Marine Environmental Observation Prediction and Response

Network of Centres of Excellence

(MEOPAR)

RESEARCH PROPOSAL

MEOPAR – WHaLE

Whales, **H**abitat **a**nd **L**istening **E**xperiment

Submitted by:

Dr. C.T. Taggart (PI) – Dalhousie University

Dr. D. Duffus (co-PI) – University of Victoria

Dr. T. Ross (co-PI) – Dalhousie University

Prepared with the substantial assistance of:

Dr. K. Davies

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Project Summary

Ocean-going vessels pose a threat to all large whales worldwide. Maritime commerce needs information about whale locations and vessel-whale risk to mitigate this threat. While the vessel component of risk estimation is achievable virtually anywhere, the whale component is limited by lack of data on whale and whale-habitat distributions. We propose to address this deficiency using recent advances in whale passive acoustic monitoring (PAM) technology. We have available a PAM system mountable on ocean gliders (mobile autonomous underwater vehicles) that monitors whale locations and identifies species from whale vocalisations and transmits this information to shore in near real-time via satellite. We propose to enhance MEOPAR's observation core by equipping the Ocean Tracking Network/MEOPAR-operated glider fleet with at least 3 PAM systems and one echosounder, and use the acoustic-equipped gliders in conjunction with vessel Automatic Identification System (AIS) data, an array of seafloor-mounted PAM platforms and partner-funded ship-board surveys to fill knowledge gaps in the distribution of large whales and their known and suspected habitats in locations on the east and west coasts of Canada where vessel traffic density is high and anticipated to increase, and where in coastal communities ecotourism and private recreation present small-vessel risk to whales. Further, we propose to work with our international partners and use the glider-mounted PAM information to develop, test and implement in Canada the Whale Alert system, whereby areas of concentrated and classified whale vocalizations are made available to mobile device users and can also be transmitted to vessels via an AIS-message. Finally, we will use social science methods to learn how fleets and coastal communities view their responsibilities in whale and habitat conservation through vessel risk mitigation, examine how vessel-whale risk mitigation can promote social goals such as cultural and economic resilience, identify points of conflict among the various societies (communities, industries, the fleet, conservation agencies and governments) with respect to risk mitigation, and help find options though which that conflict can be ameliorated. We will achieve this by incorporating Marine Affairs Master of Marine Management students involved in research and outreach with our 19 collaborating organisations on both coasts. Eight HQP will receive an interdisciplinary education through the WHaLE project, and each will benefit from collaboration with partners from various sectors, including through internships. This project will be enhanced considerably by external support from 8 private sector, 5 NGO, 4 governmental and 2 external academic organizations who have together pledged ~$2.6million (cash & in-kind), including 11 organizations who have pledged to host HQP interns. We will also leverage 2 large, funded projects, that parallel ours; an Environment Canada Habitat Stewardship Program grant aimed at North Atlantic right whale conservation and stewardship and a US-led glider-PAM project operating in the Gulf of Maine, making the research seamless from the Gulf of Maine and across the Scotian Shelf. This multi-sectoral commitment, which includes the fleet represented by the Shipping Federation of Canada, demonstrates that informed, science-based and collaborative vessel-whale risk mitigation solutions such as the ones the WHaLE project will deliver are desirable and achievable.

Alignment with MEOPAR Strategic Objectives: Priority MEOPAR Project Area: Reduction of the impacts of maritime commerce on marine ecosystems. MEOPAR's 5 yr goals. WHaLE will **establish pan-Canadian nodes of integrated observation systems in strategic locations** by equipping the OTN/MEOPAR's recently expanded ocean glider fleet with acoustic technology designed to monitor whales and their habitat. The gliders, already equipped to observe/measure ocean optics, phytoplankton, water masses, chemistry, depth-averaged currents and tagged-fish locations in near real-time will then be able to monitor zooplankton and whales – a fully 'integrated' ocean ecosystem observation system. WHaLE will also expand the program via vessel-whale risk assessment operations on the Scotian Shelf, off Vancouver Island and eventually the B.C. north coast. Gliders are an ideal **tools for rapid assessment during marine emergencies**; a fleet of such gliders would offers synoptic and scalable survey coverage. Glider mobility makes them transportable to regions of emergency, and their ability to communicate data in near real-time provides for near real-time marine risk assessment and response. The gliders will support vessel surveys for whales and respond to whale abandonment of protected habitats; an issue of enhanced risk of vessel strike outside protected but abandoned habitats. WHaLE will **contribute to the assessment of long term oceanic change on coastal communities, ecosystems and economic interests, including implications for resource management, regulation and policy**. We build on the successes of a ~35-year ongoing international, multi-sectoral cooperative entity that includes 12 of our 19 external supporters and facilitates recovery of endangered right whales through research, risk analysis and mitigation, industry and community stewardship, policy development, and NGO leadership. While we propose novel approaches designed to address emerging vessel-whale risk, support from this entity offers a clear gateway for incorporating our novel insights into long-term ocean monitoring, risk mitigation and policy. We will implement four **activities to train HQP with skills in natural and social science and provide them with problem solving skill related to marine risk**. These include HQP mobility, peer collaboration, non-academic experience and technical training with application to near real-time marine risk. Our balanced training strategy, which includes internships, will develop students' research, technical, professional and leadership skillsets making them highly competitive for employment. We will **implement new approaches for sharing social and natural science expertise, data, and infrastructure** because we have a strong team of researchers with breadth and depth guiding students and their research in the marine and social sciences, including the involvement of the shipping fleet and coastal communities to determine their values and perceived responsibilities in mitigating vessel risk. Several of our team members would make ideal candidates as a panel in **MEOPAR's expert forum,** including our 3 senior, internationally distinguished researchers with 25+ years' experience in vessel-whale risk assessment and wildlife stewardship. MEOPARs 15 year goals. **Operational Network**: We are a cooperative, operational and international network of academics, 4 government agencies, 5 NGOs and 8 ocean-related industries with a proven record in quantifying and mitigating the risk of marine commerce to marine ecosystems. **Information and knowledge exchange**: Knowledge exchange will be intensely promoted through vessel communication (Whale Alert), HQP mobility, east-west-international collaborations, workshops and internships. Our past knowledge exchange led to risk reduction policies that were adopted by the IMO and shipping industry – a clear demonstration that we have the communication skills. We have a framework for infiltrating science-based marine mammal risk analysis and mitigation directly to industry, policy makers and public outreach in an effective manner. **Private sector participation**: Through partnership with 8 private-sector agencies, our research will strengthen Canadian private sector participation in MEOPAR. **International cooperation with clear relevance and utility to Canada**: Some of the work proposed began in the Gulf of Maine and we have partnered with these USA researchers, NGOs, gov't and private sectors to use the novel technology and coordinate field programs to address trans-border whale migration and risk. **End-User Involvement in formulation of the project/question**: Industrial, government and NGO end-users are integral to the proposed research plan and were consulted heavily during project formulation (see Letters of Support and 'Multisectoral Structure and Support').

Research Plan, Approach & Outcomes: Ocean-going vessels pose a threat to all large whales worldwide[31,67]. Whales are an economic resource for communities hosting marine ecotourism and are cultural icons to Canadians and particularly the First Nations[21,28]. Whales have such a charismatic presence among social-conservation structures that many oppose vessel-related industrial development[48]. Large whales present a physical hazard to maritime commerce as well as a public-image hazard to the same commerce if they are injured or killed by vessels[12,19,31,67]. The recent National Energy Board (NEB) report on the Northern Gateway project affirmed the public demand for shipping practices that minimize risk to whales without compromising safety of navigation or social, cultural and economic priorities[48]. Vessel-whale encounters are frequent along Canada's coasts and the expected increases in vessel traffic, particularly in coastal approaches to BC's north coast[48] and the Bay of Fundy[24] requires that mitigating vessel risk remains a federal, provincial and societal priority. Shipping and technology industries, conservation groups, academics, and governments continue to demonstrate that risk mitigation is desirable and achievable[12,57]. Thus the strong support for this proposal – a multi-sector commitment to informed, science-based and collaborative risk mitigation solutions. Our well-developed network has successfully provided such solutions resulting in nationally- and internationally-adopted risk mitigation policies that do not unduly compromise shipping interests[57,62,63]. This record led us to propose that we 1) expand our risk analysis and mitigation capabilities by using various technologies to detect and classify whales and their habitats in near real-time; 2) undertake marine and social scientific research in strategically identified regions where risk is high and increasing and where whales are a valued component of social-ecological systems; and 3) engage the public and end-users partnerships necessary to developing and maintaining a risk estimation, communication, and mitigation capability.

Estimating the risk of vessel-strikes to whales requires estimating the combined probability of a vessel-whale encounter and the probability that a strike is lethal[30,59,61,64]. Such estimates are typically based on data-rich, long-term averages in well-known habitats and have been used to define vessel re-routing and (or) speed limitation policies[62,63]. Near real-time whale location monitoring, and communication thereof to a regional fleet, is a new tool that can be used to further reduce risk[2,18,66]. Given the information, vessel operators have the opportunity to raise awareness, alter course, and (or) reduce speed[18]. Vessel data needed to estimate risk is readily available in coastal regions through conventional ground-based (line of sight) vessel AIS receiver networks, such as we have developed (Bell-Aliant, archived letter[1])[62-64]. Satellite-AIS data, now available to MEOPAR (exactEarth, arc.), allows global vessel coverage. Thus the vessel component of risk estimation is achievable virtually anywhere and we have the analytical tools[59-65]. The whale component of risk estimation outside well known habitats is extremely limited due to the paucity of data on whale distribution and their habitats due to limitations of conventional visual surveys (Canadian Whale Institute (CWI)/ New England Aquarium (NEAq), app.)[2,66]. We propose to address this deficiency by using recent advances in passive acoustic monitoring (PAM) technology with hydrophones mounted on remotely navigated autonomous ocean gliders[1,2,40,55,56]. Our collaborator (Baumgartner, WHOI; see Team) has developed a proven PAM system (digital acoustic monitoring – digital low frequency classification system; DMON-LFDCS)[1,2,8,9,44], that monitors locations of whale vocalisations classified among fin, humpback, sei, and right whales (RW) with reasonable accuracy. The information is transmitted in near real-time to a ground station via satellite each time the glider surfaces[1,2,55,56]. We propose to expand the utility of the jointly operated and recently expanded OTN and MEOPAR glider fleet with the full support of OTN (app.) by mounting Baumgartner's PAM system and a 300 kHz echosounder (monitoring zooplankton/krill; whale food) on gliders, which along with the other glider sensors offer the possibility of monitoring the time-space distribution of large whales across large swaths of the ocean as well as the nature of the environment that the whales are inhabiting, including in near real-time. Using this technology we can monitor whales and variation (e.g., water mass, food concentration) in their known habitats, and identify other potential habitats and the presence

[1] 20 Letters of Support submitted. 5 are appended (app.) below. Others referenced (arc.) are on hand and to the RMC.

or absence of whales in a cost effective manner. This advances our ability to identify critical whale habitat to aid in identifying priority risk-mitigation options and at the same time provides new insights into the ocean dynamics that drive variation in whale distributions[1,6,12,16,39]. We propose to use the glider-mounted PAM information to test and eventually employ the Whale Alert system[18] through collaboration with EarthNC (arc.) and D. Wiley/NOAA (arc.) whereby the areas of concentrated and classified whale sounds, based on the near real-time PAM, are communicated to a ground station, verified, and made available to cell-phone-range users (e.g., vessels, public) equipped with the Whale Alert application that displays the areas of concentration. Further, we will work with Wiley and M. Brown (CWI/NEAq, app.) in establishing the technology whereby the Whale Alert message is also transmitted to vessels via an AIS-message using transceivers located in our Bell-Aliant tower network. This will provide a direct way of communicating our data to end-users to help mitigate risk in near real-time. Capitalizing on the advances will provide Canada with an enhanced capacity to address vessel-risk, particularly in near real-time. To further increase this capacity, once demonstrated on the east coast, we propose a test/demonstration of the enhanced glider technology on the west coast. For the transmissions of whale alerts to mariners to be successful in reducing risk, they need to know the information is available, know its limitations, be able to receive it, and be willing to use it in safe manoeuvring to minimize whale encounters (Shipping Federation of Canada, SFC; app.)[12,18,49,57]. Further, communities, industries, conservation agencies and governments need to be aware of the utility of what we propose for whale stewardship with respect to their social and ecological values and their economic and policy considerations[12,49,57]. It is essential to foster and maintain a constructive flow of information among these various "*societies*" in regions of high vessel-risk. In coastal regions of B.C. (e.g., north coast) and the Maritimes (e.g. Bay of Fundy, coastal Nova Scotia) these societies are undergoing major social, cultural, economic and political shifts due to expanding eco-tourism and the present and perceived future impacts of new oil and gas pipelines and increased vessel traffic[24,48]. We have the experience and new tools that can reduce the potential impacts[1,2,8,9,12,44,59-65]. However, with the shifting perceptions, strong opposition, and complex legal frameworks, it is imperative that we engage these societies, to understand their values, their social-ecological systems and how whale stewardship fits within those societies. We propose to achieve this by working with Marine Affairs (arc.) Master of Marine Management (MMM) students involved in research and outreach with our collaborators on both coasts: CWI, SFC, Raincoast (RNC) & Univ. Victoria (arc.), Canadian Wildlife Federation & World Wildlife Fund (CWF&WWF; arc.), Irving Oil (arc.), B.C. Min. Env. (arc.) and Env. Canada (arc.). **Research Objectives:** We have 4: 1) enhance MEOPAR's observation core through near real-time whale monitoring capability by equipping the expanded OTN/MEOPAR operated glider fleet with at least 3 PAM systems and one with echosounder capability; 2) use the gliders in conjunction with AIS data and an array of seafloor-mounted PAM platforms to fill knowledge gaps in the distribution of large whales and their known and suspected habitats in locations on the east and west coasts where the observed vessel traffic density is high or anticipated to increase, and where in coastal communities ecotourism and private recreation present small-vessel risk to whales; 3) develop, test, and implement delivery of whale alerts to vessel though the Whale Alert app. and transmission of AIS-messages; 4) use social science methods to learn how fleets and coastal communities view their responsibilities in whale and habitat conservation through vessel risk mitigation, to examine how whale risk mitigation can promote social goals such as cultural and economic resilience, and identify points of conflict among the various societies defined above with respect to risk mitigation and help find options though which the conflict can be ameliorated. **East Coast:** The expanded OTN/MEOPAR glider-operated fleet, when equipped with additional sensors, including an echosounder and PAMs, will enhance MEOPAR's observational core. We will focus on integrating these technologies into an existing set of observation and communication tools designed to mitigate vessel-risk to whales and their habitat; particularly the critically endangered RW[18]. Known right whale summer habitats, Grand Manan and Roseway basins, have been protected by altering vessel traffic patterns around these proclaimed Critical Habitats[18,62,63].

Aggregation/distribution of RWs east of these habitats (i.e., most of the Shelf, shelf break and several basins) is unknown[18,49]. After decades of whale surveys the whereabouts of ~1/3 of the population is unknown[18,30]. In any given year the location of ~50% of known whales is unknown[18,30]. Roseway Basin has been virtually abandoned several times[18,30] and in 2013 the Grand Manan Basin was for the first time virtually abandoned and there is no survey effort in Canadian water outside the two Critical Habitats that could explain the whereabouts of 'missing' whales. It is likely abandonments occur due to a lack of food (diapausing copepods concentrated at depth) in the above basins[3-7,15,16,45,46]. and that the missing whales occupy unknown habitats as RWs are sporadically reported elsewhere on the Scotian Shelf[37] and as far as the Gaspé Peninsula. Their 'other' food sources may be copepods concentrated at depth in other shelf basins and along the shelf break, and if as in the Grand Manan and Roseway basins, it is likely the concentrations are associated with particular oceanographic features.[6,7,15,16,25,26,38,39] Several candidate areas on the shelf are intersected by major shipping routes, but we have no means of quantifying or responding to vessel risk for the missing whales, or other large whales, despite having reliable data to assess vessel threat in any given region. Accordingly, we will address four problems: 1) As learned in 2013, there is no response plan and limited ability to discover where RWs and other large whales might be located outside known habitats, nor if candidate areas are suitable habitats, and all in relation to vessels threat. 2) Some postulated habitats in the Scotia-Fundy region are co-located with high vessel density, but we lack the ability to systematically and economically locate either the whales or the habitat indicators using conventional methods. 3) Policies used to mitigate risk in the known habitats have no supporting dynamic element to reduce vessel risk when RWs are outside known habitats, though precedence exists in the USA Gulf of Maine[12]. 4) Using glider-PAM information for Whale Alerts involves identifying and communicating risk mitigation options, measuring how the fleet views its responsibility and ability to act in mitigating risk, and determining if the fleet sees such information as useful in meeting the responsibilities. To address these problems we will: 1) prepare and execute a plan for glider deployments equipped with PAM and echosounder in concert with NGO whale surveys inside and between the known habitats, and use the gliders to respond to survey-based observations of RW distributional changes (e.g., abandonment); 2) consult with our partners to identify 3 or 4 potential and priority RW habitats that are associated with high vessel density, and glider-survey those priority areas as well as deploy seafloor-moored, archival PAM (AMAR) systems for longer term vocalization monitoring. Potential habitats will be evaluated by comparing relative variation in vocalization rates and known habitat indicators; 3) explain variation in RW, sei, fin, and humpback vocalization rates monitored by gliders in and near Roseway Basin using whale abundance, behaviour, and demographic information collected during co-located vessel surveys, and variation in habitat indicators using glider-mounted sensors. 4) During glider surveys we will test our ability to feed satellite-communicated areas of concentrated and classified whale vocalisation (subjected to quality-control) to the Whale Alert system. The longer term goal is to transmit the information to vessels as AIS messages, initially via an AIS transceiver located in Barrington (SW NS). This will offer local vessels the opportunity to alter their navigation in near real-time and we will use the AIS data to infer if a voluntary navigational change occurred and follow up with vessel operator surveys. **Logistics and Timeline:** We are already collaborating with Baumgartner and are planning (external funding) a 2014 survey in Roseway Basin using his glider and (DMON-LFDCS) PAM system, an OTN/MEOPAR operated glider with echosounder and a CWI vessel survey to corroborate whale sound classification and locations with visual observations, and echosounder zooplankton concentrations validated via DFO's (app.) AZMP samples. If funded through MEOPAR we will enhance this survey by deploying in other potential RW habitats in 2014. In the following 2 years, we will use 2 DMON-LFDCS on 2 OTN/MEOPAR operated gliders, one with an echosounder, as well as Akoostix (arc.) PAM system on the OTN wave glider. We will explore the possibility of upgrading the existing Akoostix PAM systems on the Defence Research and Development Canada (DRDC) gliders that are available for OTN/MEOPAR glider operations. We will feed all glider data to existing OTN & MEOPAR data management systems and further test and

make operational the Whale Alert and AIS messaging systems (latter is externally funded). Glider mission will be dynamically optimized to intersect previously identified potential RW habitat and new habitat if discovered. We will deploy the 5 JASCO (arc.) AMAR systems in potential habitats and collaborate in planned deployment and data acquired by the JASCO and Akoostix buoyed systems. At least one glider deployment in each year will be coincident with the CWI/NEAq vessel surveys in Roseway Basin. If unusual RW distributional changes become apparent glider missions will be modified accordingly. AMAR data collected in y-2 will be used to optimize glider missions in y-3. If glider missions locate habitat indicators coincident with persistent elevated RW whale vocalization rates, the mission may be altered to determine persistence and future missions can be planned accordingly and future AMAR and buoyed PAM systems can be deployed in those habitats. Ground-based AIS will be monitored during surveys, and Whale Alerts communicated. Early results and existing knowledge will be used by MMM students and partnering agencies in y-2-3 to design and execute their research related to Objective 4 above (see HQP Training). **West Coast**: Our team has significantly contributed to vessel risk mitigation policies adopted by Canada and the International Maritime Organization (IMO), and vessel operators generally comply[57,63]. There are no similar policies on the west coast, a region home to many large whale species, some abiding in regions of high density vessel traffic. B.C.'s north coast is expected to experience increased vessel traffic that will intersect whale habitat near coastal communities due to the Northern Gateway project[48]. Not only is vessel-risk recognized in the region, vessel related whale injury or death could be a public relations nightmare with potentially enduring societal alienation from industrial interests[48]. Risk to whales on B.C.'s north coast and elsewhere is largely unknown due to logistics and costs[10,47]. This will change with the industrial development, though there are few interdisciplinary and multi-sector research programs that focus on quantifying the distribution of large whales, their habitats and vessel risk mitigation in the region[10,48]. The NEB stipulated a whale protection program must be in place prior to ~2019[48]. However, baseline data needed for vessel risk analysis to provide risk mitigation options do not exist[47,48]. We propose to use our experiences in y-1 and -2 to transport one glider and PAM system to test and demonstrate its utility in addressing vessel risk to whales and their habitat, but in a small, regionally defined area where we can be confident of getting informative results. If renewed in y-4 & -5 we will execute an enhanced study similar to that proposed above for the east coast. Given the shifting perceptions, societal conflicts and complex legalities now in the north coast, we think it best to use our technological resources in a test/demonstration mode and use our HQP resources and collaborating agencies to first engage with coastal communities, industries (e.g., shipping) conservation agencies and governments so that they are aware of the utility we propose and we are aware of their needs. A pilot program should lead to well-established glider operations before the increase in vessel traffic by using the protocols established on the east coast and tuning them to address the west coast challenges though glider operations in the north coast region, ideally y-4 and -5. **Objectives** are to: 1) inform and engage target agencies regarding glider-PAM and associated technologies as a risk mitigation tool for various end-users on the west coast; 2) exercise existing collaborations with the B.C. Ministry of Environment (BCEnv, arc.) and Raincoast (arc.) to engage the NGO, government, community and industry sectors and gauge attitudes regarding vessel risk, particularly where industrial interests conflict (real or perceived) with the broader societal, cultural, recreational and economic valuation of whale conservation; 3) work closely with our west coast colleagues during their assimilation of knowledge and tools that have led to successful vessel risk mitigation with a focus on the glider-PAM and AIS tools, and 4) test and demonstrate enhanced glider utility in addressing vessel risk in a small regionally defined area where we can be confident of informative results. **Logistics and Timeline**: For the social science aspects we will use a workshop approach in y 1-2 in collaboration with other planning initiatives. C. Short, B.C. Min. Forests plays a significant role in the north coast Marine Planning Partnership (MaPP) and has offered to work with us and various stakeholders, including the Pacific North Coast Integrated Management Area's (PNCIMA) adaptive marine management plan[47]. By working with communities and industry via MaPP and

PNCIMA we will learn how whale conservation is linked to community activities and cultural heritage, gauge the perceived and known uncertainties with respect to vessel risk, learn how whale protection can promote social goals such as cultural and economic resilience, and examine how communication and conflict among communities and industry evolve in light of the new NEB stipulations and pending PNCIMA management plan. Shortly thereafter we will arrange sectoral or region-specific meetings/conf. calls to gain insights for future glider deployments and use of the Whale Alert (expanding to US-west coast summer 2014) and AIS messaging. Each of these initiatives will address risk assessment in relatively remote, data-poor regions and offers the opportunity to expose the capacity we will have developed to others who can look toward long term implementation of what may be the most significant vessel-risk mitigation program attempted, as well as providing a firm basis for conservation planning. During spring and early summer of 2016 (y-3), we will perform test deployments of the glider- DMON-LFDCS system and at least one AMAR on the west coast of Vancouver Island at Duffus' 25-year field site, where he studies whale-habitats and their interactions with the whale watching industry in a coastal community (Tofino). In addition to providing new insights for this enduring program and exposing our HQP to coastal community interactions in a community where whales are a significant economic resource, the deployments will aid in developing north coast operations by: 1) testing the glider and DMON-LFDCS capabilities in an accessible, well-studied, highly coastal environment where grey whales congregate and human activity is high; 2) creating an information-rich climate in Duffus' lab to engage key stakeholders with the technology; 3) use the glider and AMAR to enhance the DMON-LFDCS whale-vocalization classification library with gray whale signatures, a west-coast species with extremely coastal habitats and one of the top 5 species most frequently struck by vessels. The grey whale also inhabits the north coast and must be included in the classification library if we are to use the technology on B.C.'s north coast location in y-4 and -5.

MILESTONES AND OUTCOMES: **Y-1:** Complete preliminary WHOI and OTN/MEOPAR glider deployments in Roseway Basin (summer 2014); complete glider-PAM integration; begin to access and analyse existing PAM data (JASCO, Akoostix, Moors-Murphy); develop/incorporate Whale Alert and AIS messaging; plan for multi-sector social, policy, engagement activities; define MMM research projects for both coasts; plan for response to possible RW distributional shifts. **Y-2:** complete 5 or more ocean glider and 1 or more wave glider deployments and at least 5 AMAR and possibly JASCO and Akoostix buoyed PAM system deployment on the Scotian Shelf; conduct preliminary data evaluation, including real-time response, and plan for refinement; conduct multi-stakeholder workshop focussed on vessel risk; MMM and PhD student(s) participate in workshops/planning programs on B.C. north coast. **Y-3:** complete additional glider, AMAR and buoyed system deployments on the Scotian Shelf; complete test/demonstration of glider and AMAR deployments on the west coast. **Year 3 outcomes**: Evaluation of RW habitats on the Scotian Shelf in relation to vessel traffic and preliminary vessel-risk estimation and evaluation of efficacy of real-time response plan; plan for integration of gliders with long-term RW monitoring; add grey whale sound signatures to the DMON-LFDCS library; communication of results (e.g. Right Whale Consortium, federal Recovery Team, various stakeholders); developed strategy for deploying gliders on B.C. north coast in y-4, -5.

LONGER-TERM PERSPECTIVES: If funded, we will prepare leverage funding applications to enhance the research (e.g., NSERC-Strategic, SSHRC, etc.) and support for additional HQP such as funding from CWF (arc.) as the project will provide additional questions, problems and large amounts of data with which the problems can be addressed. When we have proof of concept and utility, and a better understanding of need, we will approach the shipping and oil and gas industries and various regulatory agencies (e.g., DFO, Envir. Canada, Transp. Canada) to demonstrate the benefits of longer term funding and secure their financial support for long-term operational monitoring. This is possible. The Boston Shipping Lane real-time PAM systems are funded by LNG shipping companies[18]and Irving Oil (arc.) has a long history of supporting RW conservation research.

Excellence & Interdisciplinary Balance of the Research Team: We are an interdisciplinary, intersectoral and international research team unified under the theme of 'whale-habitat-human interactions'. Each member has distinguished accomplishments in at least one of seven disciplines this project requires: vessel-whale risk, policy development (Taggart, Brown), social science (Duffus), coastal community, outreach and stewardship (Brown, Duffus), engineering and technology (Baumgartner), physical oceanography (Ross), ocean acoustics (Ross, Moors-Murphy, Baumgartner), and biological oceanography & whale-habitat (Davies, Duffus, Baumgartner, Taggart). We have multi-sectoral collaboration among federal researchers (Moors-Murphy), academia from two institutions (Taggart, Duffus, Ross), trans-border NGO (Brown), and international (Baumgartner). We have a balanced breadth of experience; three senior researchers with > 20 years' experience (Taggart, Duffus, Brown), two mid-career researchers (Ross, Baumgartner), two post-docs (Davies, Moors-Murphy). **Dr. C Taggart** (PI), Prof., Fac. Sci., Dalhousie Univ. since 1995, has been a principal investigator in many large multi-institutional research initiatives. He conducts a diversity of research spanning biological, physical and fisheries oceanography, marine risk, policy and conservation and is author on 101 primary publications incl. 16 relevant to this proposal[15-18,29,32,38,39,57,59-65], ~50 research reports and ~200 presentations (~30% invited or keynote). Some work in the last decade with his students has focussed on two areas that have garnered international accolades for their application to marine risk. With students he has produced probabilistic estimates of vessel and fishing gear risk to right whales. This research resulted in policies adopted by the IMO and implemented by Transp. Canada resulting in the modification of Bay of Fundy shipping lanes and establishment of the Roseway Basin Area To Be Avoided. The research in quantifying variation in the physical and biological characteristics in the Grand Manan and Roseway basins resulted in federally legislated protection of the basins as Critical Habitat (Species at Risk Act). He has mentored 10 PDFs, 17 grad students (4 of them Master Mar. Mngmnt), 19 Honours students and many research assistants and co-op student – most have found employment involving marine sciences including academic and senior government appointments. He teaches fisheries and biological oceanography and marine science and technology. Critical infrastructure he brings to the project includes his externally funded Bell-Aliant 5-station AIS network that will be used for sending whale alerts to vessels as AIS messages. **Dr. D Duffus** (co-PI), Assoc. Prof., Fac. Soc. Sci., Univ. of Victoria since 1992, has pioneered wildlife-based recreation management for coastal communities and has been an active participant in resource management processes ranging from land use planning near important whale habitat to human valuation of captive whales. He uses an enduring (~25 y) field site to study the population structure of gray whales and their foraging on zooplankton in habitats occupied by a maturing whale watching industry. He will contribute his coastal field-site infrastructure (station, boats, equipment) to this project. As member of the Soc. Ecol. Coast. Res. he has contributed to 5 books and numerous publications in natural and social science journals including 10 of direct relevance to this project[20-23,27,28,34,35,42,43]. He has mentored 25 graduate students now employed the private sector with major consultancies (LGL, Stantec), government up to the Assist. Dep. Min., and academia. Using his Marine Mammal Naturalist course he has mentored almost every whale-watching naturalist on Vancouver Island over the past 10 years. **Dr. T Ross**:(co-PI), Assoc. Prof., Fac. Sci., Dalhousie University since 2005, is the recipient of an NSERC University Faculty Award, leads the OTN-Canada glider program, and is actively involved with Ocean Networks Canada. She has spent 15 years developing novel methods of ocean observation, primarily using acoustics at the interface between physical and biological oceanography, and has produced 8 publications of direct relevance to this project[13,15,33,50-54]. She is one of the pioneers of using high-frequency broadband acoustic techniques to study physical microstructure and zooplankton in the ocean. She brings to this project, along with OTN, the glider program and echosounder. She has supervised 4 graduate students, 10 undergraduates and teaches both introductory oceanography and the highly interdisciplinary honours thesis seminar in the College of Sustainability. **Dr. M Brown**, Senior Scientist, Canadian Whale Institute and New England Aquarium, is Canada's leading and internationally recognized right whale scientist. She reorganized and

led the right whale-vessel working group, was instrumental in guiding precedent-setting conservation measures for right whales through Transp. Canada, the IMO and the Canadian Recovery Strategy for Right Whales. She has spent 30 years studying right whales in Canada and the USA through survey and monitoring efforts and uses the results to consult stakeholders and guide stewardship activities with industry & government. Her career provides a stellar example of scientists partnering with industry to effect functional stewardship resulting in several notable awards: Gulf of Maine Council Visionary Award, Canadian Environment Gold Award, Lifetime Achievement Award–International Fund for Animal Welfare, Bay of Fundy Ecosystem Partnership Environmental Steward Award and a Doctor of Laws at Mount Allison University. She has mentored ~50 right whale researchers, co-advised 3 PhD and 2 MSc students and has contributed 8+ publications of direct relevance to this research[1,12,14,30,45,46,57,62]. **Dr. M Baumgartner**, Assoc. Scientist, Woods Hole Oceanographic Institution since 2005, uses new technology, novel approaches, and multidisciplinary collaborations to study aspects of both whale and zooplankton ecology in the North Atlantic and Pacific Oceans. These include autonomous underwater vehicles, passive acoustics, archival tags, and optics. He is a primary member of a team that spent the last decade inventing, field-testing and enhancing a glider-mounted passive acoustic detection and classification hardware/software (DMON/LFDCS) PAM system for use on multiple platforms that reliably detects and classifies vocalizations from 4 species of baleen whales and transmits these data to shore in near real-time. He will effectively leading our effort to integrate the DMON/LFDCS system into the OTN/MEOPAR operated gliders. He is a key researcher involved in facilitating the operational use of the technology by the U.S. National Oceanic and Atmospheric Administration, U.S. Navy, and various marine industrial users (see vanParijs app. letter). His participation is essential for the adoption of the technology and knowledge to benefit Canadian research and risk mitigation. He authors 10 publications relevant to this project[1-9,44]. **Dr. K Davies**, PDF, Institut français de recherche pour l'exploitation de la mer, is a highly decorated scholar. She awarded NSERC-MSc and PhD and Presidents Prize scholarships and her PhD thesis on the physical-biological definition of right whale Critical Habitat was Dalhousie's sole nominee for the Canadian Association of Graduate Studies Distinguished Dissertation Award. She has supervised an Honours thesis and has three publications directly relevant to this research[15-17] and another in prep. **Dr. H Moors-Murphy**, Postdoctoral Research Scientist, Bedford Institute of Oceanography is an NSERC-PhD fellowship recipient with twelve years' experience in marine bioacoustics including several publications relevant to this project[11,36,41,58]. After working in the ocean technology sector (Akoostix Inc.) she was recruited by DFO to lead a National Science Advisory Process aimed at reviewing seismic survey mitigation and monitoring measures for whales including development of permit processes, reviewing applications, assessing environmental impacts on species at risk and Marine Protected Areas, and building collaborative relationships among researchers, industry, conservation groups and government organizations. **Social/Policy Issues to be Addressed**: We will work with our partner NGOs to address various fleet sectors whose actions are directly regulated by the IMO and Transport Canada to reduce risk to whales. As detailed elsewhere we will employ social science methods to gauge how the fleet and associated agencies view their responsibility in mitigating vessel impact on whales, their habitat, and to determine what insights, knowledge the fleet and associated agencies need to meet those responsibilities. We will dialogue with communities and industry on the BC North Coast to learn how whales are linked to community activities and cultural heritage, gauge the perceived and known risks and uncertainties with respect to whale-vessel risk, learn how protection of whales can promote important social goals such as cultural and economic resilience. We will use the team's experience and success record in providing policy options for risk mitigation through our on going affiliations including the Shipping Federation of Canad (app.), Environment Canada (arc.) Habitat Stewardship Program, DFO's Oceans and Coastal Management Division and Ocean and Ecosystem Management Division (app.) and Area Response Plans for Canada's World Class Tanker Safety System, Transp. Canada, the IMO, B.C.'s Marine Planning Partnership and the Pacific North Coast Integrated Management Area's planning initiatives for the BC North Coast.

Multi-sectoral Structure and Support: Our 19 partners pledge $2.673 million of in-kind and cash support (Table 2). They include 8 private sector, 5 non-governmental, 4 government, and 2 academic research & education organisations, including significant international leverage. Letters of Support from each, appended (app.) or archived (arch.) and available on request, are quoted as needed. **Maritime Commerce:** The Shipping Federation of Canada (SFC, app.) sees the "*development of tools allowing for near real time whale data as the logical next step*" in risk mitigation and expects WHaLE "*will provide critical information on whale distributions*", and that they "*can only support the knowledge distribution to our vessels through platforms such as the WhaleAlert application*". We are partnered with EarthNC (arch.), who manage WhaleAlert which displays whale-occupied areas and recommended routes on a mobile device and alerts can also be transmitted directly to vessels as an AIS messages. EarthNC and NOAA-SBNMS (below) will assist us in employing the AIS transceiver and messaging in Canada so we can provide "*very meaningful, actionable environmental data to* [*earthNC's*] *rapidly growing community of users*". They are expanding to the west coast and "*will be conducting extensive outreach targeting Canadian audiences and incorporating WHaLE's data and analysis in the process.*" Irving Oil (arch.) is "*an end-user of the data collected in the hopes of further vessel-strike mitigation*". Maritime Transport Consulting Inc. (arch.) will use our results "*to support* [their] *arguments that the precautions that have been, and can be, taken by the government and approved by IMO are in the best interest of the whale and mariner.*" **Ocean Technology:** exactEarth Inc. (arch.) will provide satellite-AIS data for both coasts ($126.6k in-kind, see 'MEOPAR initiatives'). JASCO Applied Sciences (arch.) specialises in autonomous multi-channel acoustic recorders (AMARs), and to complement the 3 AMARs from DFO (below), we propose to purchase two (30% discount), including extensive technical/analytical support and HQP training ($152k in-kind). JASCO & DFO are developing acoustic species-detection algorithms for all large whale species on the Scotian Shelf and protocols for AMAR data quality control. We will capitalize on this to help develop and enhance existing near real-time whale classification libraries. Akoostix Inc. (arch.) specializes in surface buoy- and glider-mounted PAMs. Akoostix supports our project by providing "*free access to existing and future data sets from Akoostix's GuardBuoy systems (surface-moored PAM), at-cost loan of 4 GuardBuoys, expert support of Akoostix system usage and data analysis, and free access to Akoostix's processing systems*" (in-kind value $180k). They have developed PAMs that include real-time detection software for wave gliders and we will equip the OTN wave glider with this system using OTN funds. Akoostix will "*support HQP development including graduate student internships. Ideally, Akoostix would hire HQP once their academic training is complete.*" Bell-Aliant Inc. (arch.) will provide free use of 5 cell tower antennas and infrastructure in continued support of Taggart's ground-based AIS receiver network ($105k in-kind). **NGOs** Canadian Whale Institute (CWI); New England Aquarium (NEAq) (app.) These two organisations collaborate on trans-border right whale issues. CWI will supports the research via a complementary Envir. Canada Habitat Stewardship Program grant that offers significant logistical and industry/gov't networking support of $406k in-kind. Raincoast Conservation Foundation (arch.) will provide in-kind time for C. Fox and C. Darimont, logistical support via a research vessel and remote field station, marine mammal survey data from their research in the North Coast Management Area, and graduate student co-supervision. Our research will contribute to their marine mammal surveys and vessel-whale risk assessments which they use for conservation planning. World Wildlife Fund Canada (arch.) & Canadian Wildlife Federation (CWF, arch.) will report "*news, results and ongoing work related to WHaLE*" through "*regular communication with membership representing more than 500,000 Canadians*". They will incorporate our research into risk assessments and species conservation plans, host student interns, contribute expert researchers, and "*CWF has established funding opportunities to which* [they] *encourage coordinators of WHaLE to apply.*" **Government:** DFO (app.) will use WHaLE research to contribute to DFO policy mandates to reduce vessel-whale risk, quantify noise risk to whales, assess marine risk, define Critical Habitat and develop Area Response Plans under Canada's World Class Tanker Safety System. DFO will

provide equipment, ship time, personnel and data ($438k in-kind). Dr. Moors-Murphy (see Team) and JASCO will assist with detection algorithms and analyses of acoustic data to quantify noise risk; vessels and seismic exploration. Environment Canada (EC, arch.) The PI and CWI have together been awarded 15 EC HSP grants aimed at right whale recovery, including the active CWI grant. EC continues to support us based on our success at "*using the credibility of* [our] *science to partner with industry stewards and achieve conservation actions*" that are directly in line with EC's policy goals. National Ocean and Atmosphere Administration (NOAA, app.) Dr. Sofie van Parijs and our partner Baumgartner (see Team) are funded for 3 years ($1.5m) beginning Jan-2015 to survey the Gulf of Maine with DMON/LFDCS mounted on gliders, buoys and profiling floats continuously for 2 yrs. Our goals are similar, we collaborate with the same groups (JASCO, DFO, CWI, NEAq, NOAA-SBNMS) and together we will achieve unprecedented coverage of whale habitat (known and as yet unknown) on the east coast. Dr. van Parijs asserts "*our objectives exactly mirror those of WHaLE, and I see many opportunities for leveraging to add value to WHaLE*." Further, NOAA's Stellwagen Bank National Marine Sanctuary (SBNMS, arch.) personnel will provide their "*highest level of support*". They pioneered the communication of near real-time whale alerts collected with PAM systems in the SBNMS to mariners and the public through WhaleAlert. We are leveraging their technological advancements considerably. They will host interns. BC Ministry of Environment (BCEnv, arch.) through Dr. M. Zacharias, Assistant Deputy Minister of Environmental Sustainability & Strategic Policy Division, who sees our research as "*timely; research outcomes will provide a strong foundation for work in joint federal-provincial marine planning initiatives.*" To that end, C. Short, Ministry of Forests, Lands and Natural Resource Operations, who manages the Marine Planning Partnership for the North Pacific Coast has offered our team introductions to stakeholders on the BC north coast. Both have offered HQP training "*so that the provincial B.C. government may gain some early insight from their learnings, share policy and operational advice and contribute to their incredibly interdisciplinary education.*"
Academia: The Ocean Tracking Network (OTN app.) will be an end-user of our marine mammal & oceanographic data and have pledged at least 2 Slocum gliders & 1 wave glider equipped with sensors (CTD, O_2, optics) & VMT acoustic receivers that track fish & seals, data management infrastructure, and technical support (in-kind $1.165 million), $35k in cash support for purchasing glider-mounted PAMs, $25K for echosounder, and access to 4 recently acquired gliders. Marine Affairs Program (MAP, arch.); an interdisciplinary degree program that fosters collaboration across six Faculties and with major research programs to facilitate graduate-level research, education, outreach. We will host 4 Master of Marine Management students who will use their internships as graduate research projects. MAP has committed $66k in-kind faculty support. **MEOPAR Initiatives:** Our project will expand the utility of the OTN/MEOPAR glider program. We should capitalize on the near real-time data and mobility. The gliders have travelled over 11 000 km since the program began in 2011, but spatial coverage has been restricted and the near real-time data are not being used for risk mitigation. OTN and MEOPAR show commitment to this end through the 4 additional gliders. We wish to capitalize on their commitment to achieve glider operations extending beyond MEOPAR's 15 year lifetime by applying the gliders to a key risk issue of broad interest. Taggart established an existing partnership with exactEarth, but now via the MEOPAR partnership they will provide us with satellite-AIS data and we have developed modeling tools to calculate vessel density etc. We will significantly benefit from the new the satellite AIS data that are a key element of our proposal. Other MEOPAR projects beginning to use satellite-AIS may derive benefit from our experience in analyzing these data, the application to marine risk from our tools and data products, and from the continuation of our productive working relationship with exactEarth. Our project is complementary to the Canessa et al. MEOPAR proposal to develop vessel-AIS tools and model vessel noise effects on marine ecosystems. We have already agreed to collaborate through joint workshops, sharing students, data & partners. Vessel-type specific sound field analyses from our collaborators can be provided to Canessa et al for use in their modeling and there modelling tools can be used by us to enhances our risk analyses.

HQP Focus: This project will train 3 PhD students, 1 postdoctoral fellow, and 4 Masters of Marine Management (MMM) students, the latter in collaboration with the Marine Affairs Program at Dalhousie. Undergraduate involvement is inevitable though not budgeted. The technical nature of the WHaLE project, diversity of partners involved, excellence of the researchers and their past success in training HQP now employed in all sectors, will create a rich training environment for HQP. As muti-sectoral end-users are integrally involved in the research, exposure of HQP to an array of potential employers is inherent. Our training program integrates four activities designed to develop research, technical, professional and leadership skill-sets: 1) *HQP mobility.* Each HQP will be co-advised by academics from different disciplines (social science, oceanography, ocean technology) and institutions from different regions and countries (Dal, UVic, WHOI), where each HQP will spend time at a minimum of 2 institutions. 2) *Non-academic experience.* **Eleven organizations have stated in their Letter of Support that they will both host HQP interns and advise theses; SFC, WWF, EarthNC, DFO, CWF, JASCO, NOAA, CWI, Akoostix, NEAq, BCEnv.** Thus, HQP will train with professionals in industry, NGO, provincial and federal government sectors, and internationally. 3) *Technical training.* HQP will operate gliders, their acoustic and other sensors, perform real-time field operations and handle vessel-AIS, passive acoustic and oceanographic data, thus acquiring an exceptional degree of technical training that is relevant to marine risk; and 4) *Peer collaboration.* Our post-doc (Dr. Davies) will coordinate monthly peer networking/problem solving sessions to promote peer collaboration and knowledge exchange among HQP. **HQP Responsibilities and Opportunities.** Seven student theses will arise from this project. Post doc-led peer collaboration activities will promote communication, knowledge transfer and integration across diverse projects. All students are required to intern with one of the collaborators at some point in their program. *MMM Student 1* **(**Advisor Duffus, co-advised by BCEnv). The student will work partly through the MaPP initiative to engage communities, government and industry for the purposes of navigating the legal and policy bases for marine mammal protection planning processes that are in place and ones that are proposed to oversee oil and gas development on BC North Coast. Questions to address: how are communication and conflict between communities and industry evolving in light of the new whale-vessel stipulations on the Enbridge pipeline project, the pending PNCIMA management plan, and/or new IMO guidelines for vessel noise, each significant pieces of marine mammal management legislation? What is the likelihood that these plans can be widely adopted? *MMM Student 2* **(**Advisor Duffus, co-advised by BCEnv). The student will follow similar networking approaches as MMM Student 1 but with a social science project topic. They will ask: how are whales linked to community activities (e.g., ecotourism) and cultural heritage? How can protection of whales promote important social goals such as cultural and economic resilience? Are communities and the fleet aware of the mitigation options, and how these might help reduce the impact of coastal oil and gas infrastructure on communities? *MMM Student 3* co-advised by Taggart and Brown (Canadian Whale Institute). The student will intern with the Canadian Whale Institute and liaise with CWI industry contacts in the fleet sector (SFC, Irving, MarTrans) to measure how the fleet views its responsibility in helping to mitigate vessel impact on whales and their habitat in the Scotia-Fundy region and determine what insights & knowledge the fleet needs to help them meet those responsibilities. The students will ask how might the fleet be engaged in helping design policy to help in real-time mitigation while at the same time minimising impact on fleet behaviour? *MMM Student 4* will work with EarthNC, NOAA-SBNMS, CWI, & the fleet sector to examine the present usage of the WhaleAlert app by mariners in US-waters and Canadian expansion of WhaleAlert. 15 000 people have downloaded the WhaleAlert app to their mobile devices, and SBNMS sends the WhaleAlert as a message through their AIS transceivers to vessels entering the SBNMS area in the Gulf of Maine. But it is not a mandatory device aboard vessels, and its effectiveness relies on ship captains seeing the written WhaleAlert message on their computer screen as they enter SBNMS and/or having mobile devices aboard. The student will work with EarthNC, CWI and the fleet to gather information about who is using WhaleAlert, ask mariners if they

saw the message, what their actions were, and determine if they see WhaleAlert as useful. Then they will explore policy and industry stewardship actions that need to be taken as we are expanding WhaleAlert in Canada. *PhD student 1* (co-advisors Taggart@Dal, Baumgartner@WHOI) will focus on glider passive acoustics with application as real-time mariner warning systems. The Dalhousie-based student will work closely with Baumgarter (DMON/LFDCS inventor, WHOI), OTN glider technicians, Akoostix, Jasco Inc., Moors-Murphy at DFO, and S. van Parijs at NOAA. They will help mount and deploy 2 types of passive acoustic monitoring equipment on gliders, then analyze the resulting field data. The student will compare near real-time subsets of whale locations and identities collected with DMON/LFDCS with the full archived datasets to determine false whale detection rates, compare vocalization rates to sightings data (CWI/NEAq) to examine whale behavioural and distributional effects on vocalization, and work with Moors-Murphy and JASCO to use AMAR data to build whale species-classification libraries for a variety of species on the Scotian Shelf. The student will liaise significantly with van Parijs and Baumgartner who are doing a very similar project in the Gulf of Maine. They will work with Dr. Taggart, CWI and EarthNC to verify and send whale location data to vessels in near real-time via WhaleAlert. The student will spend at least 6 months with Baumgartner at WHOI (via Dal-WHOI MOU) learning the DMON/LFDCS technology before coming to Dalhousie to assist in the Scotian Shelf field program. *PhD student 2* (co-advised Duffus@UVic, Taggart@Dal) will bring the tools and concepts from the east coast to begin tuning them to west coast problems. The student will spend time at Dalhousie during y-1 to learn glider technology, interact with OTN-glider technicians, local acoustics companies, and participate in a set of glider deployments. They will transfer to UVic where they will help direct B.C. glider deployments and analyze those data. The student will calculate vessel densities using vessel-AIS data from B.C. North Coast and establish areas of high risk for eventual priority glider surveys. With the Vancouver Island data, the student will study gray and humpback whale ecology in well-known habitats to establish critical habitat parameters and test the capacity of acoustic systems to measure gray whales. The student will work closely with MMM students 1 & 2, external collaborators BCEnv, Raincoast Foundation and planning initiatives therein to gain input and guidance for large-scale deployments on B.C. North Coast. *PhD student 3* (co-advisors Ross@Dal, Duffus@Uvic) will focus on bio-physical oceanography, bioacoustics and whale-habitat definition. The student will work with the postdoc (Davies) to use existing knowledge and data to select priority survey areas. They will use acoustic echosounders to detect plankton aggregations, validate these data with co-located biological samples (collected by DFO), and compare bioacoustic and physical oceanographic data to define the food and water mass characteristics of whale habitat on the Scotian Shelf. The student will direct glider surveys and, working closely with PhD students 1 and 2, will reconcile habitat parameters with whale vocalization rates and vessel locations. The student will compare datasets from known and potential habitats, evaluate potential habitats for their suitability as whale feeding areas (i.e., Critical Habitat) and compare with vessel AIS data to evaluate risk. This information will be brought to external partners to be used in marine conservation planning. This student will spend the first two years at Dalhousie then go to UVic to help with west coast field operations. Internship opportunities with WWF, CWF, DFO. *Postdoctoral Fellow.* The postdoc (Dr. Davies) is key to project integration and will play a leadership role with students. She will co-lead the collaborative, multi-sectoral field-work program on the east coast and ensure students are integrally involved. She will lead collaborative publications that synthesize multidisciplinary data-streams (passive acoustics, habitat, vessel-AIS) and theses (management, social and marine science), and work closely with external partners, as she has during proposal preparation, to integrate the research within larger policy, management and planning frameworks (e.g., right whale recovery, MaPP). She will lead monthly peer problem-solving sessions to tackle issues related to WHaLE as a student community, and encourage student from other MEOPAR projects to participate.

Budget Justification: Using RMC feedback the LOI budget was reduced by 28%; $1045.5→$748.6 K.
Table 1. Itemized WHaLE Project budget ($K). Details of partner in-kind & cash support in Table 2

CATEGORY	Unit $K	#Units	06/14-03/15	04/15-03/16	04/16-03/17	Total	%Total
HQP	Yr^{-1}					**369.6**	**49**
PhD (start date 01/15)	20.0	3.0	15.0	60.0	60.0	135.0	
MMM students (4 total, 2 yr^{-1})	5.0	2.0		10.0	10.0	20.0	
Post-Doc (start date 01/15)	54.0	1.0	13.5	54.0	54.0	121.5	
Technical support (Glider Ops)	58.0	0.25	12.1	14.5	14.5	41.1	
NGO expert advice/industry liaison	120.0	0.17	12	20.0	20.0	52	
Equipment	$Unit^{-1}$					**138.2**	**18**
DMON, hydrophones, mounting	33.0	2.0	66.0			66.0	
Glider science bay for DMON	3.0	1.0	3.0			3.0	
AMAR (@30 % discount)	25.6	2.0	51.2			51.2	
AMAR moorings	2.0	3.0	6.0	6.0	6.0	18.0	
Operations	Yr^{-1}					**148.7**	**20**
Glider deployments (5 yr^{-1})	26.2	3.0	26.2	26.2	26.2	78.7	
Field travel, glider transport	variable		7.0	7.0	40.0	54.0	
Vessel survey (fuel + Capt.)	16.0		in-kind	in-kind	16.0	16.0	
Personnel Travel	$Person^{-1}$	# ppl				**58.0**	**8**
DMON integration	2.0	2.0	4.0			4.0	
Project meetings (those at distance)	2.0	5.0	10.0	10.0	10.0	30.0	
Conferences (4 person yr^{-1})	3.0	8.0		12.0	12.0	24.0	
Other						**34.0**	**5**
Unanticipated expenses			10.0	5.0	5.0	20.0	
Publication costs			2.0	6.0	6.0	14.0	
Workshop	apply MEOPAR Partnership Workshop Program					0.0	
Totals							
MEOPAR Funds Requested			238.1	230.7	279.7	**748.6**	
Partner Funds (see Table 2)			1659.5	536.5	477.6	**2,673.6**	
Total Project Funds			1897.6	767.2	757.3	**3,422.1**	
% Requested from MEOPAR			12.5	30.0	36.9	**21.9**	

Budget Justification: $748.6 K

We request a total of $369.6 K in HQP stipend/salary support, $138.2 K for equipment, $148.7 K for operations, $58 K for travel, and $34 K for miscellaneous (unanticipated & disposables) and publication costs. We have assumed glider operations and AMAR deployments may begin as early as June 2014 and budgeted accordingly. For HQP, except glider technician, we assume recruitment to begin when funded and a start date of Jan. 2015. **HQP Stipend/Salary and Benefits: $369.6 K.** $135,000 for the stipend of 3 PhD students and $121,500 to support 1 post-doctoral fellow (Dr. K. Davies to be recruited). $20,000 in travel costs & stipend for four Master of Marine Management (Marine Affairs Programme; MAP) students working with external partners on major research papers and associated internships in MAP. Additional travel funding for HQP internships will be sought through the MEOPeer Researcher Development Sponsorship once the exact nature of the research projects have been defined. $41,100 for part-time (0.25) technical support of the OTN/MEOPAR glider operations team. $52,000 for part-time (0.17) to support Dr. M Brown (grant funded only) at the Canadian Whale Institute who will coordinate vessel surveys on the Scotian Shelf and activities interfacing with the commercial fleet, government agencies (very strong track record) and the MAP graduate students and our supporting agencies.

Equipment $138.2 K: $66,000 to purchase from WHOI, at cost, 2 proven PAM systems including hydrophones, mounting equipment, whale detection and classification system hardware/software (DMON/LFDCS), glider communication link, and fees for technicians to incorporate the DMON/LFDCS onto our gliders & data streams into our data management systems, and train us and our glider technicians. $3000 to purchase a glider science bay to house a PAM system. $51,200 (30% discount) for 2 JASCO Autonomous Multi-channel Acoustic Recorders (AMAR) to complement the 3 provided in-kind by DFO. $18,000 for AMAR moorings; replaced with each deployment. **Operations $148.7 K:** $78,700 for non-salaried and partial O&M cost of glider operations based on 5 deployments yr^{-1} "piggy-backing" on OTN/MEOPAR operations. Annual costs include zodiac fuel and maintenance (**$**2K), Iridium/ARGOS communications ($7.22K), batteries ($8.625K), boat and truck rental (**$**2.37K), electronics replacements (**$**2.5K) and miscellaneous (**$**3.5K). $54,000 to cover east coast field travel for non-OTN/MEOPAR glider operation personnel ($7K yr^{-1}) and field travel and glider transport to the west coast and return for west coast deployments ($33K) in y-3. $16,000 for pilot and fuel for the *RV Sheilagh* in y-3 for right whale survey in Roseway Basin. The Canadian Whale Institute is providing in-kind support for all whale survey-related costs for the *Sheilagh* in y-1, -2, and will provide crew and equipment for the *Sheilagh* in y-3 as in-kind. We need only pay fuel and pilot in y-3. **Travel $58 K:** $4,000 in travel costs for WHOI technical support to integrate DMON/LFDCS with OTN gliders. $30,000 for annual persons-from-away travel to MEOPAR-WHaLE meetings to address design, execution, logistic, analyses, progress, and problem solving etc., on an as-need basis. $24,000 for conference registration and travel based on 4 person conferences in y-2 & 3 with priority to HQP. **Other: $34 K** $20,000 for miscellaneous & unanticipated costs & publication (~7 to 14 papers; priority given to HQP) over the project lifetime. We will apply for MEOPAR Partnerships Workshop Program funds for workshop that includes external partners & the Canessa et al. proposed project on vessel noise.

Table 2. *External partner contributions ($K). Only contributions that are pledged in writing in Letters of Support are included and all letters are available on request. Total external support $2.6736 million.*

Category	Supporter	Y-1	Y- 2	Y-3	In-kind	$$
Equipment and Data		**1364.2**	**207.2**	**207.2**	**1718.6**	**60**
2 Slocum gliders, sensors*	OTN	390			390	
Wave glider, sensors, custom engineering	OTN	750			750	
Cash for echosounder	OTN	25				25
Cash for glider-PAM	OTN	35				35
3 AMAR w/ mooring	DFO	5	5	5	15	
30 % discount 2 AMAR, data analysis & support	JASCO	22	65	65	152	
At-cost loan of 4 Guardbouys, datasets, analysis	Akoostix	60	60	60	180	
5 Cellular Towers (AIS)	BellAliant	35	35	35	105	
3 Years vessel-AIS data for both coasts	exactEarth	42.2	42.2	42.2	126.6	
Vessel Time, Field and Technical Support		**206**	**207**	**148**	**561**	
Whale survey vessel time, crew, equip	CWI	59	59		118	
Whale survey vessel time, crew, equip, analysis	NEAq	66	67	67	200	
Vessel time deploy AMAR, oceanogr. samples	DFO	81	81	81	243	
Expert Participation		**89.3**	**122.3**	**122.4**	**334**	
2 Faculty support to research, internships	Dal MAP		33	33	66	
4 researchers, managers participation	DFO	60	60	60	180	
expert stewardship advice for industry, gov't	CWI	29.3	29.3	29.4	88	
Totals		**1659.5**	**536.5**	**477.6**	**2613.6**	**60**
Total Support from external partners	**$ 2, 673, 600**					

**There are additional in-kind costs coming from OTN/MEOPAR glider operations, data management, we don't know value*

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OCEAN TRACKING NETWORK

Dr. Christopher T. Taggart
Oceanography Department
Dalhousie University

11 April 2014

Dear Chris:

We write this letter on behalf of the global Ocean Tracking Network (OTN) to express our strong support for the Taggart et al. MEOPAR-WHaLE proposal. The OTN uses electronic tagging systems (acoustic tags; satellite tags) to document the movements and survival of marine animals, and to link them to oceanographic conditions. Among other uses, this information is critically important to inform fishery management and policy development, for the conservation of endangered species, for ecosystem management, and for the design of marine reserves.

For technical and ethical reasons, the tagging of marine mammals is problematic, leaving us with important knowledge gaps. However, many species, including the right whale, actively emit sounds that can potentially function as "pseudo-tags" from a population perspective if appropriate receivers and software are developed and deployed. OTN has been actively seeking ways to incorporate this passive acoustic monitoring (PAM) into our global infrastructure as a tool (e.g., Duff et al. 2013)[1] to document the movements of marine mammals and the ambient noise to which they might be subjected. We discussed these needs with Taggart et al. on several occasions during the conceptual development of this project because the work proposed now by Taggart et al., especially the monitoring and associated risk assessment tools, will make an important contribution toward enabling us to bring this knowledge through our distribution network to the management and policy makers who need it. OTN is also keen to use any or all of the new and relevant environmental data collected during the glider missions to enhance other OTN research initiatives related to ocean monitoring and modeling.

OTN is pleased to contribute to this effort by scheduling mission time on our two Slocum gliders and (total cost $390K with sensors), and our Liquid Robotics Wave Glider ($750K with sensors and custom engineering). Between OTN and MEOPAR, we are currently making arrangements to access four additional gliders and thus we do not foresee any difficulties in accommodating the needs of the deployment programme. We will also provide $32.5K in cash for the purchase of PAM equipment for the gliders, operations and maintenance support (boats, trained personnel) for the gliders, and we have also provided $25K for the purchase of a glider-mounted echosounder for zooplankton measurements. OTN staff would also be willing, as applicable, to assist with the training and supervision of the HQP who will be engaged in the research.

Sincerely,

Sara Iverson

Sara Iverson, PhD
Scientific Director

Fred Whoriskey

Fred Whoriskey, PhD
Executive Director

[1]Duff, J, Dean, H, Gazit, T, Taggart, C.T, Cavanagh, JH. 2013. On the right way to right whale protections in the Gulf of Maine - Case study. Journal of International Wildlife Law and Policy. 16:229-265.

15 April 2014

Christopher T. Taggart, PhD
Professor, Fisheries Oceanography
Oceanography Department, Dalhousie University,
1355 Oxford Street, PO Box 15000, Halifax, NS, B3H 4R2

Dear Dr. Taggart,

With this letter Fisheries and Oceans Canada (DFO) conveys our strong support for your Marine Environmental Observation Prediction and Response (MEOPAR) Network of Centres of Excellence research proposal entitled: "MEOPAR – WHaLE (Whales, Habitat and Listening Experiment)". DFO has a mandate and responsibility to protect listed aquatic wildlife species and develop a network of marine protected areas in our waters. The research and products arising from this proposal will address knowledge gaps and improve advice provided by DFO Science Sector and collaborators, and inform decisions and recommendations in priority areas required from DFO Ecosystem Management Sector (EM), including Species at Risk and Oceans and Coastal Management.

North Atlantic right whales are among the most endangered of all cetaceans and research efforts are needed to refine our knowledge of species occurrence and accurately characterize potential threats to recovery. The research proposed, which was developed through consultation with various parties within DFO, directly addresses recovery objectives, strategies and measures outlined in the right whale Recovery Strategy and Action Plan. This includes reducing mortality and injuries from vessel strikes, reducing injury and disturbance from vessel presence, monitoring the population and threats, and increasing understanding of life history characteristics, habitat and threats. Additionally, this work complements DFO's ongoing cetacean research efforts, including long-term acoustic monitoring of cetaceans and characterization of ambient and anthropogenic noise in important cetacean habitat that informs a number of initiatives under the mandate of DFO Ecosystem Management. Increased resolution of whale distribution, habitat and threats will also directly inform required risk assessments that will be part of mandatory Area Response Plans under the Government of Canada's World Class Tanker Safety System.

DFO will support the proposed research by providing equipment, ship time, data, expertise and advice, including participation in project planning, data collection and analysis, and dissemination of results. More specifically, DFO will undertake depth-discrete sampling of the zooplankton community (BIONESS) and deploy a Moving Vessel Profiler (MVP) equipped with a Laser Optical Particle Counter (LOCP) during the biannual Scotian Shelf Atlantic Zone Monitoring Program (AZMP) to provide data to this project on oceanographic conditions and prey composition in specified areas of the Scotian Shelf. DFO will also deploy bottom-moored Autonomous Multichannel Acoustic Recorders (AMAR) in locations of interest throughout April to October of each year of the project to monitor whale vocalizations and ambient background noise levels. DFO EM and Science sectors also are interested in participating in graduate student training through supervision of marine management interns and participation on graduate student supervisory committees should appropriate opportunities arise through this work. The in-kind contributions associated with this research program are estimated to be $438,000 over three years ($146,000/yr); which include ship time for AZMP BIONESS and MVP sampling, and AMAR deployments and retrievals ($81,000/yr), equipment rental fees ($5,000/yr) and personnel time ($60,000/yr).

The research proposed will build on over 10 years of successful collaboration with the Dalhousie laboratories of Drs. Taggart and Ross, and will enhance a partnership that has provided key information and advice to further DFO mandate and interactions with DFO clients (e.g. foreign states, other federal departments, maritime transportation, commercial fishing, non-governmental agencies). The various Sectors in DFO Maritimes Region look forward to collaborating with your research team in the future on this high priority research.

Yours truly,

R. Kent Smedbol

Kent Smedbol
Manager, Ocean and Ecosystem Sciences Division

T. Hall

Tim Hall
Regional Manager, Ocean and Coastal Management Division

Department of Fisheries and Oceans
Bedford Institute of Oceanography
1 Challenger Drive, PO Box 1006, Dartmouth, NS, B2Y 4A2

CANADIAN WHALE INSTITUTE

20 Morning Star Lane, Wilson's Beach
New Brunswick, E5E 1S9 Canada (506) 752-1986

New England Aquarium

1 Central Wharf, Boston, MA 01220 USA
(617) 973-5220

April 16, 2014

Christopher T. Taggart, PhD
Oceanography Department, Dalhousie University,
1355 Oxford Street, PO Box 15000, Halifax, NS B3H 4R2

Re: Letter of Support for Marine Environmental Observation Prediction and Response (MEOPAR) Network of Centres of Excellence research proposal entitled MEOPAR – WHaLE (Whales, Habitat and Listening Experiment)

Dear Dr. Taggart,

We have consulted extensively with you and your team regarding your MEOPAR proposal and provide this joint letter of support from the Canadian Whale Institute (CWI) and the New England Aquarium (NEAq). The proposed project is of considerable interest and value to our ongoing conservation work aimed at reducing vessel strike threats to whales and to the advancing science on the distribution and shifting patterns of right whale habitat use. Our conventional vessel and aircraft surveys, that will supplement the proposed research, are expensive and limited by weather and range from shore. The WHaLE project will provide critical information from a large area of the Scotian Shelf where there is an extreme paucity of whale distribution data so we can address known threats to right whales, and other whales, in this region.

CWI and NEAq policy outreach programs with Fisheries and Oceans Canada, Transport Canada and the national and international shipping industry will use the results of this research to improve our knowledge of existing critical habitat, identify additional potential critical habitat and associated risks, help provide options for mitigating vessel risk to whales on the Scotian Shelf and in the Gulf of Maine, and help in providing near real time data for transmission to regional vessel traffic (private client Captain Peter Turner, MARTRANS) through an existing collaboration with developers of the Whale Alert app (private client Brad Winney EARTHNC). It is clear that your proposal builds on 15 years of collaborative research, conservation, and shipping industry stewardship for right whales and it will enhance our multi-sectoral ability to address, with the Canadian Government, priority action knowledge gaps on right whale distribution and human-induced threats as identified in the Recovery Strategy for the North Atlantic Right Whale (Brown et al 2009[1]) and required to further species recovery. The shipping industry directly benefits from our ongoing and enhanced (through this proposal) whale stewardship through public awareness and there is clear evidence that the shipping industry can be engaged in changing its navigational behaviour to the benefit of right whale recovery. We are also very keen to see if our successes achieved on the Scotian Shelf will merge well with similar advances made in the U.S. Gulf of Maine waters and then be tested on the west coast of Canada where similar vessel risk to whales issues are recognized as in need of remediation.

The CWI and NEAq will provide cash and in kind support for the WHaLE proposal. CWI will provide $206K from a Canadian federally funded grant (equipment, ship time for surveys $118K, expert right whale and vessel stewardship advice for shipping industry and Canadian Government $ 88K) and the NEAq will provide $200K from annually funded grants and contracts (personnel, equipment, ship time, and right whale data analysis). CWI and NEAq will strive to enrich the research of marine management graduate students and their internships by providing guidance and participation opportunities in right whale research and stewardship programs that will be aligned with the shipping industry.

Yours sincerely,

Sarah Haney
Chair of the Board of Directors
Canadian Whale Institute

Scott D. Kraus PhD
Vice President for Research
New England Aquarium

[1]Brown, M.W., D. Fenton, K. Smedbol, C. Merriman, K. Robichaud-LeBlanc and J. Conway. 2009. Recovery Strategy for the North Atlantic Right Whale (*Eubalaena glacialis*) in Atlantic Canadian Waters. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. vi + 66p.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543-1026

Support letter for the MEOPAR - Whale, Habitat and Listening Experiment Research Proposal

To whom it may concern, 25 April 2014

I am writing to provide my enthusiastic support for the MEOPAR proposal. This proposal aims to integrate Slocum gliders using the LFDCS whale detector throughout the Scotian Shelf to to measure distributions of whales and their habitat. In addition the project will develop wave glider capabilities and utilize long term archival acoustic monitoring in collaboration with JASCO inc.

I am the leader of the Passive Acoustic Research program at NOAA's Northeast Fisheries Science Center (http://www.nefsc.noaa.gov/psb/acoustics/index.html) and bring with this decades of experience on passive acoustic monitoring and management. This project and these goals exactly mirror those of a 3 year Environmental Security Technology Certification Program (ESTCP) project that will start in early 2015 carrying out similar work throughout the Gulf of Maine, in US waters. The ESTCP is funded through the US Department of Defense under their 'Environmental Technologies' solicitation and will use similar technologies to MEOPAR and has as aim the intention to identify the best monitoring strategies for large whales in the Western Atlantic. Drs Cara Hotchkin from the Navy Atlantic Fleet Operations, Mark Baumgartner from Woods Hole Oceanographic Institute and myself are the PIs. The ESTCP will provide US$1,500,000 over 3 years and will be supported by substantial in kind NOAA aerial and vessel time. Given that the MEOPAR project could run in parallel to this endeavour I see many opportunities for leveraging the vessel and aerial survey resources that we will have in place in order to add value to the MEOPAR project. Our ESTCP project will involve extensive acoustic analysis of glider and archival data and we can offer both our expertise and where needed some analytical time from our acoustics research team to help process and evaluate the LFDCS detector.

The intent of the NOAA passive acoustics program is to better integrate these technologies for monitoring and managing endangered baleen whales. Our objectives mirror those of the MEOPAR project and have as end goal the integration of this technology into our everyday operational monitoring and conservation. The concurrent running of the MEOPAR project would provide a much bigger picture and a great platform for running and testing these technologies at the scale over which both the US and Canada will want to utilize them.

Part of the ESTCP project will also assess how the LFDCS performs across different technological platforms, from gliders to real time buoys and profile drifters. The aim of this is to understand how each platform can be used for different goals, such as monitoring presence versus avoiding ship strike and understanding the influence of anthropogenic noise on endangered species. The MEOPAR project aims to look closely at perform vessel-whale risk assessment in any whale habitat and will provide valuable data for our decision making within NOAA. Lastly, our NOAA acoustic program trains and supervises undergraduate and graduate students and I would be thrilled to be involved in any graduate training and supervision that may result from the MEOPAR project. In addition we would be happy to train and receive interns in our acoustic program and have them participate in our decision process, policy, outreach and research activities in order to help support this project.

Sincerely,

Dr. Sofie Van Parijs
NEFSC, Protected Species Branch, Passive Acoustic Program Leader
T: 508 549 2119, Email: sofie.vanparijs@noaa.gov

Montreal, April 24 2014

Christopher T. Taggart, PhD
Oceanography Department, Dalhousie University
1355 Oxford Street, PO Box 15000
Halifax, NS B3H 4R2

RE: Letter of Support for Marine Environmental Observation Prediction and Response (MEOPAR) Network of Centres of Excellence Research Proposal Entitled MEOPAR – WHaLE (Whales, Habitat and Listening Experiment)

Dr. Taggart,

The Shipping Federation of Canada (The Federation), incorporated by an Act of Parliament in 1903, acts as the pre-eminent voice of shipowners, operators and agents involved in Canada's world trade. Its overall objective is to work towards a safe, competitive and environmentally sustainable marine transportation system. We welcome the opportunity to provide a letter of support for the WHaLE project, which we expect will provide critical information on whale distribution data for the Scotian Shelf and eventually the West Coast where our ships transit regularly.

Given the ever increasing number of threats to which marine mammals are exposed, we support funding for initiatives such as the WHaLE project as a means of providing stakeholders such as Federation members with near real time data to help minimize the impacts of commercial navigation on endangered whales and their habitat. We recently collaborated with the Réseau d'observation des mammifères marins on a document entitled *A Mariners' Guide to Whales in the Northwest Atlantic* (currently in print) which provides information on whale distribution overlaid with vessel traffic maps, which is similar to the vessel-whale risk assessment included in the WHaLE proposal. We see the development of tools allowing for near real time data as the logical next step, and we strongly support the distribution of such information to our vessels through platforms such as the Whale Alert application. Our members' ships transit in Canadian waters from ports throughout the world, and the best way of ensuring their ability to minimize the impact of their operations on whales and their habitats is by providing them with accurate and timely information upon which to base their risk reduction actions.

Before closing, we would like to highlight our willingness to collaborate with MEOPAR on the WHaLE project through the provision of in-kind support. An example of such support could be through collaborations between the Federation and graduate students in the Master of Marine Management program, with a view to increasing the latters' understanding of owner/operator needs, options and restrictions related to minimizing risk to whales without compromising vessel operations and the safety of navigation.

Yours sincerely,

Caroline Gravel

Caroline Gravel
Director, Environmental Affairs
Shipping Federation of Canada