Joseph	Venitia	506-851-6475	506-851-2079	josephv@dfo-mpo.gc.ca
Julien	Brigitte	506-743-1114	506-743-7369	anglers@nb.aibn.com
Keen	Delly	902-566-7823	902-566-7848	keend@dfo-mpo.gc.ca
Kim	Kwang-Young	82-62-530-3465	82-62-530-0065	kykim@chonnam.ac.kr
LeBlanc	Leophane	506-876-1229	506-876-4283	leophane.leblanc@pc.gc.ca
Locke	Andrea	506-851-6248	506-851-6248	lockea@dfo-mpo.gc.ca
Marcoux	Olivier	418-534-4498	418-534-4122	cregim@globetrotter.net

Table 2 (continued) – Phone Number, Fax and E-mail Address of Workshop Participants

Last Name	First Name	Phone	Fax	E-Mail
McAloney	Keith	506-364-5013	506-364-5062	keith.mcaloney@ec.gc.ca
McKindsey	Chris	418-775-0667	418-775-0718	mckindseyc@dfo-mpo.gc.ca
Methven	David	506-648-5827	506-648-5811	dmethven@unbsj.ca
Milewski	Inka	506-622-2460	506-622-2438	milewski@nbnet.nb.ca
Milton	Randy	902-679-6224	902-679-6176	miltongr@gov.ns.ca
Morrissey	Krista	506-533-8880	506-533-7880	sbwa@nbnet.nb.ca
Munro	Jean	418-775-0826	418-775-0718	munroj@dfo-mpo.gc.ca
Murphy	Lea	902-566-7839	902-566-7848	murphyl@dfo-mpo.gc.ca
Ollerhead	Jeff	506-364-2428	506-364-2625	jollerhead@mta.ca
Pinks	Clinton	902-421-7241	902-423-3938	clintonp@cbcl.ca
Pinsent	David	709-576-1458	709-576-2126	dpinsent@jacqueswhitford.com
LeBlanc Poirier	Nathalie	506-523-8884	506-523-8885	rrassoc@nbnet.nb.ca
Provencher	Lizon	419-775-0598	418-775-0718	Provencherl@dfo-mpo.gc.ca
Sharp	Glyn	902-426-6042	902-426-6042	SharpG@mar.dfo-mpo.gc.ca]
Tremblay	Eric	506-876-2443	506-876-4283	eric.tremblay@pc.gc.ca
Thomson	Lewis	902-426-1188	902-426-6434	lewis.thomson@ec.gc.ca
Vandermeulen	Herb	902-426-8202	902-426-6695	vandermeulenh@mar.dfo-mpo.gc.ca
Wile	John	902-667-8726	902-667-0916	j_wile@ducks.ca

Acknowledgements

I would first like to thank the presenters and attendees for their participation in the Workshop and assistance in preparing this Technical Report. The depth and breadth of experience, expertise, and enthusiasm contributed to the success of the workshop and this document.

Thanks to Melanie Ball and Krista Baker for their logistical support to the workshop. Lea Olsen provided assistance in assembling this document. Thanks to Richard Elliot for providing valuable editorial advice which improved the consistency of this Technical Report.

The Eastern Habitat Joint Venture provided funding to pay for costs associated with hosting the workshop and producing this document.