Ocean Literacy in Canada: Literature Review

A scan of current research knowledge and understanding related to ocean literacy in Canada, and an analysis of key areas for future research

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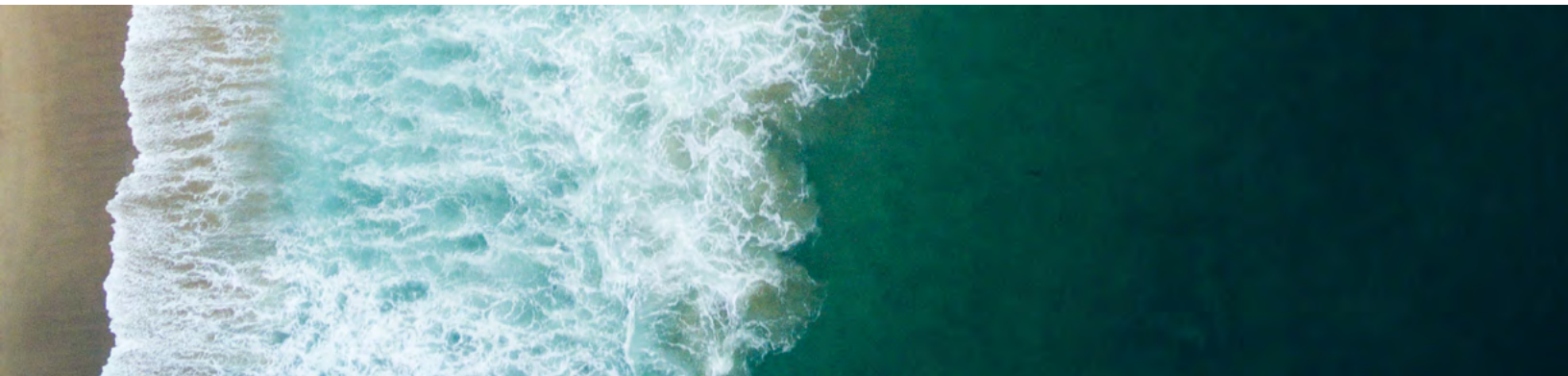

NOTE

This report was part of a nine-week project to create a development plan for advancing a national ocean literacy strategy in Canada. The project was funded by Fisheries and Oceans Canada, in partnership with Ingenium Corp and Ocean School (a joint initiative of the National Film Board of Canada, Dalhousie University and the Ocean Frontier Institute). The initiative was project managed by Janet Stalker (Ocean School / Ocean Frontier Institute), and directed by the initial members of the Ocean Literacy Coalition: Jason Armstrong (Ingenium Corp.), James Bartram (Ocean Wise), Tara Donaghy (Fisheries and Oceans Canada), Diz Glithero (Canada C3 / University of Ottawa), Geoff Green (Students on Ice Foundation / Canada C3), Heather Murray (Canadian Network for Ocean Education), Sherry Scully (Scully Research Consulting), Janet Stalker (Ocean School / Ocean Frontier Institute), and Anne Stewart (Canadian Network for Ocean Education).

The report is designed to inform the development plan for the national ocean literacy strategy, as well as the strategy itself. Given the brief timeline of the project, the Coalition recognizes the need for further investigation into key areas of ocean literacy research, as noted in the research analysis section of the report.

The report was researched and written by Dr. Sherry Scully (Scully Research Consulting), with input and feedback from the Ocean Literacy Coalition members.

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Executive Summary

This literature review examines extant literature from peer reviewed journals, industry reports, and NGO websites, conference proceedings, and unpublished research, to establish a baseline of what we know, what has been tried, what has worked well, and where gaps remain, all to better inform an evidence-based approach to developing a national Ocean Literacy Strategy. Literature was examined in areas relating to public and key stakeholder engagement, communities of practice, Indigenous perspectives, formal and informal approaches to ocean education, and methodologies for assessing impact. Among the key findings from this review were;

- Knowledge holding was found to correlate with numerous factors, however the most significant factor in influencing the shift to knowledge mobilization and motivation to act was trans-situational conditions (i.e. being connected to the issue, seeing the impact of the issue on them and their families/communities)
- Findings showed that youth had impact and developed agency through their community and citizen science (CCS) experiences when certain conditions were in place, including having long-term CCS experiences and having repeated experiences to build connections to a place or issue, and having a chance to explicitly contribute to authentic research. Several researchers recognize citizen science as a paradigm for a collaborative approach to tackling broad and complex issues that fall into the socio-scientific categories
- Research from indigenous scholars outlined the necessary components of Indigenous pedagogy for successful programs promoting indigenous knowledge, and necessary components for integrating Western science into Indigenous environmental education programs. This work emphasised grounding programs in Indigenous philosophies of education and Indigenous ways of teaching and learning, which reinforces the concept that Indigenous Knowledge is not only content but also process. The research identifies how traditional ecological knowledge (TEK) reflects the Indigenous connection with land, ocean, resources, and culture
- Studies found that social network sites and other digital channels can be effective tools for ocean researchers to reach the public and share recent findings, but that not all sites are effective at building interaction, dialogue and participation from and between users
- The critical influence of media framing of environmental issues was explored by several researchers. Researchers found that the media tended over-utilize conflict frames, focusing their reporting on polarized stakeholder views, and were not

effective at conveying the key issues that were most germane to the public. Research showed that while the public do tend to trust information from the media, the level of reporting left the public poorly informed about the most relevant issues and the science in which those issues were grounded

- Presently, several groups have identified impact assessment models, but there are few reports on the actual impact of ocean literacy at this time. This is a significant gap and relies on groups having the foresight to conduct baseline assessments with which to compare current metrics to determine if progress has been made on any or many of the established assessment criteria.

The literature and the search for research highlighted key research gaps and opportunities that are essential to supporting an evidence-based strategy for developing a national Ocean Literacy framework and strategy. Some recommendations for further study include;

- Research to better understand how to integrate traditional knowledge with Western science in our formal education systems, to benefit from the process of knowing as well as the knowledge, and from the stewardship principles that are inherent in an Indigenous pedagogy.
- Research to examine the utility and efficacy of formal and informal curricula and resources in terms of if and how they are being utilized by educators, and the impact on student ocean-positive attitudes, behaviours and activities. Additionally, research into sustained behaviour and attitude change arising from Ocean Literacy programs, ocean curricula, awareness campaigns and communication strategies
- Research to develop a more informed understanding of how to match communication channel with message, or channel with stakeholder group in order to increase receptivity of communication. It would also be helpful to understand which channels most readily influence public perception in order to either leverage these channels better with appropriate communication or to monitor these channels for counter-productive messages. And finally, more research is needed to understand how to in-turn influence the media to adopt more productive frames to better-leverage their agenda-setting capabilities.
- Research that examines learning transfer and integration of scientific and personal knowledge on issues relating to marine and coastal areas, particularly regional or locally relevant issues where personal or community impact can be more readily apparent, to determine if the same argumentation skills are applied. It would also be interesting to understand how different stakeholders view and prioritize different socio-scientific issues, and how culture, beliefs, values, demographics and regions influence these perceptions
- Develop a framework and criteria to assess the impact of informal education and awareness programs such as citizen science programs, public talks, youth informal education; digital and online awareness and information initiatives, and inter-sector/ inter-stakeholder sharing sessions

- Examine how individuals and groups make the cerebral-to-affective leap between science knowledge and awareness into feelings of concern, responsibility, and readiness to act in ocean-positive ways. It would be interesting to understand what factors facilitate or mitigate this transfer, and what factors are common to and unique among key stakeholder groups.
- Much of the literature explored proximity and visit-frequency as factors influencing awareness, knowledge holding, concern and likelihood to demonstrate environmentally positive behaviours. What wasn't clear from the research, and would be worth study, is if the context of the coastal visit (i.e. family trip, class trip, day camp, etc.) was a factor at play. This is a recommended area for follow-up study, as it is likely that the context of the visit is significant in creating meaning about and from the experience and building issue salience. It is also recommended that further study be done to determine the link between visits to ocean and coastal regions and citizen engagement in ocean issues, as a vast majority of Canada's people live in land-locked provinces, where visits to these regions would likely be infrequent or rare. This research may provide insights into ways to bring the experience to people by leveraging virtual reality or other digital technologies that mimic the salient elements of an ocean visit experience.

Across the globe ocean literacy frameworks and strategies have been rooted in the assumption that awareness, relevance and knowledge will lead to engagement in, and support for, ocean restoration and sustainability initiatives. These assumptions have been well-supported by the literature examined in this review. However, it is worth emphasising the point that knowledge alone is insufficient for engendering the type of engagement needed to produce and sustain broad ocean-positive behaviours, attitudes and actions. What became very clear through this literature review was the importance of the inclusion of traditional and local knowledge, issue relevance and salience to individuals and their communities, the influence of values and priorities in inferring relevance and salience, and the importance of finding ways of connecting all stakeholders to the issues.

A unifying framework for Canada, that truly reflects all Canadians, will require strong involvement and co-leadership of Canada's Indigenous communities. This involvement needs to happen from the start and continue throughout implementation and assessment phases.

Communication of the framework and its priorities will require the use of multiple channels to reach the myriad stakeholder groups and subgroups and to allow for multi-directional communication, as these groups share information, debate, discuss and build a deeper understanding of ocean and coastal issues and their individual or group role in contributing to or resolving those issues.

Enactment of the framework and its priorities will rely on informed and engaged educators in formal, informal and non-formal contexts. It will rely on the establishment of clear and relevant ocean principles and essential ocean science concepts that need to be included in

formal curricula. This will also depend on the development and sharing of effective resources to support an inquiry-based experiential pedagogy.

There is much to be done and the clock is ticking to ready the Canadian public for action and behaviour change in how each of us regards and interacts with our ocean and its resources. A national ocean literacy framework will be an essential map to guide the shift from ocean user to ocean steward and build and reinforce an understanding of our role in preserving the earth systems that sustain us all.

About this Document

This literature review examines peer reviewed journals, industry reports, and NGO websites, conference proceedings, and unpublished research, to establish a baseline for establishing an evidence-based approach to developing a national Ocean Literacy Strategy. What became evident during this literature review, is the lack of research specifically on ocean literacy. As a result, this report will also include a research gap analysis with recommendations for future focus.

1. THE IMPETUS FOR A NATIONAL STRATEGY ON OCEAN LITERACY IN CANADA

The ocean has long been a source of fascination and interest for researchers and ocean scientists, citizens and nature-lovers, dazzled by its mysteries and beauty. Only recently has it become urgent to highlight the ocean as a compelling and critical topic of interest to the broader public. The ocean impacts society, the economy and our environment. By advancing ocean literacy, Canada can generate broader enthusiasm for sustainability policies and ocean-positive behaviours.

Generations of citizens have been under-educated about our ocean in our formal public-school systems (Strang, Decharon, & Schoedinger, 2007), and under exposed to the ocean through informal education programs (Scully, Marine People Partnership Student intentions and perceptions study: Report of findings, analysis and recommendations., 2016). The incontrovertible need for immediate and thorough ocean restoration actions and sustainability measures, coupled with a surprising public apathy and lack of knowledge among the public (Eleiton, Corless, & Hynes, 2015) have led to a contemporary approach to mobilizing action, that yields neither a stick nor a carrot, but rather aims to lead the public towards action by equipping them with relevant knowledge. The origin of ocean literacy lay not in producing more ocean scientists, but rather in producing a more literate public able to comprehend their impact on the ocean and the ocean's impact on their lives, the actions needed to improve and preserve this symbiosis, and the pathways and motivations to do so.

INTERNATIONAL RESPONSES TO OCEAN LITERACY

Many regions have been swift to respond, especially Europe and the United States, with progressive dialogue and policy development. Some efforts have been regionally or issue focused, while others have swiftly established strong and broad guiding strategies to draw together existing efforts and harness collective effort toward key priorities.

For example, the Pew Oceans Commission report (PEW, May 2003), called for new approaches to respond to the deteriorating conditions of the ocean. The Pew report also argued for the need to elevate the general public's knowledge about their impact and reliance on ocean and coastal ecosystems. The Pew report highlighted the need for relevant and understandable information, so the public would be able to comprehend and support policy-level changes as well as day-to-day behavioural changes that are needed. To accelerate the momentum needed for progress and sustainable development, and to produce citizens who are able to make informed decisions and support policy changes, the Pew report underscored the need for an informed and engaged public. This has been the rationale behind an ocean literacy movement that has circled the globe. From this we can glean that knowledge-building will be a first step in establishing a national ocean sustainability effort in Canada.

The Atlantic Ocean Research Alliance (AORA) which was formed with Canada, the United States and European organizations in May 2013 as an output of the Tri-lateral Galway Agreement also provides early demonstration of Canada's commitments on ocean literacy. This alliance is organized to fund collaborative projects and has established an international ocean literacy working group which has identified key actions. Their website (https://www.atlanticresource.org/aora) provides access to numerous studies on Canada's ocean sectors.

As further evidence of the international momentum that has gathered, the Ocean Literacy for All initiative published a toolkit (Santoro et al) in 2017 to encourage an exchange worldwide on ocean education in support of ocean literacy frameworks. "It provides to educators and learners worldwide the innovative tools, methods, and resources to understand the complex ocean processes and functions and, as well, to alert them on the most urgent ocean issues. It also presents the essential scientific principles and information needed to understand the cause-effect relationship between individual and collective behavior and the impacts that threaten the ocean health." (Foreword). The UN Ocean Conference in 2017 established global objectives relating to raising awareness to create a "global movement for conservation, restoration and sustainable use of our ocean" (UNESCO, 2018). The conference proceedings also outlined activities and initiatives that will take place in the next two years in pursuit of these objectives.

Similarly, Sea Change (Sea Change Project, 2018), is a European Commission H2020 funded project that is aimed at elevating ocean literacy across Europe. With 17 partners across nine countries, the Sea Change Consortium draws together experts to develop projects, programs and initiatives to support a broad range of stakeholder groups, including educators, policy makers, and citizens with the shared goal of elevating ocean literacy across Europe. In addition to videos and teaching resources, the website provides access to policy-oriented research and reports. Sea Change is a collaborative project that is nearing the end of its three-year project phase. It provides an excellent model for a regional approach to improving ocean literacy.

A sister project, the ResponSEAble Project (ResponSEAble, 2018), which is a similarly funded collaborative project involving 15 European partners, has directed its focus on mapping marine research and knowledge to deepen understanding of how societies and economies harm or benefit from interactions with the ocean. The ResponSEAble project is also applying a multi-media approach to engage the public in knowledge-building and debate that includes films, digital gaming, social media campaigns and an interactive website.

CANADIAN CONTEXT

Implicit in these ocean literacy strategies is the integration of social, cultural, environmental, and economic dimensions into a framework that reinforces the connection to people and place. It is the addition of the economic dimension into the definition of ocean literacy that may distinguish Canada. The concept of Blue Growth came out of the United Nations Conference on Sustainable Development, Rio+20 held in 2012. The conference stressed the importance of conservation and sustainable management as a necessary and central condition for ocean-based economies (COM, 2014). With the Blue Economy emerging as the 'new' unexploited frontier in Canada, and with Federal funding directed towards research (i.e. Ocean Frontier Institute, Department of Fisheries and Oceans), defense (i.e. National Shipbuilding Strategy, national supply chain development), and commercialization of ocean innovations (i.e. Ocean Supercluster, The Centre for Ocean Ventures and Entrepreneurship), it is critical that industry be recognized as a key player in building a collaborative ocean literacy strategy

As Canada moves to develop its own ocean literacy national strategy, there is an opportunity to scan and learn from activities globally, look for gaps in information or activities, and determine where we can borrow from existing programs. There is an opportunity to thoughtfully and strategically construct a framework that integrates best practice and common objectives with Canada's novel issues and unique heritage — to bolster an engaged public. A second unique distinction for Canada's approach to building an ocean literacy framework is the strong need and desire to co-create a strategy with Canada's Indigenous communities. As an example, Rutherford (Overview of Ocean Literacy in Canada -Department of Foreign Affairs and International Trade, 2013) outlined opportunities to link Arctic literacy with ocean literacy in Canada, through research and education programs aimed at studying and understanding the changing Arctic.

We have learned from terrestrial efforts to promote environmental issues, that early involvement with industry and with Indigenous groups is essential to mitigating adversarial positions. This literature review explores how stakeholder engagement can be leveraged with positive outcomes, indicating that early collaboration can yield fruitful industry and Indigenous leadership for sustainability efforts.

This process highlights key questions that need to be considered in the development of a national ocean literacy strategy, key among them being, how do we define and measure ocean literacy? Does it comprise equal measures of awareness and knowledge? Is it also characterized by a propensity to act and endorse ocean-positive behaviours? We also want to go beyond assessing the ocean literacy levels of Canadians generally, to better understand how ocean literate distinct cohorts of stakeholders are, such as youth, business owners, government officials, teachers, Indigenous groups, and key media personnel. Which of these groups are presently being underserved with existing ocean literacy initiatives, and which new efforts could have the most impact? And in terms of addressing our most pressing ocean and coastal restoration needs, which stakeholders and which key issues and challenges need to be prioritized? And finally, what can we learn from efforts internationally about assessing impact? Is it possible to quantify informed decision making? Or the role of heritage and culture? Or behaviour change?

2. PATHWAYS TO ENGAGEMENT OF THE PUBLIC

The need for public engagement in developing (?) a national ocean literacy strategy and in its concomitant behaviour change has been shown to be paramount to its efficacy and endurance. Public involvement at policy and decision-making levels was partially spirited by an interest in democratising these processes, and partly derived from the recognition that it is easier to enforce potentially unpopular policies when the public has played a role in understanding and developing them (Rowe & Frewer, Winter 2000). There are added benefits of building trust between, and stewardship from, a broader range of potentially antagonistic stakeholders. Keen to promote these democratic ideals, many of the voices calling for more public participation are from Government or academic institutions (Rowe & Frewer, Winter 2000).

There is a relationship between an individual's knowledge about marine areas and their support for the conservation in these areas (West, 2004), however few practitioners in environmental communication would point to knowledge gaps as the principle or sole explanation for a reluctant public. The knowledge-deficit model (Miller, 2001) provides an overly simplistic explanation for collective action mediated by individual knowledge levels. The knowledge-deficit model "treats information as neutral and objective" (Potter & Oster, 2008, p. 121). This is counter to the ritual model of communication which recognizes that a key element in working with so many stakeholders is the reality that an objective truth is filtered through cultural, social and local priorities and perceptual screens that mediate the perceptions of truth and importance, influencing the quality and accuracy of communication between groups (Carey, 2002) .Indeed, perceptual screens have been shown to influence individual's perceptions of pro-social messages, such as climate change (Hart, 2010), reinforcing the reality that filling knowledge gaps alone is insufficient for engaging the public (McKenzie-Mohr D. , 2011).

BARRIERS TO ENGAGEMENT

As strategies are developed to drive public behaviour change, it is important to first understand what barriers exist, and what effective routes to engagement have been forged elsewhere, and how best to build relevant science and policy knowledge to ready the public for participation and stewardship. A journal article by Lorenzonai et al (Barriers perceived to engaging with climate change among the UK public and their policy impliations., 2007) examined barriers to public engagement in climate change. According to this article, engagement is comprised of cognitive, affective, and behavioural elements, that motivate individuals to action through deeper understanding of an issue and how they are connected to it. The authors warn that policies risk being ineffective or rejected if the public doesn't understand the issue or care about it. Common barriers to participation were found that operate at the individual and social levels. Individual barriers include dissonance and denial, social identity, and self-efficacy, of all which relate to a lack of belief (or denial) that one's personal actions contribute to the environmental issue or that changes in their actions can positively affect those issues. Other individual barriers included

lack of knowledge, lack of interest in seeking information, inaccessibility of information to non-experts, perceived information overload, mistrust of information, failing to acknowledge the immediacy of the threat, externalizing responsibility, other competing priorities for their engagement, reluctance to change lifestyles, and fatalism which typically communicates withdrawal from an issue due to a belief in lack of efficacy to resolve it, or general hopelessness. Lorenzonia's article reinforces the importance of establishing a sense of individual relevance and impact, as well as the crucial role of emotional connection for driving behaviour change.

SOCIAL BARRIERS

Social barriers were identified as perceptions of limited or little action by governments, business and industry, inactivity by others around them that makes their own behaviour change seem unfair or pointless, prioritizing personal and financial needs in a community over environment, and lack of enabling initiatives that offer more environmentally friendly alternatives (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007). These barriers, insofar as they mitigate or halt public involvement, are argued to have significant implications for achievement of behaviour change targets, as well as implications for policy development. If people can't easily do the action/behaviour (e.g. recycling), then they will need an even stronger sense of connection and value to overcome the divide and actually engage in the behaviour.

It is also important to understand these barriers to ensure ocean literacy communication campaigns don't inadvertently trigger these default reactions. This gives caution to our strategies for information sharing with the public, in volume, source, and balance of negative (current state) with optimistic (desired future state), and with clear actionable and achievable steps for individuals and citizens at large. It also suggests that local information, being more visible and individually relevant, and thus with more opportunity for the public to connect at the cognitive, affective and behavioural levels, should be emphasized to build engagement and mitigate the overwhelming effects of tackling too big a challenge that seems too distant.

At the same time, the collective challenges need to be addressed at a policy level that mandates behaviour change. This will ensure behaviour change is motivated by perceptions of equity and collectivity, providing pathways that improve accessibility to target behaviours. The Lorenzoni et al article also warns that when it is perceived that there is a choice to not change, and that others may do so without penalty, then citizens tend to be immobilized by perceptions of the free-rider effect. This demonstrates that local initiatives will be most salient if anchored in parallel activities in other areas locally and internationally, and if the efforts of others are highlighted and celebrated.

While much can be learned from the Lorenzoni et al study, it is important to note that contrary to ocean issues, there was a nearly universal awareness of climate change issues. The findings relate to a know-do gap, or attitude behaviour gap that was explored in an article by Blake (Overcoming the 'Value-Action Gap' in environmental policy: Tensions between national policy and local experience., 1999) that demonstrated widespread awareness and concern doesn't always translate into engagement in an issue. This concept of a know-do gap is relevant

to strategies relating to transferring ocean literacy knowledge into action, and to arguments that suggest ocean literacy strategies should be emphatically oriented around knowledge-building. These reports suggest that an effective ocean literacy strategy will need to tap into a combination of cognitive, affective, and behavioural motivations to be most impactful and enduring.

INHERENT BARRIERS

A different approach to understanding barriers to participation in environmentally focused activities, identified evolutionary links to counterproductive behaviours (i.e. why people continue to behave in unsustainable ways, despite knowledge and awareness to behave otherwise). A 2012 study by Greiskevicius et al (The evolutionary basis for sustainable behavior: Implications for marketing, policy, and social entrepreneurship., 2012) provides a novel point of view on why it can be so difficult to change behaviour, even when it's in an individual's best interest to do so. Drawing evolutionary links to sustainable behaviour, this study cited five adaptive evolutionary tendencies to explain why humans engage in behaviours that drive ecological damage. According to the researchers, the five adaptive tendencies that promoted survival in our ancestral environments, but that are sometimes counterproductive in modern society, include: prioritizing self-interest over group welfare, motivation for relative rather than absolute status (which drives consuming behaviour to satisfy the need to have more than others), a proclivity to unconsciously copy others (which leads people to compare their ecological efforts relative to others, and regress to the average), a predisposition to be short-sighted which makes it difficult to connect present behaviour with future impact; and proneness to disregard impalpable concerns which make it difficult to be engaged in environmental issues that seem remote or delayed or not tangibly consequential to them. These adaptive tendencies align well with the individual and social barriers identified by Lorenzoni et al (2007).

The authors suggest that strategies to influence behaviour towards more ecologically sustainable practices might be more effective if they are matched to the evolutionary mechanism driving the unwanted and change-resistant behavior. For example, in response to the self-interest tendency, rather than urging behaviour change for the sake of others (misaligned strategy), emphasize the benefits to the individual. And, in response to the relative status tendency, instead of asking people to be content with what they have or to give up what they have (misaligned strategy), encourage pro-social competitions and publicize (celebrate, elevate status of) prosocial companies, celebrities and citizens. In response to impalpable concerns, instead of presenting international environmental problems and citing flat statistics (misaligned strategy), present issues anchored in local challenges and emphasize the connection between behaviour and immediate consequences to the environment. According to the authors, these aligned strategies will produce a more visceral response and deepen connection to environmental issues.

PATHWAYS TO ENGAGEMENT: KNOWLEDGE HOLDING

Several reports and articles have highlighted the influence of knowledge holding as a pathway to participation in environmental activities (Perry, Needham, Cramer, & Rosenberger, 2014) (Steel B. S., July 2006) (Steger, Pierce, Steel, & Lovrich, 1988), and proponents for knowledge-based ocean literacy highlight the need for clear, relevant and regional ocean and coastal knowledge as a precursor to active less involvement in ocean activities. A study published in Ocean & Coastal Management (Steel, Court Smith, Opsommer, Curiel, & Warner-Steel, Public ocean literacy in the United States, 2005) investigated existing levels of (policy relevant) public knowledge about the ocean among citizens of the United States who live in coastal versus inland communities and sought to determine variables correlating with relevant knowledge. The researchers approached this study with the assumption that there is a strong correlation between enhanced awareness and ocean knowledge and increased public support for policy-level efforts to restore and sustain the ocean. A knowledge gap among citizens was examined by the researchers, who looked at variables such as socio-economic status (SES), proximity to coastal regions, and trans-situational conditions to explain differences in knowledge holding. The study found the gap did correlate with SES, but not with living close to/far from a coastal area. And while lower level of policy-relevant knowledge was found among citizens with lower SES, this correlation was mediated by trans-situational conditions (i.e. being connected to the issue, seeing the impact of the issue on them and their families/communities) that are motivational in character. This showed that education, employment and income levels of families and individuals may explain some of the knowledge gap across society, but that issue salience (relevance and impact to the individual) can motivate citizens to minimize that gap, driving them to seek and use knowledge to engage in an issue. This research seems to further reinforce the inadequacies of a knowledge-deficit theory by citing connections between factors relating to the individual and their community (i.e. trans-situational) and knowledge holding. Additionally, this study did not sufficiently relate knowledge to ocean-positive behaviours and activities, the assumption upon which this study was based. However, it did demonstrate the counterintuitive finding that while a large proportion of people live close to coastal areas, this doesn't always lead to improved knowledge about the ocean.

A 2005 survey study by Bord, O'Connor & Fisher (In what sense does the public need to understand global climate change?) in the United States looked at behavioural intention to act in response to an environmental issue (i.e. climate change), and found that correct knowledge of what causes climate change (and what does not) was the biggest predictor of intention to take voluntary action and to participate (by voting) in policy decisions. This study demonstrated that general environmental awareness and concern were not enough to motivate behavioural intentions and concluded that knowledge was essential to eliciting a behavioural response to act. What was not evident from this study was how knowledge related to awareness of personal impact and relevance. The study seemed to emphasize scientific and technical knowledge as it related to public participation, but not community-level knowledge. Additionally, the directionality of the correlation between knowledge and participation was not clear (i.e. they participated because they had more knowledge, or they had more knowledge

because they participated). Finally, it would be interesting to examine how knowledge confidence, and confidence in the participatory debate process relate to participation. It may be that objective knowledge leads to participation, or subjective confidence in knowledge (i.e. confidence in having the information necessary to weigh in on the particular issue). Or, it may be that the public's willingness to participate in voluntary action is related more to self-efficacy (the belief that their actions can make a difference) than it is to objective knowledge.

In an article by Brent Steel (Ocean and Coastal Literacy in the US: The state of the American public's knowledge on ocean policy issues, July 2006) the author puts forward an argument for engaging the public in ocean literacy based on the assumption that knowledge is essential to develop perceptions of environmental problems and understand the actions and behaviours needed to address them – and their part in it. In particular, Steel highlights the importance of knowledge of policy to comprehend how citizens contribute to destruction of the ocean and coastal regions, and the type of policy change needed to address this. He highlights complexity of scientific and technical knowledge as a barrier to participation by public citizens. Steel proposes a strategy that involves communicating directly to the public to elevate policy knowledge – so they can also choose to make individual changes that could positively impact the environment. Low levels of policy knowledge are explained by two theories:

1. Trans-situational conditions such as low income, low education level, low job level have been shown to correlate strongly with environmental awareness. This theory suggests that where these conditions remain relatively static, there is little opportunity to influence knowledge levels.

2. The second theory proposes that situational factors such as having a stake (what's in it for me) tend to lead to more knowledge seeking regardless of socioeconomic status. This is consistent with the aforementioned studies by Lorenzoni et al (2007) and Greiskevicius et al (2012). The study concluded that the public is generally poorly informed about many ocean and coastal policy issues. **The study also found that the factor that correlated strongest with knowledge indicators was how frequently citizens visited a coastal area (irrespective of where they lived).** This suggests that public outreach and education would be most successful if coupled with visits to a coastal area (authentic experiential learning). Conversely, the study also found that coastal residents were only slightly more knowledgeable than those living in non-coastal areas, suggesting that proximity does not directly correlate with experiential engagement with coastal regions or with knowledge holding. This also suggests that there is something about visits to coastal areas that produces a more deliberate and reflective experience than merely living in proximity to the beach. The study did not indicate if the context of the coastal visit (i.e. family trip, class trip, day camp, etc), was a factor at play. This would be an interesting area for follow-up study, as it is likely that the context of the visit is significant in creating meaning about and from the experience.

PATHWAYS TO ENGAGEMENT: PROXIMITY

A study released by Mangun et al (Neighbors yet strangers: Local people's awareness of Cypress Creek National Wildlife Refuge, Southern Illinois, 2009), did show some correlation between proximity and general knowledge (i.e. name, location) about a marine protected area. However, this study also found that general knowledge did not extend to policy or resource management related knowledge, meaning that even those who possessed basic ocean science knowledge did not possess policy or resource management knowledge, and/or did not know how to connect that knowledge with environmentally oriented activities and behaviours. The researchers highlighted the need to define ocean literacy in broader terms with policy and management concepts and behaviours in mind if we are to be successful in engaging the public at the policy level.

A 2014 study by Perry et al (Coastal resident knowledge of new marine reserves in Oregon: The impact of proximity and attachment) also examined resident proximity, as a variable for knowledge holding. The study featured in Ocean & Coastal Management journal, looked specifically at proximity to marine protected areas (MPAs), and assessed knowledge holding in terms of awareness of policy and environmental issues and conservation efforts in those areas. Similar to the trans-situational conditions reported in the Steele et al study, this research looked at 'attachment', or salient emotional or identity connection to the marine reserves. The Perry et al study evaluated self-assessed and factual marine-related knowledge and found there was no difference between the knowledge of participants living proximally to the marine reserve, and those located more distally. Additionally, it found that attachment did not relate to factual knowledge but did relate positively to self-assessed knowledge. **This meant that citizens who felt a stronger connection to the MPAs, believed they had more knowledge about those areas, but did not actually possess more factual knowledge than others with less attachment. This highlights the need for a public literacy strategy that connects personal experience to knowledge building.** Encouraging the public to be involved and invested in MPA planning and management requires that public engagement be not just emotionally anchored but be anchored in a knowledge-based awareness of the relevant issues. The researchers suggest that education and awareness campaigns may not need to invest in tailored approaches to different audiences (in terms of proximity or attachment to marine areas), as knowledge levels did not differ significantly by these groups. However, this statement was based on their evaluations of knowledge holding and not on any evidence of knowledge gathering or of environmentally-conscious behaviours.

A more recent study by Frisch et al (Gauging perceptions of ocean acidification in Alaska, 2015) examined local awareness, understanding and level of concern for ocean acidification with respect to its impact on local fishing industries. Despite the regions considerable reliance on ocean-based proteins, residents in the study had low awareness of the issue (they had higher general awareness of the term ocean acidification, but practical awareness was no higher than the general population), low awareness of its potentially disproportionate economic impact on the region, and low understanding of the causes of ocean acidification. In this example, proximity did not engender greater understanding of a regionally relevant ocean sustainability issue. Level of concern for the issue was found to correlate strongly with an understanding

of how ocean acidification would influence the local seafood and fisheries industries, and the individual access to protein, but did not seem to correlate with proximity, suggesting it is issue salience, rather than proximity, that stimulates concern for an environmental issue. This highlights the need for ocean literacy communication strategies to customize and target the most salient messages regionally.

PATHWAYS TO ENGAGEMENT: SOCIAL STRATEGIES

McKenzie-Mohr's book Fostering Sustainable Behaviour: An introduction to community-based social marketing (2011) also challenges traditional attitude-behaviour change models like the knowledge-deficit model, contending that "education alone often has little or no effect upon sustainable behaviour" (p.3), and cites several research studies that support this assertion. However, this does not mean information and knowledge building are not important components of behaviour changing campaigns. McKenzie-Mohr also challenges the economic self-interest theory that contends that positioning a behaviour change in terms that relate to self- interest (i.e. financial gain/savings) is sufficient to change behaviour. According to McKenzie-Mohr, these overly simplistic theories overlook the human factors such as social interaction, cultural practices, personal priorities and feelings that collectively influence the behaviour of individuals and groups. An alternative model is community-based social marketing, which addresses internal and external barriers to behaviour change, and targets numerous strategies and communications towards mitigating these myriad barriers in order to make the behaviour more convenient or more available, and to enhance the benefits.

Sinclair and Diduck (Reconceptualizing public participation in environmental assessment as EA civics., January 2017), propose a new approach to public participation in environmental assessment, that is anchored in a new conceptual model built on a 'civics approach' for next generation participation that is oriented towards learning, incorporates engaged deliberation from an active citizen base. The environmental assessment civics approach proposes "developing common understanding through communication, adaptive learning and collaborative engagement." (p.176). This model envisages processes that are responsive to all citizens who want to engage across an entire assessment cycle that begins with communication and the sharing of common relevant knowledge, planning, and monitoring and assessing, with active participation at all stages. This article emphasizes the role for citizens at the community-based monitoring and assessment. The intention of this model is the mitigate the imbalance of power experienced by citizens in environmental assessments and provide a framework that endorses community involvement. The focus, however, is on people who choose to engage. If the biggest source of resistance to public involvement and influence over policy decision is the lack of an informed public, then this approach attempts to resolve that. This approach assumes citizens will choose to engage with an issue that is salient (by proximity, impact or interest), and will be encouraged to review the relevant information. **The limitation with this model is that opposing parties may filter through shared information and only focus on knowledge that reinforces their point of view. Or if one group controls the information, they may provide only information that leads to a desired conclusion.** These self-confirming

and information-filtering tendencies are well-documented in research on confirmation bias and perceptual screens. The information sharing part would need to be collectively populated. This might become cumbersome, as interested stakeholders overwhelm one another with information, which may unduly slow down a process, or lead individuals to filter out what they perceive to be relevant.

PATHWAYS TO ENGAGEMENT: COMMUNICATION CHANNELS

A report by Climate Change and European Marine Ecosystem Research (Climate change impacts on the Marine Environment: Research results and public perception, 2018) looked at European projects that demonstrated best practices in communicating marine climate initiatives with the public or policy makers. Successful projects featured excellent outreach both in terms of breadth and diversity (as determined by user counts). The research looked at traditional channels for reaching the public, such as expeditions, workshops, feedback and public involvement, newspapers, TV and radio, films and movies and celebrity endorsements, as well as novel outreach approaches that included social media and innovative tools, gadgets and data visualization. Their report recommended a more-effective, evidence-based approach to communicating with the public and building engagement would include exhibitions (especially traveling exhibitions) to provide experiential learning, the active involvement of the public in data collection and debate (i.e. citizen science), leveraging local or nationally recognized artists, celebrities or politicians to increase interest, prioritizing social media as the route of choice for communicating with the public, and tailoring approaches to different stakeholder groups. According to the report, this last recommendation is best achieved by establishing an advisory group comprising representatives from or knowledgeable about accessing the respective stakeholder groups. The report also highlights the importance of outreach and engagement across and throughout the program, driven by an interest in involving the public versus a requirement to do so.

The Sea Change website features several relevant reports, one of which, conducted by Bishop et al (Review of routes of engagment between citizens and Ocean Literacy's EU Sea Change Project. (2015), 2018) looked at effective routes to engagement with the public found results consistent with the CLAMER study. The Bishop et al study summarizes two research approaches that assessed strategies for engagement of the public in ocean literacy initiatives. The researchers employed a survey of key partners inquiring about the routes of engagement they use to reach the public, and a literature review of reports on engagement in informal science education. Results of the survey of key partners showed that the top 10 routes of engagement (by number of responses) were website/blogs, social media, citizen science projects, sea fairs/family days, public lectures, field trips to beaches, videos, museum exhibits, and art initiatives. According to this study, the key variables that related to public engagement were use of social media, visibility of the group, providing regular updates, leveraging other similar projects, focusing on local marine topics, working with policy and government, having personal contact with citizens, having consultation with stakeholders, interactive exhibits, and mobilizing a variety of stakeholders. These routes of engagement are purported to be effective

across a wide variety of audiences, including children, families, teachers, and policy makers. Neither this report nor the CLAMER report indicated if their metrics evaluated durability of behaviour change. This presents an interesting avenue for future study of impact.

PATHWAYS TO ENGAGEMENT: INVOLVEMENT IN POLICY DECISIONS

There are many ways in which the public can be engaged. Whether it's through educational and experiential activities, activism, or through passive (i.e. writing letters to MLAs) or more active involvement, the benefits of involvement are incontrovertible (Sinclair & Diduck, January 2017). Public participation in environmental assessment practises is another avenue for citizen engagement. The importance of public participation in these practices has been well-established, if not always well-communicated (O'Faircheallaigh C. , 2010), and effective approaches to garnering effective public participate are not well-understood (Chavez & Bernal, 2008). An article by O'Faircheallaigh (Public participation and environmental impact assessment: Purposes, implications, and lessons for public policy making., 2010), examines the various purposes for public participation in environmental impact assessments (EIA) to determine how this purpose relates to policy discourse and decision making. Purposes for pubic participation that range from sharing information, access to local knowledge, avoiding the financial and time costs of litigation, to building individual and community empowerment and ownership through participation throughout. **According to O'Faircheallaigh, it is important to have a clear vision of the purpose for public involvement to mitigate conflict arising from misaligned or competing goals (e.g. public champions vs public influencing policy decisions) and fairly assess the benefits of involvement.** Common and collective understanding of a public that comprises numerous different facets with different goals (i.e. treaty rights), and satisfaction of one goal might seem to over-ride or erase pursuit of another goal. This points to a strong recommendation to consider and plan for participation by different stakeholder groups at the community level, to understand what their goals might be, rather than putting community into a single interest and activity bucket.

PATHWAYS TO ENGAGEMENT: INFORMAL SCIENCE EDUCATION

Some researchers have focused on informal science education as a primary avenue to engaging the public. In a report by McCallie (Many experts, many audiences: Public engagement with science and informal science education, A CAISE Inquiry Group report (March 2009), 2018), the authors argue for an approach to citizen engagement that emphasizes informal science education, and mutual learning by citizens, scientists and policy makers. This approach endorses a holistic approach to building awareness and knowledge that integrates science with society and culture to deepen understanding of a shared issue and broaden participation across society. This approach to science literacy reflects, in many ways, a community of practice that involves three levels of involvement by the public:

1. receptive learning (i.e. participants learn by watching, listening, and receiving information from several sources and channels)

2. learning by interactive inquiry (i.e. participants learn by interacting with STEM-experts)
3. learning through discourse (i.e. participants are involved in debates, discussions, and group problem solving, to arrive at a common understanding or to make recommendations.

This approach to engaging the public in science-oriented issues integrates personal, community and societal values into a discourse that is anchored in and enhance by scientific knowledge. This is a model of a democratized approach to engaging regular citizens in dialogue or decisions on ocean and coastal issues. While the author does not address the metric of sustained behaviour change, it can be surmised that for individuals who engage in all three levels of involvement, some change durability may ensue due to the compounding engagement approach of the levels. Once again, this highlights the need for more research into sustained behaviour change and underscores the significance of this metric in any behaviour change initiative.

3. PATHWAYS TO ENGAGEMENT OF OTHER KEY STAKEHOLDERS (INDUSTRY, MEDIA AND GOVERNMENT)

The ocean literacy movement has principally been led by the ocean education and ocean science sectors and has therefore been largely focused on ocean science for youth. While ocean science and youth engagement are two critical components, an effective ocean literacy strategy extends to more knowledge domains and more stakeholders. The role of other key stakeholders in ocean literacy has been under-explored in research and other extant literature. Traditionally, with terrestrial environments, we have seen government and policy as the vehicles that force private industry to employ more environmentally sustainable practices.

There is not much writing available on ocean literacy initiatives that are targeted to industry or government groups specifically. If we look to literature on corporate sustainability efforts that focused more on terrestrial and air ecological issues, we see this key group has been characteristically motivated by compliance-based (Georg & Fussel, 2000), market-based (consumer demand), or value-based drivers (Post et al, 1994). Even as recently as the turn of the century, the ideological and practical implications of this approach to industry engagement have sometimes led to an insipid 'race to the bottom' (World Bank, 2001). Indeed, compliance has remained, for some industries, the most powerful prompt for corporate sustainability (Tilley, 1999; Barchard, 2006).

The know-do gap, mentioned in the previous section relating to engaging the public, has also been widely studied with respect to corporate adoption of environmentally sustainable practices (Merritt, 1998; Tilley, 1999; Perron, 2006). Studies by Merrit, Tilley, and Perron found similar results to Blake's study (1999), supporting the claim that awareness and attitude of sustainability issues are not the primary drivers of behaviour or practice change among businesses. Rather, like individuals, businesses tend to be motivated by issue salience (i.e.

how does this potentially impact public image, economic bottom line, employee identity and satisfaction, operational sustainability). Sometimes salient business issues coincide with environmental priorities, and when they do, industry is often quick to lead and find innovative solutions. But when issues are not relevant to a key business metric, it would seem that knowing the right thing to do is not always enough to motivate action. Indeed, even a positive attitude for sustainability has not always proven sufficient to produce actions and initiatives consistent with those attitudes (Naffziger et al, 2003; Biel, Dahlstrand, & Grankvist, 2006). These reports are relevant to understanding routes to engagement with industry and business, which represents a key stakeholder group in a national ocean literacy strategy. Not only is the blue economy a significant and growing contributor to Canada's GDP, but few industries or businesses don't have some reliance on the ocean across their value chain.

More recently, we have seen industry go beyond compliance to emerge as a key stakeholder or even a leader in ocean research, and in public-oriented ocean awareness and education initiatives. A report by Mabardy et al (Perception and response of the US west coast shellfish industry to ocean acidification: The voice of the canaries in the coal mine, 2015) on responses from shellfish industry participants to ocean acidification is a case in point. In the mid 2000s, an industry-led collaboration with the science community from academia and government identified a connection between ocean acidification and reduced oyster seed production. The economic impact to the industry led to initiatives to better understand the issue and predict the future impact. This report summarized a study of perceptions and understanding (i.e. knowledge holding and knowledge using) of ocean acidification of industry players. The study examined experience, understanding, concern, and adaptability, and found that half of the industry had already experienced some negative impact from ocean acidification, and as a result, had elevated levels of concern, and anticipated being more impacted by acidification in the future. The industry participants also communicated strong optimism in their ability to adapt the industry to the changing ocean. This further reinforces the concept that relevance of an issue or behaviour to a company will play an important role in getting them involved or motivating willingness to change.

The media represents another key stakeholder in an ocean management framework. A report by Compas et al (Murky waters: Media reporting of marine protected areas in South Australia, 2007) examined the media's role in informing the public about marine protected areas in South Australia. The researchers found the media tended over-utilize conflict frames, focusing their reporting on polarized stakeholder views, and were not effective at conveying the key issues that were most germane to the public, such as the significance of local marine areas, the social and economic benefits of a marine protected area, and the impact of long delays in the process to form these protected areas. While the public do tend to trust information from the media, the study found the level of reporting left the public poorly informed about the most relevant issues and the science in which those issues were grounded.

A more recent study by Voyer et al (Who cares wins: The role of local news and news sources in influencing community responses to marine protected areas, 2013) also looked the influence of media framing on the establishment of marine protected areas (MPAs) in Australia. This

study found that the media tended to highlight the ideological debate between stakeholders, framing issues around conflict (which is consistently rates at the most attractive frame to readers) rather than reporting on the issues which may share more common ground. This reduced the focus of the reporting to summarizing the debate between opposing positions, rather than providing a platform for educating the public about the broader issues between the two sides. This study found the media could readily influence public opinion about proposed MPAs, a finding that is consistent with agenda setting theory (McCombs & Shaw, 1972). According to this theory the media can influence the public's opinion about an issue, and about the importance of an issue, by the emphasis they give to certain details or positions, and by the frequency and prominence of coverage. In this way, the media can actually establish salience for an issue. Recommendations were made to provide more balanced and informative reporting, including citing a broader range of relevant sources, emphasizing the common ground and common values of the stakeholders involved. Agenda theory points to an additional recommendation to leverage the influencing powers of the media to build more collective salience of ocean sustainability issues to help facilitate public behaviour change.

A third study by Ahchong & Dodds (Anthropogenci climate change coverage in two Canadian newspapers, the Toronto Star and the Globe and Mail, from 1988 to 2007, January 2012) examined the reporting of climate change in two of Canada's national newspaper. This study found the media emphasized different sources depending on how they framed the issues. When problems and causes were reported, scientists were referenced, and when judgments and solutions were presented, government officials and other stakeholder groups were referenced. This highlights an ongoing challenge with the media that perpetuates the myth of polarized and competing stakeholder silos, rather than presenting the integrated roles of all stakeholders in presenting relevant facts and contributing to solution building, or accurately reflecting the spread of consensus of opinion among the scientific community (e.g., climate change).

These articles demonstrate that the media is a powerful public influencer. Little has been formally studied on the media's role in communicating issues relating to ocean management in Canada, or on strategies to better-equip the media with the relevant ocean literacy to enable them to more robustly frame and present the key issues. The role of the media as an essential platform for educating the public can not be over-stated. More consultation with members of Canada's news media is required to better understand how to engage the media in this essential role and invite their participation in a way that is less about framing controversial positions, and more about informing the public about the ocean.

PATHWAYS TO ENGAGEMENT: CO-OPERATIVE FRAMEWORKS

An article by Hartely & Robertson (Stakeholder engagement, cooperative fisheries research and democratic science: The case of the Northeast Consortium, 2006) examined the effects of employing a cooperative research framework to the fisheries industry in the Northeast Atlantic. **The researchers found that the cooperative research approach resulted in both scientists and industry members ('fishermen') becoming more informed, and the fishermen were more likely to accept the science as credible. Both groups became more actively involved**

in marine management and were more likely to replace formerly adversarial relationships with long lasting cooperative ones. This demonstrates how an industry engagement process can evolve into a community of practice with potentially broader application. It also provides some evidence of durability of behaviour change.

An article by Pandya (A framework for engaging diverse communities in citizen science in the US, 2012) considers how to engage groups of citizens who have been traditionally under-represented in science careers, in citizen science activities. Pandya identifies the potential link between the lack of diversity among voluntary science participants and the ensuing lack of diversity among those pursuing careers in science. Pandya identifies several barriers to participation in voluntary science activities among under-represented groups, that range from lack of access to natural areas, less formal education which can lead to feelings of intimidation in a public science-oriented dialogue, to the perception that science is not addressing the most urgent community priorities. The author suggests citizen science may be a more effective approach to engaging diverse stakeholders than traditional preparatory science activities, as it aligns well with the democratization motives for participation that many groups can relate to. Additionally, citizen science programs are generally locally and community oriented, providing access, a familiar setting, and context-relevant issue for individuals to rally around. Most citizen science projects provide participants with a common grounding in the subject knowledge and in the research process which can mitigate feelings of knowledge imbalance or marginalization among participants. According to Pandya, a general framework to encourage diverse community engagement in citizen science includes aligning the research and education with community priorities (which may include some early education on why an issue is a local priority), encourage co-management of the project (with community leaders), engage the community authentically and throughout the project, incorporate multiple kinds of knowledge, and, disseminate results widely in ways that are accessible to a broad audience, reinforcing the alignment with community priorities. Sharing the results of citizen science can deepen feelings of empowerment, accountability, and engagement with an issue. This framework is very similar to the civics approach outlined in the previous section.

Domestically we have seen other examples of academic researchers working with government, industry and communities with similar outcomes, such as Dr. Max Liboiron at Memorial University (marine plastics) or Dr. Jay Cullen at University of Victoria (citizen science program monitoring levels of Fukushima radionuclides along the BC coast in collaboration with Health Canada and local community members). BC Ferries has also engaged in citizen science – they not only let University of Victoria / Ocean Networks Canada install oceanographic instruments on their vessels, they also partnered with Parks Canada to provide an onboard naturalist program to passengers in the summer, which sometimes includes gathering oceanographic data for research use.

4. COMMUNITIES OF PRACTICE

Since the turn of the new century, environmental management projects have largely employed participatory approaches to planning, decisioning, and even monitoring and evaluation. The

participatory approach emerged out of a recognized need to balance out the heavily weighted ecological approach with a social science approach to resource management (Dalton, 2005). Different communities of practice have emerged from activities oriented around environmental management generally. These communities of practice are typically characterized by how they organize or define themselves around shared goals, collective engagement, and the internal culture that develops around rules and interactions and involvement.

PARTICIPATORY MODELS

Reed (Stakeholder participation for environmental management: A literature review., 2008) provides a detailed literature review of other participatory approaches to environmental management. This report highlights several normative benefits of participation, including democratized processes for resources that impact the public, increased trust in and compliance with decisions, and active, empowered citizenship, and pragmatic benefits such as the quality and durability of decisions. Reed also identifies some of the potential drawbacks with a participatory model, including consultation fatigue, dysfunctional consensus which can arise from inauthentic empowerment, and delayed action that results from decision by committee. Additionally, involving stakeholders who don't possess the knowledge or expertise to meaningfully participate in an information sharing and decisioning process, can risk the credibility of that stakeholder group, and of the participatory process overall. According to Reed, more comprehensive input into decision making arises from a participatory process can lead to improved quality of environmental decisions, as long as the process leading to those decisions has been genuinely participatory. Eight features for a best practice participatory process are identified:

1. guiding philosophy of empowerment, equity, trust and learning
2. early involvement of all stakeholders
3. employ stakeholder analysis to ensure the appropriate groups and individuals are included
4. clear objectives for the participatory process must be articulated and agreed upon by all stakeholders
5. determine a method for participation and engagement
6. employ highly skilled facilitation
7. integrate local and scientific knowledge
8. institutionalize participation to mitigate many of the potential drawbacks to participation.

A report by Schroedinger et al (From the principles to the scope and sequence: A brief history of the ocean literacy campaign., March 2010), the authors track the response, in terms of activities and outcomes of the ocean literacy campaign in the United States, specifically with an ocean science lens. This report summarizing the essential principles and the scope and sequence that are intended to inform ocean literacy activities in the k-12 public education

system. This report highlights the collaborative and unmandated efforts of numerous groups and organizations, including the College of Exploration, the National Geographic Society, and subsequently, the Centre for Ocean Sciences Education Excellence, the National COSEE Network (Centre for Ocean Sciences Education Excellence), the National Marine Educators Association (NMEA) and the National Oceanic and Atmospheric Administration (NOAA). Schroedinger et al offer a compelling summary of the inclusive, transparent, democratic and iterative process that was applied to developing these resources through online participation. The authors describe a participatory community of practice that evolved from relentlessly pursuit of collaborative effort.

Halversen & Tran identify in their report (Scientist and Educator Partnerships and Ocean Literacy: Creating a new community of practice, March 2010) the numerous ways in which the 'new community of practice' that emerged while developing the ocean literacy campaign in the United States parallels the participatory approaches summarized by Reed (Reed, 2008) Central to this report is the conveyance of how application of a participatory model morphed into a new community of practice, and the authors' endorsements to re-employ this approach with other future activities related to the ocean literacy campaign. This paper concludes with some recommendations for building strong partnerships that are essential to this community of practice. **Many of these recommendations mirror 'principles' outlined by other researchers but emphasize the importance of knowledge as an asset to be shared, cultivated, and revised by all members of the community.** It also expands on the concepts of respect and open dialogue to recognize distributed expertise.

A report by Luyet et al (A framework to implement stakeholder participation in environmental projects, November 2012) provides another comprehensive framework for stakeholder engagement is presented and illustrated with a river restoration case study from Switzerland. The authors begin their report by providing a definition for participation, to emphasize stakeholder influence and shared control over initiatives, decisions and resources that affect them. This establishes both the active involvement of stakeholders, and the cognitive, social and affective attachment that stakeholders have to the issues and the outcomes of participation. **This report identifies similar principles for effective participation already outlined in the paragraphs above but also includes adequate resources (including time) as a key principle.** This report also breaks down the stakeholder analysis into more detail, outlining critical steps to identify, characterize (i.e. attitudes, interest, access to resources, expertise, influence, power), and structuring (i.e. determining how and when each stakeholder will be involved and degree of involvement). This report also highlights the importance of evaluating stakeholder participation, and generally separates them into three groups: those related to the process, those related to the outcomes, and those linked to the political, social, cultural, or historical context.

The newly establish Oceans Research in Canada Alliance (Oceans Research in Canada Alliance (ORCA), 2018) is a community of practice comprising Canada's ocean science and technology community from academia, government and industry, as well as from NGOs and Indigenous groups. Initiated in 2016 by the Department of Fisheries and Oceans, the alliance was formed

to improve coordination of research efforts and investments across this community. At its first workshop in February 2017, the alliance identified key challenges, policy proposals, and barriers to progress, and established five recommended initiatives summarized in a report (ORCA, February 2017). Among the key questions being addressed at the upcoming 2018 ORCA workshop: How do we increase public awareness about the importance of healthy oceans?

ECO-SYSTEM-BASED MANAGEMENT (EBM)

An article in the Marine Policy journal (Byron, Bengtson, Costa-Pierce, & Calann, May 2011) examined ecosystem-based management (EBM) of coastal aquaculture industries. The researchers found EBM approaches often fell short, resulting in misuse of resources and user conflict. The article advocates for a new framework for communication and collaboration between scientists and other stakeholders to enhance sustainability of the marine environment and of the aquaculture industry. **A key insight from this framework is the inclusion of human beings, with their socio-economic needs, in the ecosystem and the EBM process.** Where the current definition of ocean literacy does emphasize our impact on the ocean and the ocean's impact on us, the EBM framework explicitly highlights the economic reliance of people on the ocean's resources, and central to this paradigm, the continuing reliance and exploitation of those resources. By incorporating science into the decision making and management processes, this framework integrates economy with ecology and sustainability rather than polarizing them, which offers an accessible starting point for ocean management in Canada. **The primary gap to effective implementation of EBM is identified as poor communication between the science community and industry, which often results in the failure to integrate the science into practice.** The researchers identify four criteria that improve stakeholder engagement in the EBM process that would transfer across other communities of practice:

1. stakeholders involved in the decision process should be representative of the stakeholders utilizing the marine environment or resources
2. stakeholder processes should be unbiased
3. stakeholders should be involved early and have influence over final decisions
4. the stakeholder process should be objective and transparent.

Other stakeholder engagement projects, such as the cooperative research that occurred in the fisheries industry in the United States (Hartley & Robertson, 2006), have shown that when these criteria are met, the science is more readily accepted and used to inform resource management decisions.

SOCIAL INNOVATION MODELS

The participatory framework has evolved in recent years into social innovation models that are built on the same roots of inviting citizens to exercise their rights in a democracy to actively

participate with a common social mission (Davies, What is citizen engagement in social innovation?, 2018). The rationale for citizen engagement in social innovation models is built on a series of principles and assumptions:

- that engagement helps to better understand social needs
- that citizens may possess unique and relevant knowledge to be the source of innovation
- engaging citizens introduces divergent thinking that can lead to novel solutions
- engagement builds legitimacy of decisions
- citizen involvement is essential in helping to address complex problems that may not have clear solutions or end points.

Sea Change employs an approach to stakeholder engagement called Social Innovation Participation Process (SIPP), to engage various audiences in different programs and initiatives. The SIPP process was not well detailed in the report by Bishop et al (Review of routes of engagment between citizens and Ocean Literacy's EU Sea Change Project. (2015), 2018), but seemed to draw on the same principles of social innovation for citizen engagement practiced in other contexts (European Social Innovation Research, 2018) and outlined above by Davies. What appears to distinguish SIPP from the more common concept of citizen action is that the innovation activity is driven by a social enterprise or development agency and not by a traditional institution or government body.

5. INDIGENOUS PERSPECTIVES ON OCEAN LITERACY

In an article by Craig Strang (Education for ocean literacy and sustainability: Learning from Elders, Listening to Youth, 2008), the author identifies a limitation in the United States' efforts to promote ocean literacy that arises from the fact that much of the work done to date represents the perspectives of a relatively narrow cross-section of society with notable gaps in traditional knowledge and Indigenous viewpoints. A unifying framework for Canada, that truly reflects all Canadians, will require strong involvement and co-leadership of Canada's Indigenous communities.

INDIGENOUS PEDAGOGY

An article by Leanne Simpson (Indigenous environmental education for cultural survival, Spring 2002), the Director of Indigenous Environmental Studies program at Trent University, provides a starting point for understanding Indigenous perspectives on ocean literacy. Her article outlines necessary components of Indigenous pedagogy for successful programs promoting Indigenous knowledge, and necessary components for integrating Western science into Indigenous environmental education programs. According to Simpson, the necessary elements include:

- Involvement of Elders as experts, as keepers of tradition and guardians of culture.

Elders should be involved throughout program development and instruction.

- Grounding programs in Indigenous philosophies of education. This is described as a wholistic approach to education that incorporates emotional, intellectual, physical and spiritual realms that are tailored to the individual learner with flexible teaching and learning and periods of reflection. This philosophy is often difficult to apply within the established model of post-secondary education where methodologies tend to be more linear, time-bound, and off-the-shelf.
- Utilize Indigenous ways of teaching and learning, which reinforces the concept that Indigenous knowledge is not only content but also process. These teaching and learning processes may involve ceremonies, visioning, dreams, storytelling, observing, doing, reflecting and creating. This also includes anchoring the curriculum in Indigenous content.
- Incorporate Indigenous language. The author describes Indigenous languages as "the basic repositories of Aboriginal worldviews and thus contain within their grammatical structures the values and teachings of the people that construct them" (p.18). Words themselves can convey such depth of meaning, values and comprehension that it is difficult to communicate traditional knowledge without the traditional language. This too poses a challenge in conventional education programs that prioritize education in Canada's two official languages.
- Connect to the land (or in the case of ocean literacy, to the ocean or the coast), by having opportunities to provide instruction, opportunities for reflection and connection at spiritual, intellectual, emotional and physical levels outside of the classroom.
- Making a space for resistance involves encouraging learners to consider how they can protect land, culture and knowledge, and how their ancestors have done so before them.

Simpson provides some insights into how Indigenous worldviews differ from the Western philosophies. An ocean literacy framework that is genuinely co-developed with Indigenous leaders will need to reflect both Western and traditional pedagogies.

A very recent study, published in the Journal of Cognition & Development (Children's Play with a Forest Diorama as a Window into Ecological Cognition, 2017) and profiled in the April 2018 edition of Scientific American, investigated how young, rural, Native American children understand the natural world in comparison with their Native and non-Native peers from urban settings. The study found that all three cohorts of children, but especially the Indigenous youth from rural settings, were more likely to enact realistic than imaginative scenarios with toy animals when they were presented in a realistic setting (i.e. a diorama) rather than an imaginary setting. The Indigenous children also tended to assign them animal qualities (i.e. realistic) rather than human qualities (i.e. anthropomorphism) and were much more verbal and talkative during their play. Indigenous research assistants explained that the Indigenous way of knowing the natural environment made it difficult for rural Native children to make sense of

animals when divorced from their ecological contexts. This study provides a great example of how ways of knowing are well-inculcated among Indigenous people from a young age, and how this should inform approaches to teaching and learning.

TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK)

In a Masters thesis, Schlagg (Engaging Inuvialuit youth in oceans stewardship: A proposed strategy., February 24, 2004), argues there is a great opportunity to involve Inuvialuit youth in ocean stewardship activities that is being missed due to limited opportunities to invite their involvement. Schlagg identifies how traditional ecological knowledge (TEK) reflects the Inuvialuit connection with the land and ocean, and the relationship that exists between land, ocean, resources, and culture. Her report outlines a strategy for youth engagement in stewardship activities that recommends combining traditional ecological knowledge (TEK) that is passed along through their communities, with formal science education to build connection and engagement. Schlagg proposes a comprehensive strategy for engagement that relies on youth, community Elders and mentors, the formal school system, industry, and government agencies, each with a role to play in raising awareness, providing resources and support to facilitate involvement, sharing traditional and formal knowledge, and presenting stewardship opportunities for youth. According to Schlagg, stewardship of the Earth's resources has long been common practice among Canada's Indigenous people. Balance, respect for, and connection to the environment are central concepts in most Indigenous communities (Kamljit, Sangha, Le Brocque, Costanze, & Cadet, Ecosystems and Indigenous well-being: An integrated framework July 2015). The urgency for elevating youth involvement in ocean stewardship, Schlagg contends, lies in the relative separation many Indigenous youth have experienced due to fewer opportunities to develop their TEK as formal education competes for their time. Industrial development is occurring and will be ramping up in marine and coastal areas, which adds to the urgency to consult with and engage this key stakeholder group.

An article by Leonard et al (The role of culture and traditional knowledge in climate change adaptation: Insights from East Kimberley, Australia, 2013), the researchers investigated how traditional ecological knowledge (TEK) plays a role in the understanding of climate change and how it may influence future decision making and the acceptability of regional adaptation responses. This article explores how different knowledge frameworks are connected to values and beliefs that shape perceptions of different responses and of preferred responses. **The researchers also highlight the fact that there is significant alignment between scientific and indigenous concerns, and that early involvement helped to identify common ground.**

INDIGENOUS INVOLVEMENT IN ENVIRONMENTAL ASSESSMENTS AND POLICY DEVELOPMENT

As we create a national ocean literacy strategy in partnership with Canada's Indigenous communities, it's important to understand how they have been involved in the past, how engagement has been established or leveraged, and how Indigenous knowledge has been

applied. The journal article by O'Faircheallaigh (Environmental agreements, EIA follow-up and aboriginal participation in environmental management: The Canadian experience., May 2007) looks at the utility of environmental assessments in promoting Indigenous participation in environmental management of major resource projects in several jurisdictions across Canada. The historic exclusion of Indigenous groups from this process on ancestral lands has been well-established (Galbraith, 2005) (O'Faircheallaigh & Corbett, 2005). O'Faircheallaigh argues that effective Indigenous participation will require meaningful and substantial involvement in the environmental assessment process from the beginning and throughout the management process. This point of view has received broad international support, by Nakamura (Nakamura, 2008), whose report summarized the first attempt to implement a site investigation to preserve an ethnic culture (the Ainu) in relation to construction of a dam in their region. This report details the successful involvement of Indigenous people in the development of a cultural impact study through early and ongoing participation, and Hanna et al (Hanna, Vanclay, Landon, & Arts, 2014), whose research into Indigenous involvement in several Brazilian resource projects also called for the early and active participation in all stages of project planning.

O'Faircheallaigh emphasizes the added benefit to more enduring engagement, is improved environment impact assessment follow-up. Without well-established institutional structures, management processes, and ongoing follow-up, the relevant environmental assessment activities are rarely sustained (Morrison-Saunders & Arts, 2005). According to O'Faircheallaigh, Indigenous ways of knowing and managing the environment are inherently orientated towards adaptive environmental management already, the custodial function of ongoing environmental impact assessments can be well-championed or enacted by participating Indigenous stakeholders. O'Faircheallaigh proposes a framework of requirements for Indigenous involvement that includes:

- drafting goals, purpose and mandate of the environmental assessment that requires Indigenous involvement;
- establishing structures and decisioning processes that support Indigenous involvement;
- an agreement to provide resources (financial or other) to support Indigenous participation; agreements to assist Indigenous groups in gaining the relevant basic scientific knowledge needed to contribute to the discourse and decision making;
- establish processes and protocols that reflect Indigenous values;
- and formal recognition of Indigenous knowledge and perspectives on the environment or region in question.

Udofia et al (Meaningful and efficient? Enduring challenges to Aboriginal participation in environmental assessment., July 2017) provides an updated assessment of Indigenous involvement in environmental assessment processes, that identifies ongoing and newly understood barriers to participation by Indigenous groups. These include systemic challenges relating to late involvement in the participation processes, limited financial resources to

support participation, limited influence in decision making and over project outcomes, failure to prioritize relationship building, especially by Governments, and the lack of opportunity for sustained involvement. The authors also identify participation fatigue in development intense regions. The authors also identify key benefits to Indigenous involvement, such as improved project design and solution options, and heightened legitimacy of findings and mitigation strategies. Where most environmental assessment projects have become more streamlined and rigidly timebound, it is often difficult to balance meaningfulness with efficiency, as essential elements of Indigenous involvement, such as relationship building and knowledge sharing, unequivocally take time. The study uncovered other challenges to meaningful and efficient involvement that related to the documentation (or rather lack of documentation) of Indigenous knowledge which limited the efficient sharing of Indigenous knowledge. According to the researchers, the challenges with knowledge sharing and limited up-front relationship building are well-understood by key stakeholders, but still not well-responded to, often due to lack of agreement about whose role it is to initiate contact or share information. These highlight ostensibly easy fixes with earlier involvement and agreement on roles and responsibilities throughout (and beyond) a project's official timelines.

INDIGENOUS ENVIRONMENTAL CURRICULA

A teaching guide has been developed in British Columbia to support science education in Indigenous communities and schools, with an emphasis on links to Indigenous knowledge. The "Science First Peoples Teacher Resource Guide -Grades 5-9 (FNESC, 2018). This teaching resource includes a chapter on Ocean Connections. This document aims to 'incorporate unappropriated First People's perspectives into Science courses' (FNESC, 2018, p. 4). The guide is intended for both Indigenous and public schools and provides guidance on recognizing and integrating Indigenous perspectives into science inquiry. This document corresponds with the Big Ideas and Learning Standards outlined in the British Columbia provincial science curriculum. The section on Ocean Connections begins with the Seven Essential Principles of Ocean Sciences, which correspond with the seven essential ocean literacy principles of ocean science (U.S. grade K-12). The guide focuses largely on life-sciences concepts but makes the consistent connection between knowing and practice (i.e. how does this knowledge and understanding of the ocean affect harvesting practices) to embed the application of scientific knowledge and a mindset of continuous reflection on impact on the environment around us. The guide also provides cross-curricular links to social studies.

CANADIAN COLLABORATIONS

We are seeing more effective collaborations between and among industry, government and Indigenous communities. One example is the Northern Marine Transportation Corridors Initiative, consisting of Transport Canada, Department of Fisheries and Oceans, the Coast Guard, and Indigenous communities, which is working to establish marine commercial traffic corridors in the Arctic. Projects include identifying where to prioritize bathymetry mapping and the locations of emergency response coast guard facilities. Dr. Jackie Dawson (University

of Ottawa) and her students are working with Indigenous communities to identify marine areas of importance to these communities so the corridors are not directed through them, and to ensure the needs and locations of these communities are also factored into decisions about the locations of any new emergency response stations or facilities.

An ongoing consideration is that Indigenous communities may have different ways of conceptualizing the ocean that do not fit neatly into a scientific framework (Genz, et al., 2009). As well, there is no one unifying mechanism or language for Indigenous groups across Canada and there may be a wide variation in ways of knowing between Indigenous communities. What is common, however, is the importance of honouring that knowledge with a best-fit model for co-development of ocean engagement, remediation or assessment strategies.

6. OCEAN EDUCATION: FORMAL AND INFORMAL

When national science education standards were published in 1996 in the United States, there was almost no mention of ocean topics (Strang C. , 2008). A review of science curricula across Canada's provinces and territories reveals similar findings (Scully, 2016). Various reports have highlighted gaps in ocean science in public school education, and in informal learning and awareness programs for the public, highlighting a systemic challenge that has resulted in generations of citizens not being educated in ocean sciences, or not even having an opportunity to cultivate curiosity about the mysteries of the ocean.

Strang (Education for ocean literacy and sustainability: Learning from Elders, Listening to Youth, 2008) expresses the goal of ocean literacy as, "To become the underpinning of a system of education that leads to sustainability", and "the body of knowledge representing what we think every person should know about the ocean," (p.7) by the end of high school. It has been well-established that the key and common objective of international ocean literacy strategies is to address complex ocean and coastal issues by way of an informed and engaged public. (UNESCO, 2018; DFO, 2018; CLAMER, 2018; Perry, Needham, Cramer, & Rosenberger, 2014; Strang C., 2008; Reed, 2008; Hoffman & Barstow, 2007; Grace & Ratcliffe, 2002). This is rooted in the assumption that awareness will lead to engagement in, and support for, ocean restoration and sustainability initiatives. However, this approach exempts the adult population from an obligation, or an opportunity, to become ocean-informed. As a result, it fails to recognize the collaborative impact of an ocean literacy strategy that relies on both formal and informal education and awareness initiatives targeting broad audiences.

IN-CLASS EDUCATION

The PEW Commission report (America's Living Oceans: Charting a course for sea change., May 2003) became a call to action across the United States, highlighting the current state of harm, the challenges of fractured policy, and society's reliance on ocean resources. Among the numerous recommendations from the report, was the need for a new era of ocean literacy, with

regular citizens at the centre (nationally), and with collaborative approaches, internationally. In the absence of provincial or national curricula on oceans in Canada, several Government and NGOs have developed public outreach and education resources and programs that are made available to educators and the public. As an example, the Department of Fisheries and Oceans has developed an ocean literacy curriculum that is available through their website (K-12 Education: Stream to Sea, 2018). The program and resources are focused on science education and features a summary of the education strategy, links to teaching curricula and classroom resources, and connections to education coordinators. The site advocates for an ecosystem approach to education that emphasises the interconnectedness of marine and terrestrial life that is intended to advance a mindset for stewardship and sustainability. The focus is on ensuring teachers are well-informed and possess current knowledge of life sciences as they relate to water systems in Canada. The curriculum focuses on Western Canadian waterways and coasts. A recommendation for future research is to examine the utility of these resources (i.e. are they being used by educators) as well as the efficacy and impact of the curriculum on student ocean-positive attitudes, behaviours and activities.

A recent, relevant, and award winning doctoral theses by Simms (Bringing environmental identity research into the classroom context, PhD. Thesis, 2017) was inspired by the failure of current science curricula to promote and translate classroom learning into active stewardship outside of the classroom. The author investigated identity theory for insights into cultivating environmental identities in youth through classroom learning. The study discovered several dimensions of student environmental identity which included; awareness of environmental threat, emotion and personal meaning of that threat, recognition of individuals and social opportunities for environmental action – especially with peer groups, perceived individual agency, and behaviour change across a social context. These concepts correspond with the pathways to engagement explored in Section 2, including, knowledge building and holding, efficacy, and personal and community relevance of an issue, but emphasize the importance of social contexts to promote, express, and reinforce environmental identity. This suggests another pathway to engagement with youth that should receive further study.

CITIZEN SCIENCE

While the public-school system is an obvious channel for cultivating the ocean literacy skills, knowledge and attitudes of the next generation, there is an opportunity to augment that learning and reach broader audiences nationally with informal learning initiatives. Citizen science (The European Marine Board “Advancing Citizen Science” report, 2018), or participatory action research, is a growing approach to connecting the public and the scientific communities around shared, and usually local, science issues. Citizen science is a way of increasing the number of people involved in science research, with key contributions being the opportunity to provide local data collection resources that might not otherwise be feasible in a private study. With citizens actively sampling and running tests, citizen science can also be a useful way to overcome public distrust or misconceptions and build faith in the credibility of scientific findings. Citizen science has long been identified as an effective way to promote

a more science literate and engaged public. Several researchers recognize citizen science as a paradigm for a collaborative approach to tackling broad and complex issues that fall into the socio-scientific categories.

An article (Citizen science programs advance the public understanding of science, 2018) by CAISE (Centre for Advancement of Informal Science Education) examines the impact of citizen science programs in terms of improving participant understanding of science concepts and research processes, attitudes towards science, skills for conducting science, and interest in science careers. According to CAISE, the citizen science projects studied did seem to deepen knowledge about the specific research subject but did not transfer more broadly to other science areas, or to an understanding of how researchers use the data collected. Also, they found that increased subject specific knowledge did not influence attitudes about the environment or science more generally. It would seem that the expected link between knowledge improvement and engagement in a broader issue was not occurring as expected. The study did not assess impact on behaviours. The projects reported in this study involved research on birds in their habitats and did not explore marine or coastal subjects.

A contrasting study by Ballard, Dixon & Harris (Youth-focused citizen science: Examining the role of environmental science learning and agency for conservation, April 2017) looked at community and citizen science programs (CCS) in coastal management and stream restoration projects. The study examined impact on conservation projects (i.e. contribution to the project with data or activities) as well as impact on environmental science agency (ESA) which is a combination of understanding of environmental science as well as efficacy or belief in the capacity to act on that knowledge in support of an environmental cause. Findings showed that youth did have an impact and did develop agency through their CCS experiences when certain conditions were in place, including having long-term CCS experiences and having repeated experiences to build connections to a place or issue, and having a chance to explicitly contribute to authentic research. It is important to note that the study did not provide any long-term metrics around the impact of these activities on sustained behaviour change, which is important to assess as behavioural intent does not necessarily equate to behavioural action. The true impact of an effective environmental behaviour change initiative is reflected not in one-time behaviour change, but rather in ongoing, voluntary, self-directed and self-sustained behaviour change.

Another report by McKinley et al (Citizen science can improve conservation science, natural resource management, and environmental protection, April 2017) found evidence that citizen science programs can build involvement in conservation efforts by building scientific knowledge, which deepens awareness of the issues and builds capacity to participate in a knowledgeable dialogue about the issue. The report calls for greater investment in citizen science programs, especially in data collection toolkits for the public. With so many citizens enjoying marine, coastal and freshwater systems with private leisure-craft, the potential to deploy vast resources of citizen scientists to help with data collection is an obvious benefit. What is not clear from this study is the direction of the relationship between scientific

knowledge-building and participation. It may be that involvement in citizen-science, irrespective of knowledge building, engenders greater participation in issue debates and behaviour change because of the sense of agency, connection or concern that develops from 'getting your hands wet'. It may also be more related to frequency of interactions with a marine environment through citizen science, which has been established as a factor in knowledge building (Steel B. S., July 2006; Eleiton, Corless, & Hynes, 2015).

DIGITAL CHANNELS FOR EDUCATION

Other researchers are exploring digital channels for reaching youth with socio-scientific issues. Greenhow et al (Re-thinking scientific literacy out-of-school: Arguing science issues in a niche Facebook application, 2015) explore how social network sites (SNSs) and computer-supported collaborative learning (CSCL) theories can help bridge formal and informal learning, develop science literacy, argumentation skills, and build engagement in socio-scientific issues (SSIs). The researchers highlight the established efficacy of argumentation of SSIs for learning science – especially with youth. Correspondingly, computer-supported collaborative learning has been shown to be effective in supporting informal learning among this age group. Combining these theories, the researchers examined the extent to which young people are able to develop argumentation skills (i.e. constructing a sound argument) and social co-construction skills (i.e. drawing on contributions of others) and deepen participation in an argument, when given an opportunity to participate in a digital dialogue. These represent key 21st century skills that will be essential within future workplaces and for engagement in current affairs and democratic processes. The study found that SNS can provide channels to engage youth in socio-scientific issues, but co-construction argumentation is limited by the engagement and knowledge levels of other participants. This means that if other participants are able to contribute diverse expertise, knowledge and perspectives that contribute to the dialogue, that this channel can be effective. A related study (Fauville, Dupont, von Thun, & Lundin, 2015) found that social networks can be an effective tool for ocean researchers to reach the public and share recent findings, but that not all social media tools are effective at building interaction, dialogue and participation from and between users.

On the practical side, we have seen numerous responses to filling the gap in ocean literacy curricula and resources. EMMA (European Multiple MOOC Aggregator) (EMMA, 2018) has released an ocean literacy MOOC (massive open online course) for teachers in multiple European languages, supported by Sea Change and UNESCO. Sea Change provides open-access to resources on their own website (http://www.seachangeproject.eu/resources#audience=educators), with a broad range of classroom resources, teaching modules, and background research. The Ocean Literacy for All Toolkit is available online (http://unesdoc.unesco.org/images/0026/002607/260721E.pdf) and provides a detailed overview of the ocean literacy principles, and outlines key players in the ocean literacy movement internationally, and many of the best practices and activities happening globally.

At home, the Canadian Network for Ocean Education (CaNOE, http://oceanliteracy.ca)

connects a national network of key players and individuals involved in public or educational outreach, and regional programs and initiatives. CaNOE also circulates a monthly Splashmail magazine and has on-line video content https://www.youtube.com/channel/UCL8XbsiqbRwT2zF5tqzOkoQ available to members and the public. The Institute for Ocean Research Enterprise website (iore.ca) hosts educational resources and research developed by the Marine People Partnership, with a focus on cultivating current and future workforce across the broader marine industries through ocean literacy. Other experiential ocean programs for youth are offered through Universities across the country, and through not-for-profit groups like Nova Scotia Sea School (http://www.seaschool.org/)which offers profound outdoor adventure and leadership experiences for youth and adults, oriented around ocean and coastal contexts.

7. OCEAN LITERACY – AN INTEGRATED APPROACH TO SCIENCE EDUCATION

Contemporary ocean literacy efforts are built on the premise that a more informed public, holding more relevant scientific knowledge, will make more ocean positive decisions and behaviours. **Advocates for an integrated approach to ocean literacy argue that it is imperative that stakeholders not only contribute and build their scientific knowledge base to enable their participation in debate and decision making, but also that they have insights into their personal and social barriers to behaviour change, their current values, attitudes and behaviours, and their propensity to contribute to co-created and co-delivered actions (Kania & Kramer, Winter 2011).** A study by Grace and Ratcliffe, (The science and values that young peole draw upon to make decisions about biological conservation issues, 2002), explores this premise to determine the extent to which scientific knowledge informs decision making about an environmental issue. The authors contend that nature conservation is not universally informed by scientific principles, and identify other paradigms where factors such as cultural, aesthetic or utilitarian are more relevant to deciding conservation priorities in some communities or networks. When nature conservation is exclusively wedded to science, this leaves little room for public engagement, involvement, and ownership of sustainability activities. These are not contemporary paradigms. Nearly a quarter of century ago, the UK Government published national action plans for sustainable development, which highlighted the importance of making decisions based on a combination of scientific information, and personal and community values.

In the Grace & Ratcliffe study, the researchers investigated the extent to which students, teachers, and experts draw on scientific knowledge and personal values in their decision making about environmental issues. Participants were given a decision-making framework and partook in two decision-making activities involving endangered species. The study found that students used both scientific concepts and personal values in making decisions — but far more weight was given to their values. Teachers regarded some scientific concepts, such as ecology concepts, as more important than other general science concepts. The researchers suggest this

would likely influence their approach to teaching conservation as a stand-alone science concept rather than an integrated one. The study also found that experts tended to rely almost entirely on complex biological concepts but found those same relevant concepts were not successfully integrated into practical decision making by non-experts. This study is relevant to the ocean literacy framework, as it demonstrated that for all groups, there is a need to 'add depth and balance to discussions', and incorporate values into conservation education, to deepen the understanding as well as the connection to the issue. **This also demonstrated that, while scientific knowledge is essential, that we need to ensure that we are educating the public in a way that makes that knowledge accessible and easy to apply to discussions, debates, and decision making. Without this, the public and the scientific community will continue to be polarized by their points of reference on an issue.** A limitation of this study is that it seems to be assessing intent and not actual behaviour change.

Sadler (Informal reasoning regarding socio-scientific issues: A critical review of research, 2004) was also interested in understanding how people leverage fact and feeling in decision-making about environmental issues. This study examined social issues that have strong conceptual or technological ties to scientific factors, calling socio-scientific issues (such as cloning, global warming, alternative energy). These topics differ from other science concepts insofar as they have a high degree of societal interest, cause or consequent, and thus an approach to reasoning should integrate science, technology and society (STS). They also tend to be open-ended, debatable, complex, lacking clear-cut solutions, or poorly constructed. These features render these topics open to a complex interplay between formal (i.e. objective, logical with derivative conclusions) and informal (i.e. subjective perceptions, inference, with inductive conclusions or numerous supporting or competing conclusions) reasoning. In this study, Sadler reviewed evaluation processes regarding socio-scientific issues and found that approaches to analysis used by most individuals tend to be shallow and inconsistent, meaning that most individuals failed to asses the usefulness of information related to a complex issue. This calls into question the efficacy of an ocean literacy paradigm that is knowledge focused. As Sadler's research suggests, even with relevant facts available, and with an awareness of the need to evaluate that information, many individuals lacked the skills to do so. **This points to a critical step in an ocean literacy curriculum, to go beyond promoting conceptual understanding of ocean science knowledge, to also build an understanding of how to recognize and evaluate data and valid sources of scientific and traditional knowledge, and how to apply it to decision making.** The studies reviewed also highlighted the benefit of a curriculum or campaign with direct instruction on how to deal with contradictory evidence, how to form a counterargument, and why it is important to seek or provide justification for a claim. This approach fits well with shifts across the Canadian public-school systems towards a competency-based pedagogy that focuses more on 21st century competencies (Ananiadou, December 2009) i.e. problem solving, critical thinking and communication, rather than on traditional fact-based learning.

Other studies examined by Sadler have also shown that reasoning does not necessarily improve with elevated knowledge levels. Zohar & Nemet (Fostering students' knowledge and argumentation skills through dilemmas in human genetics, 2002) proposed that this phenomenon occurs as the result of individuals applying the filters of personal experiences and

values which seem to mediate scientific knowledge. Studies also found that when individuals were able to integrate personal and scientific knowledge, that they tended to be more engaged in the topic. This suggests that an ocean literacy campaign should select local issues in order to make the science more relevant, and to ensure the public feels more connected to the issue. Several of the studies cited in Sadler's work examined student learning transfer and application to socio-scientific issues that may have seemed less relevant or urgent to the learners (i.e. cloning). It would be interesting to examine learning transfer and integration of scientific and personal knowledge on issues relating to marine and coastal areas, particularly regional or locally relevant issues to determine if the same argumentation skills are applied.

It has been proposed in the studies above that objective scientific knowledge alone is insufficient for developing an ocean literate public. Lambert (High school marine science and scientific literacy: The promise of an integrated science course, 2006) composed a descriptive study that compares existing high school marine science curricula and the instructional practices of different teachers with the students' levels of scientific literacy. Students whose teachers integrated the sciences into an ocean curriculum (i.e. biology, chemistry, geology, physical sciences), demonstrated higher content knowledge than students whose teachers chose a non-integrative approach to teaching science. The integrated approaches mimicked a well-known instructional approach known as STS (Science-technology-society), which emphasises science and technology instruction through inquiry-based learning, with investigation of real-world issues. According to Lambert, "Marine science is one area of study that meets the requirements for a broadly inclusive integrated science course that can offer a common theme or context for an entire academic year". Key benefits of this approach are that it develops essential analysis skills that are needed to connect science concepts to an understanding of real-world impact and stewardship activities. This is built on a constructivist approach to teaching and learning, which emphasizes active participation of the learner, and knowledge building over knowledge transmission. Lambert concludes that marine sciences courses lend themselves to an instructional approach that integrates multiples sciences around relevant ocean issues that society is facing.

Schoedinger et al (The need for ocean literacy in the classroom, 2006), presented an argument more than a decade ago for ocean literacy in the classroom, citing education standards as lacking and not producing young citizens with a sound understanding the importance of the ocean in their daily lives. This article also drew the link between knowledge of ocean sciences and the basic ability to make sound decisions on matters relating to sustainability. The authors summarized efforts to incorporate the scope and sequence for ocean literacy, which at the time was newly drafted. Presently in Canada, ocean issues are not well-integrated into current provincial / territorial curricula. With the movement in curricular revisions, towards 'big ideas', there is an opportunity to provide resources that support teachers in planning their approach to instruction of these big ideas within an ocean context. Several teacher development initiatives organized by the Marine People Partnership have provided this type of professional development to teachers. These programs have gone beyond integrating the ocean into science instruction, to demonstrate how concepts relating to ocean ecology, ocean economy, and ocean careers, can be integrated into teaching of earth systems, energy, and optics, while also

connecting these concepts to culture, society and traditional knowledge.

In an article by Strang, Decharon, & Schoedinger (Can you be science literate without being ocean literate?, 2007), the researchers argue that because the ocean is so interconnected to all other systems on the planet, that one can not be said to be science literate without a good grounding in ocean science. Sparked in large part by the Pew Oceans Commission report (PEW, May 2003), a national ocean literacy campaign was launched to link people to marine environments, through education and awareness. A key outcome of the ocean literacy campaign has been to change the way that educators think about ocean education – that it comprises essential learning for basic scientific literacy. According to the authors, the principles of ocean literacy that have been broadly adopted are now influencing formal curricular materials, and informal programs, through museum and aquarium exhibits, and guiding the priorities of major funding agencies such as NOAA and the National Science Foundation. Strang et al give recognition to the efforts of the national COSEE Network (established in 2002) and the National Marine Educators Association (NMEA) in accelerating the national ocean literacy campaign across the United States.

The study by Hoffman and Barstow (Revolutionizing earth system science education for the 21st century: Report and recommendations from a 50-state analysis of earth science education standards, 2007) examines earth science education in the public school system to establish a baseline of which earth science concepts are well-covered and which are not. It espouses a '21st century' view on earth sciences that elevates it in status among other science domains which tend to be emphasised and assigned higher status. This study is motivated by an espoused need to align pressing environmental needs that are impacting society, with current levels of understanding and practice. The study found there is great variation in how earth science concepts are taught across the United States, as well as how modern earth science perspectives are incorporated into curricula. The study also found that the ocean literacy principles established in 2005 were not reflected in the science standards for most states.

Overall, the researchers concluded that there is a "disconnect between the pressing need for an Earth system literate society and the current K-12 education system that is responsible for developing this capacity" (p.6). With regard to ocean literacy, Hoffman & Barstow recommend incorporating ocean principles and science concepts into a systems perspective to emphasise the interactions between the various earth systems, and to help educators anchor ocean literacy within the broader study of Earth sciences. Rather than being taught as a stand-alone subject, ocean sciences would be best taught as an anchor subject for relating the various earth sciences. This supports the argument for an integrated approach to teaching ocean literacy.

An unpublished study by Marrero (Uncovering students' conceptions of the ocean: A critical first step to improving ocean literacy (Dissertation), 2009) examines students' conceptions of the ocean and how these can change as a result of participation in an ocean literacy-focused curriculum called ACES (Animals in Curriculum-based Ecosystem Studies), a program that was developed with funding from NOAA. The ACES program is designed to support teachers in using the ocean as a context for teaching science concepts (i.e. food chains that have traditionally been taught in a terrestrial context, can be taught in a marine context).

The program was supported with a variety of resources, including a dedicated ACES website with access to online data, scientists who are engaging in relevant research, teacher training, other educational materials. According to the study, pre-knowledge of the ocean was poor, but following participation in the ACES program, youth were able to acknowledge the impact the ocean has on their lives, and in turn, their impact on the ocean. In addition, students were able to apply their new knowledge to basic decision making. Review of the ACES website (http://www.signalsofspring.net/aces/about.cfm) indicates the program is ongoing (currently in its tenth year), and while it is based on a constructivist paradigm, it has not embraced a fully-integrated systems approach to teaching ocean science within an Earth systems paradigm. It does now include a focus on science research skills and processes.

In this article by Braman et al (The polarizing impact of science literacy and numeracy on perceived climate change risks, 2012), the authors challenge the assumption that public apathy towards environmental issues (i.e. climate change) is rooted in a lack of science knowledge and sufficient comprehension of the issues. The researchers refute the notion that people refuse to behave in environmentally conscious ways because their inability to think as scientists makes them incapable of perceiving the problems as they should. Instead they propose a cultural cognition thesis which suggests people adjust their perceptions of societal risks to align with the values of groups with whom they identify, and then adjust their interpretations of the available science to support the chosen philosophy. The theory proposed in this study is based on the assumption that increased knowledge should in turn increase level of concern with the environment. Opponents of this theory indicate that public knowledge of an issue is not sufficient — that they need to also have cognitive skills to assess and assimilate that knowledge. **The researchers conclude from this study that public engagement strategies that are entirely knowledge-building focused will not succeed. Instead they recommend creating "a deliberative climate in which accepting the best available science does not threaten any group's values."(p.11).**

In this article (Commentary: Ocean Literacy - There's more to it than content, 2008) Cudaback argues that an effective and formal ocean education (i.e. oceanography programs) should comprise four key domains: science content, science attitudes, stewardship content, and stewardship attitudes. According to Cudaback, much of our ocean literacy efforts focus on the first domain, yet we rely on the other three domains to manifest in support and behaviour change. Attitudes about science relate to how we use science as a tool to help us understand the world. Stewardship content refers to an understanding of how my actions affect the ocean. Practitioners often hope the public will make the leap from science content to stewardship content, though this is often the gap in environmental literacy campaigns. Stewardship attitudes relate to feeling concerned about, responsible for, and empowered to act in ocean-positive ways. As several of the preceding articles have shown, this leap of logic from general ocean science knowledge to personal implications and attitudes of responsibility are not automatic. In these three domains, an ocean literacy strategy can have the most impact on engagement, which could trigger additional knowledge seeking which further embeds the individual attachment to ocean literacy. A limitation of this model for ocean literacy is that it does not explicitly account for individual and community beliefs, values, cultures and

priorities, which have been shown to play a significant role in influencing the adoption of environmentally-focused attitudes and behaviours.

Sea Change (Sea Change Project, 2018) provides access to policy-oriented research and reports. The first of these reports, A review of the ways of achieving societal change (Eleiton, Corless, & Hynes, 2015), examines public perceptions of the marine environment, providing a detailed summary of research into marine and coastal regions generally, country/region-specific studies, the perceptions of young people, and issue specific perceptions (e.g. relating to marine aquaculture, fishing, tourism, etc.). The report highlights some of the key findings from review, including a general low level of marine awareness but a high level of self-reported knowledge, perceptions of low-efficacy in the face of marine environmental problems, positive levels of public interest in marine protection issues, lower than average perceptions of marine issues by young citizens, and some socio-demographic influencers such as income and education level, and frequency of visits to a marine environment relating to higher levels of concern for marine issues.

This report also identified trusted sources of marine information as a variable in engagement. Overall, according to this report, the public tends to have more trust in scientists working for research institutions, universities and environmental NGOs, and less in government institutions and private industry. This has implications for how awareness is built among the public, and the sources of information that are leveraged, as they influence how the public perceives that information. Strategies for communications need to keep this in mind in order to build public engagement. This reinforces other research that has found that citizens tend to be more engaged in dialogue around sustainability if they feel connected to the issue (need references). **This report reinforces the established perspective that it is insufficient to present sustainability issues entirely with scientific knowledge – if the intention is to influence behavioural change and build a sense of co-management, then it is essential to ensure that people understand the issue as it relates to them, feel responsibility for it, and feel motivated to take action, and also be capable of doing so.** The reference list in this report provides an exhaustive list of studies conducted internationally, focused on assessing public perceptions, awareness, attitudes, and intentions to act regarding marine conservation and policy measures.

8. IMPACT OF OCEAN LITERACY PROGRAMS

Globally, the ocean literacy movement is building momentum, and we can evaluate those efforts and determine where and how we have had impact, and how best to inform future strategies. As we look to evaluate the impact of ocean literacy programs and strategies, it is important to consider what metrics will provide the best gauge of impact, and how do we fairly assess it? What measures will give evidence of impact and are some outcome areas more heavily weighted than others? What areas should be assessed? Impact areas can range from evaluating the increase or application of environmentally-aware behaviours, to policy changes, increase in compliance, increase in voluntary adoption of sustainable practices change, endurance of

change, involvement of broader stakeholders, improved communication, and others. This section will examine several impact assessment efforts and models to draw best practices for a proposed evaluation strategy for Canada's ocean literacy strategy.

As the public becomes more involved, it becomes more important to assess the impact and effectiveness of this involvement so it can be better-leveraged or more effectively solicited. An article by Rowe & Frewer (Public participation methods: A framework for evaluation, Winter 2000) explores different evaluation criteria that are essential to the effectiveness of public involvement in science and technology policy. According to the researchers, these criteria fall into two key categories: i) acceptance criteria (i.e. the features of a participation methods that make it more acceptable to the public), and ii) process criteria (i.e. features of the participation process that make it more likely to be effective). Acceptance criteria relate to perceptions that a process has been democratic and fair and thus include criteria such as broad representation, early involvement, employment of an unbiased process or facilitation, influence criterion which relate to the process genuinely having an impact on the decision or policy, transparency, resource accessibility, task definition (common goal), structured decision making, and a cost-effective process. This article provides some guidance on key criteria to be considered for impact assessment.

A detailed framework for evaluating the impacts of informal science education projects was developed by the United States National Science Foundation (NSF). This framework, described by Friedman (Framework for evaluating impacts of informal science education projects, 2008), identified five key impact categories that included awareness, engagement, attitude, behaviours, and skills. The framework provides guidance for measuring impact on complex projects with multiple stakeholders and deliverables, and across a project lifecycle. The framework, according to Friedman, emphasises the importance of a clear understanding from the beginning of the project objectives (why) and key stakeholders (for whom).

Tooker (The Ocean Literacy Campaign -Special Report #3, March 2010) provided a general overview of the impacts and national and international accomplishments that have arisen from the establishment of the Ocean Literacy Framework. This report highlighted the development of a high school marine science textbook "Life on a Planet" to be used nationally across the United States. The textbook is profiled as a key achievement as it was developed by employing a collaborative and interdisciplinary team of educators, scientists, researchers, and curriculum writers. This collaborative approach was borrowed from the development paradigm modeled by the initial team that came together to produce the Ocean Literacy Framework and supporting Principles, and the Scope and Sequence. The textbook also integrates science learning into math, language, reading and social sciences. Tooker identifies the achievement of having a marine-focused national textbook – the first of its kind in the United States – as both a resource supporting the ocean literacy campaign, and evidence of the progress and impact that has generated demand for such a resource.

In the article by Heck, Dearden & McDonald (Stakeholders' expectations towards a proposed marine protected area: A multi-criteria analysis of MPA performance criteria, September 2011), the researchers applied an Analytical Hierarchy Process (AHP) to evaluate performance

criteria with diverse stakeholders, regarding a marine protected area. This method was developed for situations where multiple and possibly conflicting management objectives exist but can not be optimized simultaneously. With the multiple stakeholders, perspectives and priorities that need to be considered in Canada's collaborative ocean literacy strategy, this framework may provide a good starting point. This approach helps to deepen understanding of the broad stakeholder expectations that exist and provides insights into the different weights that are given to expectations by different stakeholder groups and relate that to how each group uses the resource (i.e. recreational boaters, commercial fishermen, NGOs, local government, tourism operators, recreational fishermen, etc). This study found that all groups prioritized environmental improvement criteria, but opinions varied on social enjoyment and education and economic benefit criteria. This study supports a collaborative approach to decision-making, as it demonstrates that stakeholder groups may agree on some priority objectives, and that there may be other objectives to consider in ensuring that all groups feel represented in a process.

Kazimirski & Pritchard (Building your measurement framework: NPCs four pillar approach, June 2014) developed a guidance document for measuring impact of not-for-profit projects. Built around change theory, the guide describes a 'four pillars' approach' to building a measurement framework, comprising mapping theory of change (i.e. to establish a coherent framework and understand early on what goals and objectives are being pursued, and types of data should be gathered); prioritizing what to measure (that link with most important outcomes); choosing the right level of evidence (i.e. the rigour of the evidence should match the stakeholders' expectations); and, selecting the relevant sources and tools for gathering data and evidence. This framework provides a useful though general starting point for developing an impact assessment and provides some guidance for assessing impact in a complex project where change is the priority desired outcome.

The Sea Change Project, provides a framework by Bayliss-Brown et al (The sea of change collective impact assessment framework. EU Sea Change Project. 2015) for assessing the effectiveness of the Sea Change project overall, and also for individual initiatives. A mixed methods approach to assessment is proposed, called the Collective Impact Assessment Framework, which utilizes traditional user feedback activities combined with social innovation indicators that measure changes in knowledge, networks, and intangible measures of engagement relating to learning, trust and commitment. In this article, the authors distinguish between isolated impact, which measures a single solution in a single region (e.g. beach clean-ups), or quick fix measures, and collective impact, which emphasises a systemic approach to shared, global objectives guided by collective principles. The collective impact approach stems from the SIPPS (Social Innovation Participation Process) community of practice and has pluralistic objectives of measuring the social change and action needed to develop a durable and empowered movement of an engaged and connected public. The impetus for a collective impact assessment framework lies in the urgency of the global challenge. As a nod to the philosophy that we all share one ocean, this approach goes beyond capturing small, isolated impacts, to highlight broader, collaborative interventions and integrated policies that will

have broader, collective, and more durable action for a healthy shared ocean. According to the authors, a key challenge in developing an impact assessment framework for the ocean is "the sheer diversity and number of activities and outputs present significant challenges to impact evaluation, including what should be evaluated, and how to demonstrate synergies at the macro level" (p.10). Bayliss-Brown et al identify an additional impact area, process indicators, which reflect shifts from citizen to stakeholder, and provide some insights into value and behaviour change in society. This may also be a helpful framework to consider in developing a national impact assessment strategy for the myriad regional, national and global initiatives that Canada partakes in.

At the heart of an ocean literacy strategy beats a campaign for behaviour change. Education and awareness programs, connecting issues to the local or individual impact, engaging stakeholders, influencing new policy – these are some of the countless approaches employed to change how citizens think about, interact with, and prioritize our shared ocean. The ultimate test of impact is – have citizens adopted, and do they more consistently practice, more ocean positive behaviours? Presently, several groups have identified impact assessment models, but there are few reports on the actual impact of ocean literacy at this time. This is a significant gap and relies on groups having the foresight to conduct baseline assessments with which to compare current metrics to determine if progress has been made on any or many of the established assessment criteria.

9. GAP ANALYSIS AND RECOMMENDATIONS

This literature review, and the search for other extant literature across the domains that have been explored in this review, have highlighted key research gaps and opportunities that are essential to supporting an evidence-based strategy for developing a national ocean literacy framework and strategy. The following is a summary of identified gaps and recommendations for future study.

ASSESSMENT OF PARTICIPATION AND IMPACT

Several articles provided frameworks with criteria for assessment of participation and impact, though few studies shared metrics that demonstrated actual impact in terms of sustained behaviour change. This is a gap that should be addressed going forward. Ocean literacy campaigns and initiatives have been in place for a sufficient amount of time to assess the impact of the programs both in terms of immediate effect and durability of effect. This is a significant gap and relies on groups having the foresight to conduct baseline assessments with which to compare current metrics to determine if progress has been made on any or many of the established assessment criteria. The efficacy of future programs is dependent on understanding what criteria, alone or in combination, produce the greatest impact.

Additionally, the studies that did recommend criteria for assessment did not provide insight into the best metrics (i.e. those that provide the clearest evidence of impact) or provide any

guidance on how to prioritize or weigh the various outcomes that can be measured. To a large extent this would depend on the guiding objectives of the strategy or intervention, but assuming that most public-focused environmental initiatives are oriented towards behaviour change, there must be some common indicators or predictors of change intention, actual change, and sustained change.

REGIONAL OCEAN LITERACY PROGRAMS

It would be interesting to see impact studies done on regional programs, initiatives and resources such as the ACES program, the Stream to Sea program, the Science First Peoples Teacher Resource Guide - Grades 5-9, the Ocean Literacy Principles of Ocean Science (k-12) and the Ocean Literacy Scope and Sequence for Grades k-12 developed and launched in the United States. These studies should assess the utility and impact of these programs in terms of change to and sustained ocean-positive attitudes and behaviours of students and teachers who have been engaged in the programs and assess adoption of the resources by the target audiences, and accessibility of the resources with stakeholders.

PATHWAYS TO ENGAGEMENT: MEDIA AND OTHER COMMUNICATION CHANNELS

The literature review highlighted several communication channels (i.e. television, newspapers, social networks, websites, public forums and townhalls, published reports and research, etc.) for reaching the public but were not explicit in identifying which channel is best for communicating particular messages (i.e. information sharing, knowledge building, event planning, debate and dialogue events, etc). It would be helpful to have a deeper understanding of how to match channel with message, or channel with stakeholder group in order to increase receptivity of communication. It would also be helpful to understand which channels most readily influence public perception in order to either leverage these channels better with appropriate communication or to monitor these channels for counter-productive messages.

INDIGENOUS PERSPECTIVES AND ENGAGEMENT IN OCEAN LITERACY PROGRAMS

During the brief timeframe in which this literature review was conducted, there was not much literature found on Indigenous involvement in ocean-focused initiatives specifically. Ostensibly this is a significant gap insofar as it limits the ability to gain insights into effective approaches to partnering with Indigenous groups and restricts our ability to learn from established best-practices and courtesies of approach. Much of the research that could be found focused on Indigenous groups internationally, especially Australia. It is recommended that a second phase of review be undertaken in order to consult directly with Canada's Indigenous communities and allow time to review a potentially much larger body of work in this area. It is also recommended that more research be done to understand how to integrate traditional

knowledge with Western science in our formal education systems, to benefit from the process of knowing as well as the knowledge, and from the stewardship principles that are inherent in a traditional knowledge pedagogy.

SOCIO-SCIENTIFIC ISSUES

Several of the studies cited in Sadler's work examined student learning transfer and application to socio-scientific issues that may have seemed less relevant or urgent to the learners (i.e. cloning), or less tangible (i.e. global warming). It would be interesting to examine learning transfer and integration of scientific and personal knowledge on issues relating to marine and coastal areas, particularly regional or locally relevant issues where personal or community impact can be more readily apparent, to determine if the same argumentation skills are applied. It would also be interesting to understand how different stakeholders view and prioritize different socio-scientific issues, and how culture, beliefs, values, demographics and regions influence these perceptions. It is easy to assume that everyone will value and prioritize ocean issues similarly, but the preceding research suggests that this is unlikely. This information would be helpful in anticipating positions in dialogues focused on prioritizing issues and objectives.

INTEGRATED SCIENCES FOR OCEAN LITERACY

Several of the studies recommended integrating ocean science with other science concepts. Some even suggested incorporating ocean principles and science concepts into a systems perspective to emphasise the interactions between the various Earth systems, and to help educators anchor ocean literacy within the broader study of Earth sciences. Others stretched the concept of integrated ocean science to include ocean economy, careers, sociology, and society, culture and heritage. It would be interesting to study some teaching and learning environments where this fully integrated approach to ocean literacy is applied to determine if, and how, the other science and non-science concepts resonate and give personal or regional context to the learning. It would also be helpful to see the impact of this on knowledge holding, knowledge use, argumentation skills, intention to act in ocean-positive ways, and actual ocean positive behaviours. It would also be interesting to see how these multiple anchors to ocean science influence durability of ocean-positive attitudes and behaviours over time.

KNOWLEDGE HOLDING AND STEWARDSHIP BEHAVIOURS

Several studies that examined knowledge building and knowledge holding were based on the assumption that students and the public will make the cognitive leap from science content to stewardship behaviours. Research has not consistently demonstrated that this leap occurs, and indeed, several studies have shown that knowledge was not predictive of behaviour. An interesting area of study would examine how individuals and groups make

the cerebral to affective leap between science knowledge and awareness into feelings of concern, responsibility, and readiness to act in ocean-positive ways. It would be interesting to understand what factors facilitate or mitigate this transfer, and what factors are common to, and unique, among key stakeholder groups. A next step for research might look into better understanding what elements of attachment beyond those studied so far, might better engage individuals to build knowledge and awareness.

Indigenous communities internationally share common Earth stewardship values that are embedded in their cultures and ways of life. Much of this is likely connected to Indigenous worldviews, ways of knowing, and ways of interacting with the natural environment. Nevertheless, it would be interesting to try to understand how stewardship values are so well-integrated, to tease out models that can be adapted to broader Canadian application.

KNOWLEDGE HOLDING AND PARTICIPATION

Further study into the directionality of the relationship between knowledge holding and participation should be conducted (i.e. stakeholders/citizens participated because they had more knowledge, or they had more knowledge because they participated). Finally, it would be interesting to examine how knowledge confidence, and confidence in the participatory debate process relate to participation. It may be that objective knowledge holding leads to participation, or subjective confidence in knowledge holding (i.e. confidence in having the information necessary to weigh in on the particular issue), or it may be that the public's willingness to participate in voluntary action or voting is related more to self-efficacy (the belief that their actions can make a difference) than it is to objective knowledge holding.

KNOWLEDGE HOLDING AND REASONING AND ARGUMENTATION SKILLS

According to the research studies summarized in this document, reasoning does not necessarily improve with elevated knowledge levels (Zohar & Nemet, 2002). It would be interesting to examine learning transfer and integration of scientific and personal knowledge on issues relating to marine and coastal areas, particularly regional or locally relevant issues to determine if the same argumentation skills are developed and applied, and to determine if other factors are better predictors of argumentation skills than knowledge holding.

LEVERAGING MEDIA INFLUENCE

More research is recommended to better understand the influence of the media in constructing salient messages for public understanding of ocean sustainability issues to help facilitate public behaviour change. It would also be interesting to see how capricious or durable these messages are, and the factors that influence persuasiveness and salience. The media will be a key stakeholder in communicating ocean literacy messages regionally and nationally, and it will be

important to better understand how to leverage their agenda-setting influence positively. It is also worth further research to better understand how frames can be constructed that are both compelling to readers, and build knowledge, concern, relevance and commitment to an action or behaviour change.

DEVELOP CANADIAN OCEAN LITERACY PRINCIPLES AND PRIORITIES

Building upon the work done in the United States to develop common ocean literacy principles, research should be conducted to determine the extent to which those principles have been adopted and applied, and how they inform practice and decision making. Research could help understand how the principles can be adapted and expanded for the Canadian concept, especially to include principles about the role of the ocean in Canada's economy, society, culture, and heritage (including Indigenous). Some additional concepts that might be considered for inclusion in a Canadian definition of ocean literacy are:

a. Humans are inextricably linked to the ocean.

b. The Earth has one big ocean with many dynamic features;

c. The ocean is an integral part of Earth's weather and climate systems;

d. The ocean made the Earth habitable;

e. The ocean supports a great diversity of life and ecosystems;

f. The ocean is largely unexplored;

g. The ocean is vulnerable;

h. The ocean has and continues to play a critical role in the development of human civilization;

i. The ocean plays an important role in Canada's society, culture and heritage;

j. A substantial part of Canada's economy depends on the ocean;

k. There are a variety of interesting and rewarding careers linked to the ocean; and

Individual actions matter. There are actions that an individual and/or group of individuals, can do to reduce negative impacts on the ocean and apply innovation to generate new sustainable opportunities and value from the ocean.

The Hoffman and Barstow study found that the ocean literacy principles established in 2005 were not found in the science standards in most educational institutions in the United States. It would be interesting to conduct a similar study in present time to see if these principles have been more broadly adopted and applied. Often big initiatives like this fail in promoting frameworks or resources widely to key audiences or in supporting them with implementation and fail in evaluating the utility and impact of the framework/resource. It is recommended that a similar study be conducted in present time to see if these principles have been more broadly

adopted and applied, to glean some best practices to facilitate the development, distribution and adoption of Canadian ocean principles.

KNOWLEDGE DEVELOPMENT

Much of the research looking at adoption of environmental attitudes and behaviours focused on knowledge development and knowledge holding. The research varied in their conclusions regarding the need to tailor education and awareness campaigns and communications with different audiences. It would be worthwhile investigating this further to better understand how different groups gather knowledge, how they rank credibility and trustworthiness of different sources of information. Also, understanding which citizen groups engage in more environmentally conscious behaviours and how knowledge relates to that would be useful data.

PROXIMITY AND VISIT-FREQUENCY

Much the literature explored proximity and visit-frequency as factors influencing awareness, knowledge holding, concern and likelihood to demonstrate environmentally positive behaviours. What wasn't clear from the research, and would be worth study, is if the context of the coastal visit (i.e. family trip, class trip, day camp, etc) was a factor at play. This is a recommended area for follow-up study, as it is likely that the context of the visit is significant in creating meaning about and from the experience and building issue salience. It is also recommended that further study be done to determine the link between visits to ocean and coastal regions and citizen engagement in ocean issues, as a vast majority of Canada's people live in land-locked provinces, where visits to these regions would likely be infrequent or rare. This research may provide insights into ways to bring the experience to people by leveraging virtual reality or other digital technologies that mimic the salient elements of an ocean visit experience.

UNIQUE AND COMMON STAKEHOLDER IMPACTS

It is recommended that some research be conducted to gain insights in unique and common stakeholder impacts. For example, which stakeholders/target audiences are actually impacting the ocean the most (i.e. where are the highest sources of pollution, green house gas emissions, overfishing, etc.), who has the most influence on policies and regulations that directly affect the ocean; what industries and businesses are in the best position to affect positive ocean change; what government departments and initiatives could be integrating ocean literacy objectives but presently aren't? This would provide some insights into any disparity between those that have a high ocean impact, and those that are being reached by existing ocean literacy initiatives. By identifying gaps, we can strategically develop ocean literacy programs to issues and the stakeholder groups that need it most. Part of the research should also include the identification and reduction of barriers to behaviour change by these target audiences.

SOCIO-ECONOMIC STATUS PREDICTORS

Many of the studies explore socio-economic status (SES) as a barrier to engagement of the public. It would be interesting to dig deeper into how SES trends might relate to values and priorities of stakeholder cohorts, or how SES influences interactions with ocean and coastal regions (i.e. cost of recreational ocean activities, participation in swimming lessons, availability of a parent/guardian to visit the ocean, etc.). It would also be worth examining any trends that illustrate differences between urban and rural populations.

BLUE GROWTH

Blue Growth is a concept that requires further study, to gain insights into how blue growth and the blue economy are perceived and understood by different stakeholders and determine where key priorities and objectives align or conflict across stakeholder groups.

FORMAL OCEAN EDUCATION

It is recommended that a framework for evaluating and assessing the effectiveness of ocean-related education programs, K-12 professional development programs, and best practices for incorporating

ocean-based examples into K-12 education and public education programs be developed to establish starting metrics and benchmarks in order to evaluate progress and impact over time.

YOUTH ENGAGEMENT

The study by Simms (Bringing environmental identity research into the classroom context, PhD. Thesis, 2017) provides new insight into understanding how to environmental concepts learned in the classroom are transferred into stewardship behaviours in other contexts by cultivating environmental identity and providing social contexts to exercise this identity. It is recommended that more research be conducted to better understand how identity theory and social identity theories (Sanford, 1955) relate to contemporary approaches to environmental behaviour change and action.

INFORMAL EDUCATION

It is recommended that a framework and criteria be developed to assess the impact of informal education and awareness programs such as citizen science programs, public talks, youth informal education; digital and online awareness and information initiatives, and inter-sector/ inter-stakeholder sharing sessions. With the shift to more inquiry based experiential pedagogy, the integration and collaboration between formal, informal and non-formal education is

growing, and it may be appropriate for a complimentary framework to be developed that integrates all.

COMMUNITY OF PRACTICE

Several of the participatory design models examined in this report have been applied in a single sector or to tackle a single environmental challenge (i.e. marine protected areas, climate change, air pollution). A Canadian ocean literacy strategy will be multi-sector and will cover multiple ocean challenges, issues and opportunities. It is worth further study to determine the most appropriate framework for a broader multi-sector and multi-stakeholder collaborative approach.

Conclusion

At first glance the concept of ocean literacy seems emphatically science-knowledge oriented. However, frameworks used internationally have emphasised the relevance and utility of scientific and socio-cultural knowledge, and the application of that knowledge into action. Some frameworks have implicitly or explicitly included other sources of knowledge in recognizing reciprocity of impact, including cultural, regional, economic, social and traditional. Indeed, the ongoing international and national dialogue has reiterated that ocean literacy is more than just ocean science and it involves more than just youth as its key target. It is also applicable to policy makers, business leaders, parents, the general public, and other groups.

Key to supporting this sustainability movement, is knowledge in combination with personal values, beliefs and priorities, and individual and community relevance. There is only one ocean. It is hoped that with a strong integrated national ocean literacy strategy, we will share a common understanding of the numerous ways in which we impact the ocean, and how the ocean impacts our daily lives. And through this common understanding, see more Canadians using ocean-positive behaviours in their day to day lives. From the early work that has already been done overseas and south of the border, it is apparent that it will take more than the plight of charismatic marine life to catch and hold the attention and engagement of the public and other key stakeholders.

A national framework for ocean literacy in Canada will need to establish a common understanding of what are we trying to accomplish in the long run. Ostensibly the goal is to improve ocean literacy in Canada, but this is also a movement to change the paradigm for public involvement in grand issues that impact us individually and collectively. In some ways, the work being done to establish a framework for ocean literacy in Canada is plotting a new course for public involvement that bridges age-old gaps between subject matter experts and citizens, and partners scientific knowledge with local knowledge, united by the reality that we have a shared interest in the outcome.

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