2. Marine invasive species: Issues and challenges in resource governance and monitoring of societal impacts

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Approximately four million people live in the Arctic, and the majority of residents reside in communities along the Arctic coast (AHDR 2004; Forbes 2011). The Arctic – although small in size and with a relatively harsh climate – is a region characterized by its richness in peoples, societies and cultures and with human settlements ranging from small isolated and scattered communities to larger urban and industrial centers, and with variation in the relative importance of formal and informal economies (Larsen 2010a; Huskey 2010). An important characteristic is the close connection between Arctic residents and their surrounding environment, especially for many indigenous peoples – who number about 10% of the Arctic population – but also for a large segment of other Arctic residents (AHDR 2004; Aslaksen *et al*. 2009). These well-established human-environment connections contribute to the effects of global change being both strongly felt and immediate. For many Arctic residents the growing pressure to adapt to a changing environment is not only real but increasing, and for some it represents growing threats to their daily livelihoods and wellbeing. At the same time as economic and political autonomy is growing in the region, Arctic residents are confronted with an unprecedented combination of rapid changes including environmental processes, cultural developments, and economic changes. Traditional ways of life and nature-based livelihoods are met with increasing disruptions for many, thereby challenging the socio-economic stability of local and indigenous communities. Many of the region's narrowly resource-based local and regional economies are facing increasing pressures by global change impacts, with these impacts being felt on employment opportunities, distribution of income and wealth, and the allocation of resources. Where communities are already

stressed, even small changes in the availability or quality of natural resources may have large effects on their livelihoods (Larsen 2010; Rasmussen *et al*. 2009). Against this backdrop of increasing and multifaceted socio-economic challenges, the following offers some reflections on the societal impacts of marine invasive species in the context of global change, including brief considerations of issues and challenges in governance and monitoring.

Climatic change – including reductions in sea ice extent, duration, and thickness – will likely increase human presence and economic activities in the Arctic in the near to long-term (AMAP 2011; IPCC 2007). Increased marine invasions – including the introduction of invasive species through ballast water and vessel hulls – presents important ecological challenges for ecosystems and economic and cultural livelihoods in the Arctic (Lassuy *et al*. 2013; Arctic Resource Development 2012). Longer ice free seasons and reduced ice coverage could increase Arctic shipping (Stephenson *et al*. 2011; Arctic Council 2009; Prowse *et al*. 2009; Lawson 2010), and introduce new threats to food security and quality of life in the region (see Miller, Chapter 3 of this volume). For many local communities, continued access to resources is linked closely to livelihoods and overall wellbeing; just as access to living resources and a meaningful role in resource governance are closely tied to cultural survival for many (ASI 2010, 2014).

Consequences for Arctic local communities of an increase in marine invasive species and their ecosystem impacts may be further amplified when communities are located in areas which are particularly vulnerable to new activities competing for natural resources (Rasmussen *et al*. 2009). While Arctic indigenous peoples have a reputation for being resilient and for having an ability to adapt to changing environmental conditions, the multiple and compounding stressors confronting the Arctic today may leave many communities less resilient than witnessed earlier (AHDR 2004). Climatic change, increased human activity, including increased marine shipping, may lead to more marine invasions, including the potential demise of traditional subsistence systems, and with consequences for community viability (Arctic Council 2013). Climate change presents new challenges for institutions in the north to be more flexible, resilient and robust, and to find ways of increasing the ability to cope with rapid change in biological systems.

Marine invasions have potentially serious ecological, economic, cultural and human health impacts. External hull surfaces and internal ballast tanks of vessels can support a wide variety of non-native marine organisms. Much of the increased risk of invasion may come from in-

creased shipping due to globalization and climate change, including Arctic cruise tourism. The present and projected future increase in ship traffic adds to risks of biological invasion. Ship-based tourism is a potential source of non-native species, and with the number of cruise ships on the rise, it has become an increasingly important pathway (Stewart *et al*. 2010; Lassuy *et al*. 2013).

Loss of Arctic biodiversity also means loss to the potential human uses of that biodiversity (Lassuy *et al*. 2013). Economic impacts in the Arctic may include the interference with fisheries in a variety of ways and scales, which can have potentially large effects for narrowly based economies, in particular when important commercial species, and species critical to subsistence based economic livelihoods, are affected.

Also, impacts may include disruption to tourism due to environmental impacts; damage to critical infrastructure; and potentially large costs related to cleanup, control and monitoring, and quarantine and treatment. Cultural impacts of marine invasions may include competition with native species important in subsistence harvest, and the degradation of habitats and resources important to cultural survival. Cultural impacts may be especially hard felt in predominantly indigenous communities. Here, the potential for conflict between industrial activities and economic and cultural interests of indigenous peoples is evident in cases where the water or impacted species in question are important for the survival of traditional livelihoods. The close ties between local economies, cultures and tradition in the Arctic makes it a growing concern for livelihoods and the state of human wellbeing. For example, invasive species may force traditional knowledge to adapt and new harvesting patterns to be developed. Marine invasions can also have impacts on health and wellbeing of Arctic residents, such as via introduction of disease and parasites. Additionally, they may decrease or destroy opportunities for recreation (Lassuy *et al*. 2013; Arctic Resource Development 2012; Forbes 2011).

The potential for significant economic, cultural, and health impacts of invasive species underscores the importance of finding viable long-term solutions in governance and risk management. Climate and weather conditions and long distances may hamper response action and restoration efforts. It is therefore important to establish procedures in the Arctic to address existing and emerging vulnerabilities and high environmental risks. A complicating factor in this regard is the lack of data to measure impacts. The vulnerable character of the Arctic, the economic, social and cultural complexities, differences between regions, including difficulties of monitoring, and still being in the early stages of relevant

technology all present significant challenges to overcome. The more knowledge generated regarding the environmental conditions of the Arctic and the potential consequences of human activities, such as the consequences from increased marine shipping, the better the prospects will be for effectively addressing the challenges of marine invasions in ways that lead to fair outcomes for affected communities (ASI 2010; Arctic Resource Development 2012; Mikkelsen *et al*. 2011).

Many of the critical issues and questions related to the occurrence, consequences, and solutions to marine invasions remain challenging due to significant and persistent gaps in knowledge and lack of comprehensive community based monitoring programs for broad scale data collection and effective social indicator measurement (ASI 2010, 2014; Kannen *et al*. 2011; Mikkelsen *et al*. 2011). Furthermore, all human activity represents some type and level of risk, and therefore part of the answer to addressing the challenge of marine invasion is to find ways of assessing and managing the risk. This includes efforts to control the probability that an event will occur, or to limit the consequences of an event that will occur (Arctic Resource Development 2012; see Floerl, chapter 4 of this volume). This also makes it imperative that more be done in terms of exploring the question of acceptable levels of risks, the trade-offs for different stakeholders and the development of mechanisms to better safeguard against intolerable risk levels. Risk may for example be reduced by cleanup or by introduction of measures such as the Polar Code (Arctic Resource Development 2012). Effective cleaning and treatment of ship hulls and drilling rigs brought in from other marine ecosystems also reduces risk. The increased threat to Arctic livelihoods from climate change and related impacts for marine ecosystems necessitates an assessment of risk, and the projected consequence for different economic sectors and social systems. This raises important questions about who should define the risks and benefits of society, what the tolerable levels of risk are or ought to be – which may differ between different Arctic stakeholders and regions. It also brings to the forefront issues of potential conflicts of interest over resource use by different stakeholders. There is a growing and urgent need for better assessment of Arctic vulnerabilities and risks.

On the question of governance, Caulfield (2004) emphasized as key trends in resource governance in the Arctic the growing importance of property rights, the incorporation of traditional or local ecological knowledge with western science in decision-making, the transfer or devolution of power to local decision makers and co-management, and the widening involvement of Arctic peoples in ownership and develop-

ment of lands and resources (pp. 121–137). These trends continue to be central to the protection of resources in the Arctic. But today, current challenges of resource governance have been extended to consider climate change, extensive land use change, and economic change concurrently occurring (AHDR 2014). Forbes *et al*. (2014) argue that to meet the challenges of sustainability, adaptive approaches to governance must be implemented– and these include flexibility in decision making, high levels of responsiveness, monitoring of social and ecological systems, and the active integration of knowledge systems. In general, it will be necessary in the future to find solutions that allow for a high capacity to be responsive to changing conditions, and to making decisions under conditions of greater uncertainty (AHDR 2014). While systems of governance that are particularly adaptive will have an important role to play in the near and long term, it is clear that efforts to establish a framework for effective monitoring of socio-economic impacts, including risks and mitigation measures will play a key role (ASI 2010, 2014; Kannen *et al*. 2011; Hoel 2011).

The development of cost-effective early detection monitoring networks will be a challenge due to the distribution of resources in the Arctic, just as the cost of primary data collection to enable measurement of social indicators and the assessment of human impacts presents significant challenges. Further development and implementation of such networks and monitoring systems would help facilitate more rapid and efficient response, and provide for better protection for more environmentally and economically efficient solutions early in a possible marine invasion process. Also, Arctic residents with traditional knowledge may greatly assist information gathering and monitoring by offering their observations and evaluations. Efforts to understand, manage, and respond to change in Arctic coastal systems may benefit from the integration and complementarily of both scientific and traditional approaches (Forbes 2011). Potential advantages of integrating various forms of knowledge include decision-making that is better informed and more flexible. Recognizing the value of traditional ecological knowledge may also contribute to enhanced resilience and adaptive capacity in many Arctic communities (ASI 2010; Kannen *et al*. 2011; Hoel 2011).

A critical step is to assess what information already exists and what information still needs to be gathered, and to address the issues and challenges to implementing monitoring and data collection. Important knowledge gaps can be closed through development of indicators and comprehensive modelling, mapping, monitoring, and analysis (Larsen 2009, 2010). The Arctic Social Indicators (ASI) project offers a first at-

tempt at implementing a system for the long-term monitoring and tracking of change in human development in the Arctic (ASI 2010). Provided that appropriate adjustments are made, this system may offer valuable contributions towards meeting the challenge of obtaining reliable estimates of societal impacts of marine invasions in the Arctic. In particular, the ASI system includes among its six domain areas for indicator measurement, domains on *economy*, *culture* and *health*, as well as *contact with nature*. These domain areas are important to capturing the societal impacts of marine invasions in the Arctic. Other ASI domains include *education* and *fate control*. Specifically, the ASI system is based on the premise that Arctic communities highlight three aspects as key factors in their lives: fate control, contact with nature, and cultural wellbeing. The Arctic Human Development Report (AHDR 2004) and ASI found that for people in the Arctic, fate control, cultural integrity and contact with nature are central for well-being and should be included in future statistical data collection efforts. ASI aims to construct indicators that are valid across space, time, scale, and robust to change. Based on a series of case studies to test the strength of the indicators – including Sakha-Yakutia, the North West Territories, the West Nordic region (Greenland, Faroe Islands, Iceland, coastal area of Norway, Norwegian Sápmi), and the Inuit Regions of Alaska – the ASI report confirms the strength, applicability, and value of the monitoring system, and concludes that human development in the Arctic has been increasing, but that regional differences persist. An application of ASI to the case of societal impacts of marine invasions would be feasible via a series of targeted adjustments to specific indicators, but in addition would also require costly data collection including broad scale primary data collection on subsistence harvest and consumption. In particular, adjustments can be made to the ASI indicators for material wellbeing, cultural wellbeing, health, and closeness to nature (ASI 2010), to help capture specific impacts. For example, ASI indicators for material wellbeing include income generated from both formal and informal economic activity, but valid estimates of material wellbeing that takes into account impacts of marine invasions would need to account also for impacts on subsistence harvest. Similarly, ASI indicators for cultural wellbeing and closeness to nature must account also for harvest and consumption of country food; and cultural wellbeing can be measured also by participation in cultural activities – which may be negatively impacted by marine invasions. It is therefore feasible to apply the ASI system to the case of marine invasion by including data on these invasions, and by making appropriate adjustments to individual ASI indicators where needed, thereby enabling the measurement of so-

cietal impacts to the economy, health and culture in the Arctic. A series of pilot studies could be implemented to help calibrate the way in which the ASI could be adjusted, so that invasive marine species risks and impacts are reliably picked up if and where they exist.

ASI has presented a series of recommendations for an ASI monitoring system, to be designed based on a set of principles and data criteria (ASI 2010), and to be made a priority for current and future circumpolar monitoring initiatives (ASI 2014). Such a system for human based monitoring will require a number of steps, including: the participation of national statistical agencies in development of a meta database to identify ASI indicators that are already monitored by a national agency; the establishment of an international task force composed of national statistical agency analysts and Arctic researchers to identify the special tabulations required to produce comparable ASI indicators; and the engagement of local communities, non-government organizations and private parties in developing and conducting locally-focused monitoring projects for social indicators, including community self-monitoring (ASI 2014; Larsen *et al*. 2010). The details of the methodology for such projects must be created via collaboration among communities, stakeholders and scientists. An important step will be to encourage national and international funding agencies and scientific associations to assist in building a circumpolar network of scientists actively engaged in monitoring of socio-economic well-being, and to promote data sharing, exchange and dissemination among researchers and research organizations (ASI 2010, 2014).

The goal of creating an Arctic human development monitoring system is to assist Arctic governments and communities to promote human development and quality of life in Arctic communities, and to help facilitate action to ensure and advance the wellbeing of all Arctic peoples. Improved access to reliable and high quality data at different scales and across regions will help facilitate the measurement and tracking of different domains of human development, and in turn may contribute to meeting the challenge of providing valid and robust estimates of societal impacts of marine invasions and facilitating more effective risk management and improved social outcomes for Arctic residents, their communities, and other stakeholders.

2.1 References

AHDR (Arctic Human Development Report) (2004). Akureyri: Stefansson Arctic Institute.

AHDR (Arctic Human Development Report) (2014). TemaNord. Nordic Council of Ministers: Copenhagen (forthcoming 2014).

AMAP (2011). Snow, Water, Ice and Permafrost in the Arctic (SWIPA): Climate Change and the Cryosphere. *SWIPA Scientific Report. Arctic Monitoring and Assessment Programme*. Oslo, Norway.

Arctic Council (2009). *Arctic Marine Shipping Assessment 2009 Report*.

Arctic Council (2013). *Arctic Resilience Interim Report 2013*. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm.

Arctic Resource Development (2012). Risks and Responsible Development. A Joint Report from FNI and DNV. Prepared for the ONS Summit 2012. Fridtjof Nansen Institute and Det Norske Veritas AS.

ASI (2010). *Arctic Social Indicators – a follow-up to the Arctic Human Development Report*. Larsen, J.N., Schweitzer P, Fondahl G (eds.). TemaNord:519, Nordic Council of Ministers, Copenhagen.

ASI (2014). *Arctic Social Indicators*. Larsen, J.N., Schweitzer P, Petrov, A., Fondahl G. TemaNrd. Nordic Council of Ministers, Copenhagen (in print).

Aslaksen, I., W. Dallmann. D. Holen, E. Hoydahl, J. Kruse, B. Poppel, M. Stapelton, and E.I. Turi (2009). Interdependency of subsistence and market economies in the Arctic. *The Economy of the North.* Glomsrød, S. and I. Aslaksen (eds.) pp. 75–97. Oslo: Statistics Norway.

Forbes D.L. (ed) (2011). *State of the Arctic Coast 2010 – scientific review and outlook*. International Arctic Science Committee, Land-Ocean Interactions in the Coastal Zone, Arctic Monitoring and Assessment Programme, International Permafrost Association. Helmholtz-Zentrum, Geesthacht.

Hoel, A. H (2011). Governance and Adaptation. In: Forbes D.L. (ed) (2011). *State of the Arctic Coast 2010 – scientific review and outlook*. International Arctic Science Committee, Land-Ocean Interactions in the Coastal Zone, Arctic Monitoring and Assessment Programme, International Permafrost Association. Helmholtz-Zentrum, Geesthacht.

Huskey, L. (2010). Globalization and the economies of the North. *In*: Heininen, L. and C. Southcott (eds.). *Globalization and the Circumpolar North*, pp. 57–90. Fairbanks: University of Alaska Press.

IPCC (2007). *Climate Change 2007 – impacts, adaptation and vulnerability*. Fourth assessment report, Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Kannen A., Forbes D.L. (2011). Integrated Approaches to Coastal Change in the Arctic. In: Forbes D.L. (ed) (2011). *State of the Arctic Coast 2010 – scientific review and outlook*. Interbational Arctic Science Committee, Land-Ocean Interactions in the Coastal Zone, Arctic Monitoring and Assessment Programme, International Permafrost Association. Helmholtz-Zentrum, Geesthacht.

Larsen, J.N. (2007). Samfundsøkonomiske Udfordringer for Arktiske Regioner i Norden. In: Rafnsdóttir G.L. (ed) Antologi: *Arbejde, Helse og Velfærd i Vestnorden*. Háskólaútgáfan og Rannsóknastofa í Vinnuvernd, Reykjavík, pp. 13–26.

Larsen, J.N. (2009). Arctic Monitoring Systems. In: *Climate change and Arctic sustainable development: Scientific, social, cultural and educational challenges*. UNESCO Publishing, Monte Carlo, pp. 309–317.

Larsen, J.N. (2010). *Northern Economies in a time of change*. Baltic Rim Economies (BRE).

Larsen, J.N. (2010a). Economies and Business in the Arctic Region. In: Lokacheva, N. (ed). *Polar Law Textbook.* TemaNord. Nordic Council of Ministers, Copenhagen. pp. 81–100.

Larsen, J.N.; P. Schweitzer; G. Fondahl; J. Kruse (2010b). Conclusion: Measuring Change in Human Development in the Arctic. In *Arctic Social Indicators* (2010). TemaNord. Nordic Council of Ministers. Copenhagen.

Larsen, J.N. and L. Huskey (2010). Material well-being in the Arctic. In: Larsen, J.N., P. Schweitzer, and G. Fondahl (eds.). *Arctic Social Indicators*, pp. 47–66. Copenhagen: Nordic Council.

Lassuy D.R., P.N. Lewis (2013). Invasive species: Human induced. Chapter 16. In: *Arctic Biodiversity Assessment*, 2013. Arctic Council.

Lawson, W.B. (2010). *The Fast Changing Maritime Arctic*. Proceedings of the US Naval Institute. pp. 54–59. www.usni.org

Mikkelsen, E., Hoel, A.H. (2011). Social, Economic, and Institutional State of the Circum-Arctic Coast. In: Forbes D.L. (ed) (2011). *State of the Arctic Coast 2010 – scientific review and outlook*. International Arctic Science Committee, Land-Ocean Interactions in the Coastal Zone, Arctic Monitoring and Assessment Programme, International Permafrost Association. Helmholtz-Zentrum, Geesthacht.

Prowse, T.D., C. Furgal, R. Chouinard, H. Melling, D. Milburn, and S.L. Smith (2009). Implications of Climate Change for Economic Development in Northern Canada: Energy, Resource, and Transportation Sectors. *AMBIO: A Journal of the Human Environment,* 38(5), pp. 272–281.

Rasmussen, R.O., Larsen, J.N. (2009). Future Challenges of the Arctic. In: *Structural change in Europe – innovative city and business region, vol. 6*. Harbarth Publications, Bollschweil. pp. 44–52

Stephenson, S.R., L.C. Smith, and J.A. Agnew (2011). *Divergent long-term trajectories of human access to the Arctic*. 1(3), pp.156–160.

Stewart, E. J., Howell, S. E. L, Dawson, J. D., Tivy, A. & Draper, D. (2010). *Cruise tourism and sea ice in Canada's Hudson Bay region*. ARCTIC. (63) pp. 57–66.