Ecosystem services of whales in the Arctic: co-production, valuation and governance

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2021

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Dissertation submitted in partial fulfilment of a
Philosophiae Doctor degree in Environment and Natural Resources

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Bibliographic information:
Malinauskaite, Laura, 2021, *Ecosystem services of whales in the Arctic: co-production, valuation and governance*, PhD dissertation, Faculty of Life and Environmental Sciences, University of Iceland, 159 pp.

ISBN 978-9935-9579-6-2

Author ORCID: 0000-0002-8545-4989

Printing: Háskólaprent ehf.
Reykjavik, Iceland, 2021

Abstract

The thesis examines the dynamics of Arctic social-ecological systems (SES) that enable human wellbeing benefits through whale ecosystem services (ES). It does so through a review of relevant literature, construction of conceptual models, two primary economic and socio-cultural whale ES valuation studies, and an assessment of whale ES governability. The results indicate multiple human wellbeing benefits and associated economic, socio-cultural and biophysical values derived from marine ecosystems through whale ES in selected case study communities in Greenland, Iceland and Norway. These benefits include but are not limited to tourism, education, cultural identity, community cohesiveness, commercial and indigenous whaling, biodiversity enhancement, ecosystem regulation, inspiration for arts, and existence values. The case studies demonstrate that they are obtained by communities through human-nature co-production of whale ES and governed by a multilayered web of formal and informal governance interactions. The social-ecological complexity revealed in the analysis of whale ES underlines the importance of context and plural ES values in Arctic marine resource governance. It also implies a necessity to study social and ecological phenomena together as one co-evolving Earth system. Following these observations, conceptual models were developed integrating elements of ES, their co-production, and interactive governance and governability theories. The results of the governability assessment reveal high complexity and dynamics related to whale ES, ability of actors to self-govern, and a need for reflective and adaptive governance regimes. The relevance of the methodology and conceptual models applied in this research extends beyond the Arctic and can be applied in other natural resource contexts.

Útdráttur

Í þessari doktorsritgerð er gangverk félagslegra vistkerfa á norðurslóðum sem gera mönnum kleift að njóta góðs af vistkerfisþjónustu hvala skoðað. Þetta var gert með því að rýna núverandi stöðu þekkingar á tengdum fræðum, smíði á hugmyndalíkönum, tveimur frumrannsóknum á efnahagslegu og félags-menningarlegu gildi vistkerfisþjónustu hvala og mati á stjórnhæfni vistkerfisþjónustu hvala. Niðurstöðurnar benda til margvíslegs ávinnings fyrir velferð manna og tengdra efnahags-, félags-menningar- og lífeðlislegra gilda frá vistkerfum í hafi, sem tengd eru vistkerfisþjónustu hvala í þeim samfélögum á Grænlandi, Íslandi og Noregi sem valin voru sem tilvik rannsóknarinnar. Ávinning frá vistkerfisþjónustu hvala má meðal annars sjá hvað varðar ferðaþjónustu, fræðslu, menningarlega sjálfsmynd, samfélagslega samheldni, hvalveiðar í bæði atvinnuskyni og fyrir frumbyggja, eflingu líffræðilegs fjölbreytileika, regluverk tengt vistkerfinu, innblástur fyrir listsköpun og tilvistargildi. Tilviksrannsóknirnar sýna að samfélagið í heild sinni nýtur ávinningsins með því að lifa í sátt og samlyndi við náttúruna og með góðri, marglaga stjórnun í gegnum formleg og óformleg samskipti. Greining á vistkerfisþjónustu hvala varpaði ljósi á félags-vistfræðilegt flækjustig sem undirstrikar mikilvægi þess að íhuga samhengið og margvísleg gildi vistkerfisþjónustu í stjórnun auðlinda hafsins á norðurslóðum. Þessi greining gaf einnig til kynna nauðsyn þess að rannsaka félags- og vist-fræðileg fyrirbæri saman sem hluta af þróunarkerfi jarðarinnar. Í kjölfar þessara athugana voru hugmyndalíkön þróuð þar sem þættir úr vistkerfisþjónustu, samframleiðsla þeirra og gagnvirkar stjórnunar- og stjórnhæfnikenningar voru samþættar. Niðurstöður á mati á stjórnhæfni sýndu fram á hátt flækjustig og gangverk tengd vistkerfisþjónustu hvala, hæfni aðila til að stjórna sér sjálfir og þörf fyrir sveigjanleg stjórnkerfi. Gildi aðferðafræðinnar og þeirra hugmyndalíkana sem þróuð voru í þessari rannsókn nær út fyrir norðurslóðir og er hægt að beita á aðrar náttúruauðlindir.

Preface

This thesis is a part of a work package in an international project, Nordic Centre of Excellence ARCPATH: Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies funded by NordForsk (grant number 76654), which funds and facilitates Nordic research cooperation and research infrastructure. The project is a part of the Joint Nordic Initiative on Arctic Research that was established to generate new insights into challenges and opportunities confronting the Arctic region. The ARCPATH project has three overarching, interdisciplinary objectives:

- To predict regional changes in Arctic climate over the coming decades using innovative methods to capture both anthropogenic and natural factors in global and high-resolution regional models.

- To increase understanding and reduce uncertainties regarding how changes in climate interact with multiple societal factors, including the development of local and regional adaptation measures.

- To combine improved regional climate predictions with enhanced understanding of environmental, societal, and economic interactions in order to supply new knowledge on potential "pathways to action".

This doctoral project sets out to examine the second objective and is a part of a work package entitled "Climate, Socio-Ecological Systems, Cetaceans and Tourism". This work package analyses the complex socio-ecological interactions between the climate and global change, together with cetacean distribution and ecology by studying the impacts of the fast-increasing activity of tourism in the Arctic (prior to the impacts of the COVID-19 pandemic), in particular with regard to whale-watching, as well as increased marine traffic, in tandem with the opening up of new northern sea routes and waters as sea ice diminishes. The ARCPATH project reflects the aims of larger on-going research efforts focusing on large-scale changes currently taking place in the Arctic, such as the activities of the Arctic Monitoring and Assessment Programme (AMAP), which include study of trends in biophysical changes in the Arctic, their socio-economic implications, and related policy trajectories, especially in the area of adaptation. Thus, changes in climate and Arctic social-ecological systems, coupled with rapidly varying economic and social developments, provide the background context for this PhD project.

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List of publications

This doctoral thesis is based on four journal articles, of which three have been published in high impact, peer reviewed scientific journals and one is in draft stage, and a published book chapter. These publications will be referred to in the text as follows:

Publication I: Chapter 3

Malinauskaite, L., Cook, D., Davíðsdóttir, B., Ögmundardóttir, H., & Roman, J. (2019). Ecosystem services in the Arctic: a thematic review. *Ecosystem Services*, *36*, 100898. https://doi.org/10.1016/j.ecoser.2019.100898

Publication II: Chapter 4

Malinauskaite, L., Cook, D., Davíðsdóttir, B., & Ögmundardóttir, H. (2020). Whale Ecosystem Services and Co-production Processes Underpinning Human Wellbeing in the Arctic: Case Studies from Greenland, Iceland and Norway. In D. C. Nord (Ed.), Nordic Perspectives on the Responsible Development of the Arctic: Pathways to Action (pp. 181-202). Springer International Publishing. https://doi.org/10.1007/978-3-030-52324-4_9

Publication III: Chapter 5

Malinauskaite, L., Cook, D., Davíðsdóttir, B., & Ögmundardóttir, H. (2021). Socio-cultural valuation of whale ecosystem services in Skjálfandi Bay, Iceland. *Ecological Economics*, *180*, 106867. https://doi.org/10.1016/j.ecolecon.2020.106867

Publication IV: Chapter 6

Malinauskaite, L., Cook, D., Davíðsdóttir, B., Ögmundardóttir, H., & Roman, J. (2020). Willingness to pay for expansion of the whale sanctuary in Faxaflói Bay, Iceland: A contingent valuation study. *Ocean & Coastal Management*, *183*, 105026. https://doi.org/10.1016/j.ocecoaman.2019.105026

Publication V: Chapter 7

Malinauskaite, L., Cook, D., Ariza, E., Davíðsdóttir, B., & Ögmundardóttir, H. (2021). Interactive governance of whale ecosystem services: governability assessment of three case studies in the Arctic. *(Manuscript under review in Ecology & Society)*

Abbreviations

ABA – Arctic Biodiversity Assessment

AMAP – Arctic Monitoring and Assessment Programme

ARCPATH – Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies

CAFF – Conservation of Arctic Fauna and Flora

CBD – Convention on Biological Diversity

CICES – Common International Classification of Ecosystem Services

CVM – Contingent Valuation Method

EBM – Ecosystem-Based Management

ES – Ecosystem Services

IUCN – International Union for Conservation of Nature

IWC – International Whaling Commission

KNAPK – Kalaallit Nunaanni Aalisartut Piniartullu Kattuffiat (Organization of Fishermen and Hunters in Greenland)

MEA – Millennium Ecosystem Assessment

MPA – Marine Protected Area

MSP – Marine Spatial Planning

NAMMCO – North Atlantic Marine Mammal Commission

NGO – Non-Governmental Organisation

PAME – Arctic Council's Working Group on Protection of the Arctic Marine Environment

SDG – Sustainable Development Goals

SES – Social-Ecological System

TEEB – The Economics of Ecosystems and Biodiversity

UN – the United Nations

WTP – Willingness-to-pay

Acknowledgements

This doctoral research is a part of the ARCPATH project funded by NordForsk (grant number 76654). I consider myself very lucky to have had the opportunity of being a part of such an international and interdisciplinary undertaking as well as getting to know and work with brilliant scientists from different fields. Being part of the project has really exposed me to the merits and challenges of trans- and inter-disciplinary work that is so important in sustainability research. I sincerely hope that this doctoral research is used to inform sustainability pathways in the Arctic, at least to some extent. I would also like to extend my gratitude to NordForsk and the University of Iceland's Doctoral Fund for their financial support that enabled me to do this work, as well as the Erasmus+ European researcher mobility grant that enabled me to spend a semester abroad as a visiting researcher at the Autonomous University of Barcelona. I am truly grateful for the opportunities and experiences that this funding provided me with.

I have been honoured to meet and work with distinguished interdisciplinary scientists, such as Dr Joe Roman from the University of Vermont, Dr Eduard Ariza-Solé from the Autonomous University of Barcelona, and Dr Lawrence Hamilton from the University of New Hampshire who, luckily for me, ended up being on my PhD committee. I would also like to extend my sincere gratitude to Bjargey Anna Guðbrandsdóttir, the coordinator of the Environment and Natural Resources programme at the at the University of Iceland, for her assistance in every step of the way and the two master students in the programme who helped to implement the socio-cultural valuation survey – Sarah Seabrook Kendall and Renée Blankenstein.

Most of all, I would like to thank my ARCPATH research team – Dr David Cook, Dr Brynhildur Davíðsdóttir and Dr Helga Ögmundardóttir. I really could not have done it without them. Their support, insights, knowledge, humour, and belief in me, which I might have lacked at times myself, made all the difference. I am extremely lucky to have had this experience of teamwork with very different but equally dedicated people, and I consider this to be the most precious lesson and invaluable experience that I will be taking away from this journey. I would also like to express my appreciation to my closest colleagues at the University of Iceland who have become close friends, especially Dr David Cook and Dr Ingunn Gunnarsdóttir. I have learned so much from them both, but most of all I appreciate their resourcefulness, comradery and ability to face adversity with optimism and a dry sense of humour.

I would also like to give thanks to my family and friends, near and far – for bearing with me for the past four years and always giving me the encouragement and support that I needed in every way they could. I wish I could have them all nearer to me, but I guess with global opportunities have to come some sacrifices. I especially want to thank my family for believing in me without always fully understanding what I am up to, and to the Abel-Coyne family who have been encouraging me to reach for whatever I set my mind on since I was 17 years old. I would not be where I am today without them.

Finally, I would like to thank and dedicate this work to the interviewees and survey respondents whose participation enabled this research. I thank them for their time and insights and am in awe of the commitment that many of them have to making their communities, the ocean, the Arctic, and the world a better place. I hope that at least some of the findings reflect what is important to them and their communities. And, of course, the whales, who have become my favourite animals since the start of this research. I hope that future generations get to experience their majestic presence the way we do.

1 Introduction

Cetaceans have been an important part of the lives of the communities in the Arctic for millennia. Humans have coexisted with marine mammals and benefited from them in terms of food, clothing, raw materials, social activities associated with their harvesting as well as cultural and spiritual identity in some indigenous societies in the region (Caulfield, 1997; Hovelsrud et al., 2008; Kalland, 1994). Whales, in particular, have contributed to sustenance and the cultural continuity of the Arctic people, such as the Inuit (Caulfield, 1993; Freeman, 1998; Sakakibara, 2017). Between the seventeenth and twentieth centuries, commercial whaling in the Arctic depleted whale stocks dramatically, but its effects have been partly averted and stabilised since the establishment of the International Whaling Commission (IWC) in 1946 and the moratorium imposed on commercial whaling in 1986, which resulted in the discontinuation of commercial whaling with the exceptions of Iceland, Norway and Japan (Ackerman, 2002; IWC, 1946). Strict harvesting quotas mean that overharvesting is no longer the biggest threat to whales in the Arctic, with climate change (Chambault et al., 2020; Huntington et al., 2017) and the consequent development of extractive industries, shipping and tourism emerging as new threats (CAFF, 2015; Lusseau & Bejder, 2007). Huntington (2009) lists six main areas of human influence on marine mammals in the coming decades: climate change, environmental contaminants, offshore oil and gas activities, shipping, hunting, and commercial fishing. Various marine management regimes aimed at protecting whale stocks exist under the designations of international organisations and governments, yet there is a lack of universal guidance on how these activities should be managed (Ritter, 2003).

The relationship between marine mammals and people in the Arctic region[1] has changed not only in terms of threats but also in the ways that communities connect to and utilise these species (Worden et al., 2020). Appreciation of wildlife and its intrinsic values is a major motivation for species conservation, and aesthetic enjoyment of cetaceans facilitated the development of whale watching, which is now a global, multimillion-dollar industry (O'Connor et al., 2009). In the Arctic, whale watching has been growing steadily since the 1990s, and has now become one of the main attractions in remote coastal areas. Whale watching is a non-consumptive yet resource-dependent industry, which provides motivation for the conservation of marine mammals and creates a potential conflict with other industries that affect whales, the most controversial of which is commercial whaling (Bertulli et al., 2016; Parsons & Rawles, 2003; Rasmussen, 2014). The disputes between whaling and whale-watching companies in Faxaflói Bay in southwest Iceland is an example of the potential trade-off between the two activities, which at least partly motivated the creation of two whale sanctuaries in Faxaflói and Skjálfandi bays, the nation's most popular whale watching destinations. Whaling and whale watching also coexist in Norway and Greenland, the other case study countries in this research, with the latter mostly engaging

[1] The Arctic in this research refers to the Earth's northernmost region centred on the North Pole and is characterised by polar conditions of climate, plant and animal life, and other physical features (Dunbar et al., 2019). The geographical definition of the Arctic refers to the regions north of the tree line, but the definition used in this thesis extends beyond this geographical area to a broader context of the Arctic states that includes ecological, economic, social, political, and security matters (Arctic Council, 2016).

in indigenous subsistence whaling, which is important to consider when discussing their significance to communities (Caulfield, 1997; Mosbech et al., 2018).

Since the wellbeing benefits of as well as threats to marine mammals outlined above are anthropogenic, it is important to include human preferences in environmental decision-making. One way of doing this is exploring how people value marine mammals in absolute and monetary terms and what role they play in the socio-cultural and economic lives of local communities. For this purpose, the concept of ecosystem services (ES) is employed, referring to the benefits that people obtain from ecosystems (MEA, 2005). There is a general consensus in the contemporary environmental sustainability debate that humans draw multiple benefits from ecosystems and that the ability of ecosystems to provide the services necessary for human survival is being hindered (Jacobs et al., 2016; Pascual et al., 2017). This is true for many ES around the planet (Dasgupta, 2021), and the concept has proved to be a useful way of thinking about human-nature interactions in social-ecological systems (SES) (Arctic Council, 2016; Berkes et al., 2000; Reyers et al., 2013). The ES topic has been little explored in the context of the Arctic, most notably through focused scoping studies in the Millennium Ecosystem Assessment (MEA) (Chapin et al., 2005), Arctic Biodiversity Assessment (ABA) (Huntington, 2013), and The Economics of Ecosystems and Biodiversity (TEEB) Scoping Study by the Conservation of Arctic Flora and Fauna (CAFF, 2015), all of which called for more research in this area. The ES concept has been applied to an even lesser extent for studying the benefits provided to humans by whales, with a few exceptions (Riisager-Simonsen et al., 2020; Roman et al., 2014; Roman and McCarthy, 2010). An inventory of whale ES and appropriate valuation methods was also elaborated in a recent study by Cook et al. (2020b), which is affiliated with and sets the background for this doctoral research.

Answering the call for inter- and trans- disciplinarity in Arctic research (Baztan et al., 2017; Falardeau & Bennett, 2019), this doctoral thesis explores the links between social and ecological domains through the concept of ecosystem services in order to identify the values, trade-offs and governance strategies for whale ES in the Arctic, using a systematic literature review, economic and sociocultural ES valuation, case study analysis, and governance assessment.

1.1 Arctic social-ecological systems

"Perhaps its greatest value lies in its metaphor of a living Earth, which reminds us that we are part of it and that human rights are constrained by the needs of our planetary partners." James Lovelock (2003, p. 770) on Gaia Theory

Around four million people live in the Arctic today, most of them in coastal areas, which means that they are in close interaction with marine ecosystems that are affected by human activities and vice versa (CAFF, 2015; Hovelsrud et al., 2008; Huntington, 2013; Meek et al., 2011). It is becoming increasingly clear that human and natural systems are not separate but interdependent entities, and therefore need to be studied together as SES (Arctic Council, 2016; Berkes et al., 2000). Social-ecological resilience in this context refers to a system's capacity to adapt or transform in the face of SES change in ways that continue to support human wellbeing (Biggs et al., 2015; Folke et al., 2016). One of the ways in which human wellbeing benefits can be conceptualised and measured is through ES resulting from human-environment interactions (Fischer & Eastwood, 2016; Palomo et al., 2016;

Solé & Ariza, 2019). Fig. 1, sourced from Arctic Council (2016, p. 12), illustrates these interactions that include the supply of ES and feedback mechanisms within SES. In this schematic, ecosystem structures and processes that enable ecosystem functions and ES are affected by human activities, which are affected by individual and collective preferences and choices guided by societal institutions and values. The left side of the graph represents the demand side of ES, while the right – the supply side. ES in this model occur at the interface between the supply and demand sides. This delineates the direction of ES provisioning from ecosystems to humans that enhances their wellbeing. An important part of the schematic to note here is human agency, through which a directed change can happen through the institutions, values, and choices that affect ecosystems and, in turn, provision of ES. This is important in the context of this research and its focus on human values and agency in relation to whale ES.

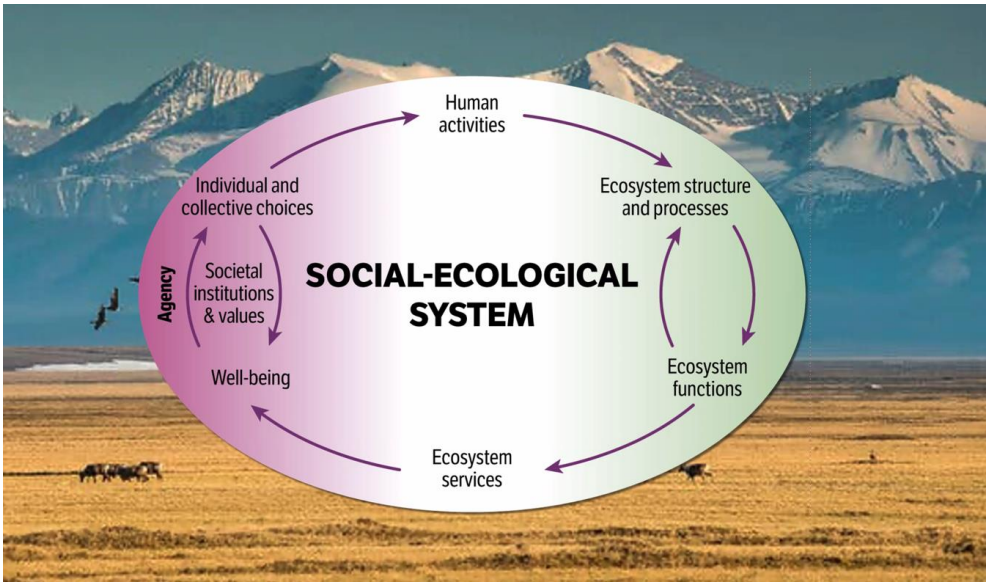

Figure 1 Social and biophysical sub-systems linked by ES. Sourced from Arctic Resilience Report (2016).

Arctic communities and ecosystems are greatly affected by the phenomena of climate change and globalisation. The change in surface air temperatures in the Arctic is more than twice the global average due to the feedbacks from loss of sea ice and snow cover contributing to the amplified warming (IPCC, 2019), with many Arctic species threatened with extinction as their northernmost habitats are disappearing (Evans & Bjørge, 2013; Michel, 2013). At the same time, melting Arctic Ocean sea ice opens up new opportunities for marine transport and natural resource extraction, attracting the attention of local and global actors alike (Stocker et al., 2020). The Arctic is one of the last places on Earth with such untapped opportunities, and this fact presents its own implications to Arctic SES, such as ecosystem and biodiversity change (CAFF, 2017) and socio-demographic impacts of industry development (Andrew, 2014).

The SES concept has been employed in the contexts of natural resource management (Lebel et al., 2006; Meek et al., 2011; Olsson et al., 2004; Ostrom, 2007, 2009), resilience

(Berkes et al., 2000; Biggs et al., 2015; Folke et al., 2016; Forbes et al., 2009; Walker et al., 2006), adaptation to social and environmental change (Folke et al., 2005; Koenigstein et al., 2016), and ES (Outeiro et al., 2017; Rodrigues et al., 2017; Solé & Ariza, 2019), among others. Perhaps the most notable publication to date that focused on social-ecological dynamics in the Arctic is the Arctic Resilience Report (2016), and this body of literature is growing. For instance, the SES concept has been applied in the context of Saami reindeer pastoralism in northern Norway (Tyler et al., 2007), tundra SES in Western Siberia (Forbes et al., 2009), climate change adaptation in north-western Canada (Berkes & Jolly, 2002), and recently – to the whole Arctic Ocean (Crépin et al., 2017). Since most Arctic communities live by the coast and many of them are dependent on marine ES for their economic and cultural wellbeing as well as sustenance (CAFF, 2017; Huntington et al., 2017), this makes SES an appropriate analytical lens for studying whale ES in Arctic coastal communities.

1.2 Ecosystem services and co-production

The concept of ES links biophysical structures and processes to human wellbeing and agency and it is therefore important to look into the processes through which ES are formed (Fischer & Eastwood, 2016; Spangenberg et al., 2015). These processes involve natural as well as social capital, and the latter has been largely overlooked in ES analysis to date (Outeiro et al., 2017; Palomo et al., 2016). To reveal the human dimensions in ES formation, (Spangenberg et al., 2014b) suggested adding co-production processes to the widely used five-stage ES cascade model by Haines-Young and Potschin (2010). In the resulting Fig. 2, the original ES cascade stages – biophysical structure – function – service – benefit – value – are altered and explained as the results of human-nature co-production processes of use value attribution, ES potential mobilisation, appropriation and commercialisation (Spangenberg et al., 2014b, p. 26).

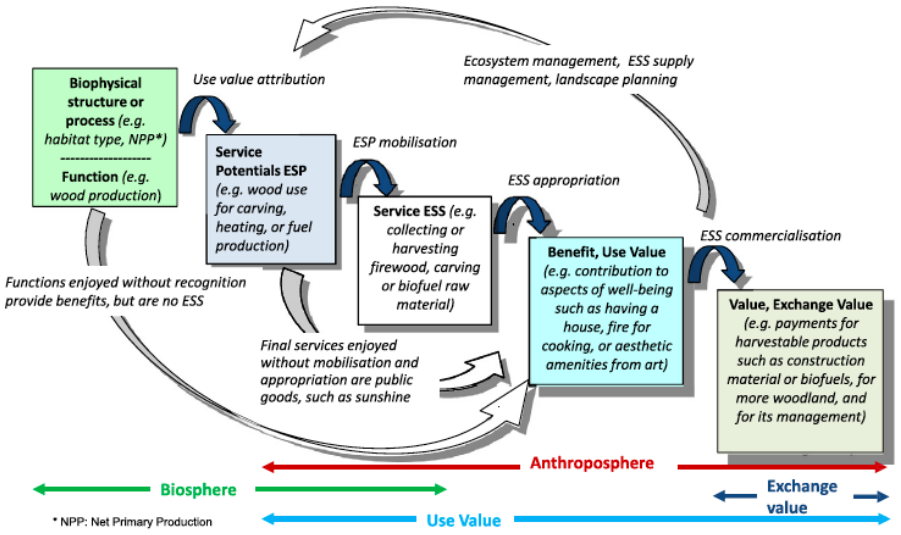

Figure 2 ES cascade model with co-production processes. Sourced from Spangenberg et al. (2014).

The details of ES co-production are further elaborated in Publication II of this thesis, but it is important to note here that ES formation requires natural, built, financial, and human capital (Outeiro et al., 2017; Palomo et al., 2016). While sourced from the biosphere, ES actually occur in the anthroposphere, making it an anthropocentric construct. Understood in these terms, ES valuation essentially aims to measure and quantify human wellbeing benefits that stem from ES and related co-production processes that can be as valuable for ES users as the end product because they often constitute important elements of sustenance, social identity, and place-based values (Fischer & Eastwood, 2016; Rodrigues et al., 2017).

1.3 Valuing whale ecosystem services

Three main ES classification systems typically used in research and policymaking are the Millennium Ecosystem Assessment (MEA, 2005), The Economics of Ecosystems and Biodiversity (TEEB) (Pascual et al., 2010), and the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin, 2018). The latter has gained prominence in the past decade; it is used by the European Union and the United Nations as it combines and simplifies the MEA and TEEB typologies, providing a more coherent approach to ES valuation and trade-off analysis. The CICES classification was developed in accordance with the ES cascade model, an edited version of which is presented in Fig. 2, and therefore links well with the ES theory used in this research. These reasons determined the selection of this ES classification system for this project. To date, the most comprehensive inventory of whale ES according to the CICES classification was made by Cook et al. (2020b)[2]. According to this list, which is presented in Table 1, the most numerous whale ES are cultural, followed by provisioning, and then regulation and maintenance.

Table 1 Whale ES CICES classification

Section	Division	Group	Class	Class type	Service
Provisioning (biotic)	Biomass	Animals for nutrition, materials or energy	Wild animals	By amount of product	Food products (meat, blubber, skin and intestines)
Provisioning (biotic)	Biomass	Animals for nutrition, materials or energy	Wild animals	By amount of product	Whale bones, teeth and baleen
Provisioning (biotic)	Biomass	Animals for nutrition, materials or energy	Wild animals	By amount of product	Oil-based products deriving from blubber
Regulation and maintenance (biotic)	Regulation of physical, chemical and biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats (including gene pool protection)	By amount and source	Enhanced biodiversity and evolutionary potential

[2] The author of this doctoral thesis was one of the co-authors of this study, but it is not included in the list of publications as she was not the first author.

Regulation and maintenance (biotic)	Regulation of physical, chemical and biological conditions	Water conditions	Regulation of chemical composition of atmosphere and oceans	By type of living system	Climate regulation (carbon sequestration)
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	By type of living system or environmental setting	Tourism (whale watching)
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems used for entertainment or representation	By type of living system or environmental setting	Music and arts (entertain-ment)
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems used for entertainment or representation	By type of living system or environmental setting	Sacred and/or religious
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable education and training	By type of living system or environmental setting	Educational
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable aesthetic experiences	By type of living system or environmental setting	Aesthetics
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that are resonant in terms of culture or heritage	By type of living system or environmental setting	Community cohesiveness and cultural identity
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an existence value	By type of living system or environmental setting	Existence
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an existence value	By type of living system or environmental setting	Bequest

Reproduced from Cook et al. (2020)

Some whale ES benefit humanity as a whole, e.g., regulation and maintenance ES, while others, such as the cultural ES of community cohesiveness and cultural identity or the provisioning ES of whale food products, depend on the socio-cultural and socio-economic context and values held by local beneficiaries. For this reason, ES valuation has to take into consideration socio-cultural and socio-ecological context and allow for plural values assigned by people to different ES (Jacobs et al., 2016; Martín-López et al., 2014; Martínez et al., 2013; Pascual et al., 2017). Otherwise, there is a risk of value oversimplification as well as ineffective or even harmful policy decisions based on the results of inappropriate ES valuation techniques, and injustices towards some parts of society whose worldviews are in danger of being left out of ES assessments (Berbés-Blázquez et al., 2016; Kosoy & Corbera, 2010; McDermott et al., 2013).

According to Martín-López et al. (2014), ES value domains can be classified into biophysical, socio-cultural and monetary. The first domain concerns the ecosystem qualities that determine ES delivery and can be measured by biophysical indicators, such as species populations' number and density or water quality. The second value domain refers to direct and indirect ES contributions to users' wellbeing through non-monetary means, such as cultural identity and spiritual experiences, social cohesion, and relationships supported by ES co-production, use, and management. These values can be measured using socio-cultural value indicators that reflect ES importance to users without the placing of a monetary value, e.g., through preference scales. The third domain has to do with ES contributions to human welfare in terms individual utility, which can be estimated by eliciting monetary values of ES, often through reference to the Total Economic Value (TEV) framework (Pearce & Moran, 2013). The biophysical value domain relates to the "supply side" of ES as it represents the biophysical structures underlying their formation, while socio-cultural and monetary – the "demand side" delineated in Fig. 1. This doctoral research is primarily concerned with the latter, i.e., how whale ES contribute to human wellbeing, as it explores the monetary and socio-cultural value domains of whale ES. As human wellbeing and values affect their choices and subsequently human impacts on ecosystems and their ability to provide ES, it is important to study them in the context in which they occur, so that human agency can potentially be directed in the ways that benefit SES as a whole.

A list of indicators for assessing ecosystem services and disservices of marine mammals was recently delineated by Riisager-Simonsen et al. (2020), and appropriate valuation methods for each whale ES was elaborated by Cook et al. (2020b). They are outlined in Table 2 below.

Table 2 Whale ES – valuation using monetary or non-monetary information

CICES classification of ecosystem service impact	Value impacts economically?	Likely valuation method(s)	Component of the TEV framework
Provisioning			
Food, oil-based, bone, baleen and teeth-based products	Yes / no	Market pricing; non-monetary valuation techniques — qualitative and/or quantitative	Use (direct) or N/A
Regulation and maintenance			
Climate regulation (carbon sequestration)	Yes	Marginal abatement costs; marginal damage costs	Use (indirect)

Enhanced biodiversity and evolutionary potential	Yes	Production function or contingent valuation	Use (indirect) and non-use
Enhanced primary production	Yes	Production function or contingent valuation	Use (indirect)
Cultural			
Tourism (whale watching)	Yes	Market pricing or travel cost method	Use (direct)
Whale music and arts (entertainment)	Yes/no	Market pricing or contingent valuation	Use (indirect)
Education	Yes/no	Market pricing or travel cost method	Use (direct and indirect)
Sacred and/or religious	No	Non-monetary valuation techniques — qualitative and/or quantitative	N/A
Community cohesiveness / cultural identity	No	Non-monetary valuation techniques — qualitative and/or quantitative	N/A
Aesthetics	Yes/no	Contingent valuation	Use (indirect) and non-use
Existence and bequest	Yes/no	Contingent valuation or discrete choice experiments; non-monetary valuation techniques — qualitative and/or quantitative	Non-use or N/A

Adapted from Cook et al. (2020)

The valuation methods for different whale ES outlined in Table 2 were selected according to whether ES values are formed individually or collectively and to which value domain they belong. In some cases, where market prices exist for ES, e.g., whale meat or a whale watching ticket, and ES values are formed individually, monetary valuation might be appropriate. In other cases, where ES values are formed collectively and the monetary value dimension of ES is not relevant, e.g., for sacred and religious or community cohesiveness and cultural identity, it might not. The valuation methods used in this thesis were socio-cultural valuation and the contingent valuation method. They were selected taking into consideration the whale ES that were analysed, which consisted mostly of cultural ES.

1.4 Policy context

The policy context of this thesis is informed by the Sustainable Development Goal (SDG) 14 — Life Below Water — especially its targets 14.2 on increasing marine ecosystem resilience and promoting ecosystem-based management; 14.5 on marine conservation; and 14.c on governance for the conservation and sustainable use of marine resources (United Nations, 2016). These SDG 14 targets correspond to the goals set out in the Arctic Marine Strategic Plan 2015–2025 (Arctic Council, 2015) to: (1) improve knowledge of the Arctic marine environment, and continue to monitor and assess current and future impacts on Arctic marine ecosystems; (2) conserve and protect ecosystem function and marine biodiversity to enhance resilience and the provision of ES; (3) promote safe and sustainable use of the marine environment, taking into account cumulative environmental impacts; (4) enhance the economic, social and cultural well-being of Arctic inhabitants, including Arctic indigenous peoples and strengthen their capacity to adapt to changes in the Arctic marine environment. The presented research is strongly linked to the goals (2) and (4) in terms of its focus on whale ES, their co-production, and impacts on human wellbeing. The whale ES valuation work presented in this thesis also corresponds to the Element 5 of the guide-

lines for implementation of an ecosystem-based approach to management of human activities in Arctic marine and coastal environments by the Arctic Council's Working Group on the Protection of the Arctic Marine Environment (PAME): to value the cultural, social and economic goods produced by the ecosystem, which is closely connected to the other five elements of the framework[3] (Logerwell & Skjoldal, 2019).

Perhaps the most comprehensive global study on Arctic ES to date — the TEEB Scoping Study for the Arctic (CAFF, 2015) — argues that incorporating ES in natural resource policy is required in order to define and balance societal needs and priorities in the rapidly-changing Arctic SES. It highlights the importance of identification and assessment of Arctic ES and finds the analysis of ES bundles on local scales to be the most informative. The key findings of the scoping study recognise the high level of uncertainty and need for a holistic approach to ES. In terms of Arctic ES valuation and implications for governance, some of the report's key findings (CAFF, 2015, p. 10) imply that:

- "recognizing, demonstrating and capturing the diverse values of ES in policy instruments for strategic planning and integrated management of natural resources and space can help reconcile biodiversity conservation with development"
- "capturing the benefits and the scarcity of Arctic ES in economic policies promotes the improvement of economic models and processes"
- "taking an interdisciplinary approach that combines economic and socio-cultural analyses to the benefits people receive from Arctic nature faces a number of challenges and concerns, but it also offers a complementary approach for communicating to decision-makers the importance of nature to people, and a toolkit for evaluating policy options and integrating stewardship into decisions"
- "the ES link is crucial when striving for sustainable management of complex social-ecological systems, and valuation in this context can provide powerful information for evaluating alternative management strategies"
- "effective, equitable and sustainable policy must account for a diversity of perspectives and encompass a diversity of value systems".

Adaptation to climate change is an integral part of the of the policy strategies of the above-mentioned documents, especially those focused on the Arctic. Adapting to the big scale changes that take place in the region and play out in SES and ES on a local scale requires joint governance efforts on behalf of the multiple state and non-state actors operating in the region (Barry et al., 2020; Cole et al., 2016; Meek et al., 2011; Young, 2010). As explained in the final Publication V of this thesis, governance in this research refers to "the aggregate of governing activities carried out by societal actors in response to public needs and visions" (Kooiman & Bavinck, 2013, p. 2). The quality of governance is then referred to as governability and it can be assessed based on its components and qualities, pointing to where improvements could be made (Kooiman, 2008).

[3] The six interlinked elements of the framework are as follows: (1) identifying the geographical extent of the ecosystem; (2) describing the biological and physical components and processes of the ecosystem including humans; (3) setting ecological objectives that define sustainability of the ecosystem; (4) assessing the current state of the ecosystems; (5) valuing the cultural, social and economic goods produced by the ecosystem; and (6) managing human activities to sustain the ecosystem.

As top predators of the Arctic marine ecosystems, marine mammals have been suggested as a "nexus" for multi-scale Ecosystem-Based Management (EBM[4]) because they have to adapt to anthropogenic environmental changes, acting as sentinels to marine ecosystem dynamics; and as a fundamental part of the Arctic indigenous peoples' culture and nutrition, they provide a link between ocean and human health (Fernandez et al., 2016). Laidre et al. (2015) provides six recommendations for marine mammal management for the 21st Century: maintaining and increasing co-management by local, governmental and international entities; understanding that species and populations exhibit variable responses to climate change over time and space; improving monitoring; understanding and mitigating cumulative impacts from industrial activities; recognising the utility and limitations of protected species legislation in a changing Arctic; and practicing forward-looking conservation that incorporates scientific evidence on species status with value based-conservation, including the communication of accurate information to the public. This doctoral thesis is primarily concerned with the first and last recommendations, which are addressed through analysis of whale ES co-production, values, and governance using case study research and a multi-method approach.

1.5 Research objectives and structure

The overarching aim of this doctoral thesis is to examine the ES of whales in the Arctic and socio-ecological dynamics associated with them through investigation of the existing research and gaps, the values that people attach to whale ES, how they are changing, and how they could be governed in a more sustainable and equitable manner.

The five main research questions aimed at fulfilling this objective are as follows:

1. What research has been done on Arctic ecosystem services so far and how much of it relates to marine mammals, including whales?
2. What are the different processes and actors involved in whale ES coproduction in the case study social-ecological systems?
3. How do people value the ES provided by whales in the Arctic?
4. How can the valuation of whale ES be used to inform their governance?
5. What governance strategies have been applied in the Arctic to stabilise whale populations and their ES? What are the actors, institutions, processes, synergies and trade-offs involved? What is the extent of their governability?

By answering these research questions, the thesis aims to map out ES research in the Arctic, identifying and filling some of the gaps, and applying the ES perspective advocated by the Arctic Council (2015) in the analysis of marine resource use and management. The focus on whale ES enables narrowing it down to one particular area in order to focus on one part of the overwhelming complexity of marine resource dynamics. It could thus be said that whales serve as a prism through which socio-ecological dynamics are analysed.

[4] EBM is defined by the Arctic Council as per the 2013 Kiruna Declaration as "the comprehensive integrated management of human activities based on best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of ecosystems thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity" (Arctic Council, 2013b).

The thesis consists of five publications that correspond to the main research questions outlined above in the following manner. Publication I (Chapter 3) sets out to answer the first research question through a systematic literature review exploring the body of literature on Arctic ES to date, as well as the main themes and gaps, forming the groundwork for further research on the topic. Publication II (Chapter 4) explores the second research question by combining the notions of the ES cascade, co-production, and case study analysis. This results in a new conceptual ES co-production model for whale ES based on the empirical data from three Arctic coastal communities. The model reveals how these ES are formed through closely intertwined social and ecological processes involving natural and human capital inputs. Publications III and IV (Chapters 5 and 6) correspond to the third and fourth research questions related to whale ES and potential usefulness of ES valuation for decision-making. They do so through socio-cultural and monetary valuation studies of whale ES and their management arrangements in two Icelandic locations. Finally, Publication V (Chapter 7) is guided by the fourth and the fifth research questions as it continues to explore the implications of whale ES values for their governance, mapping out and assessing the governance strategies for these ES in three case study locations in Iceland, Norway and Greenland from the interactive governance and governability theoretical perspective. The summaries of the aims and main findings of each paper are described in the section 1.7, and the publications follow in the order presented above.

1.6 Case study approach and locations

"*The most advanced form of understanding is achieved when researchers place themselves within the context being studied*" (Flyvbjerg, 2006, p. 236).

A case study approach is applied in this doctoral research in order to explore whale ES formation, values and governance in the real-life context of coastal communities in the Arctic (Yin, 2017). Well executed case study research presents context-dependent information that is relatable to people from different backgrounds and reveals how social phenomena play out (Flyvbjerg, 2006). The case study locations explored in the Publications II–V were partly pre-determined by the ARCPATH project as the other work packages focused on climate change data and marine mammal distribution in specific areas in the Arctic. This resulted in the presented research being somewhat location specific as it sets out to explore the socio-ecological dimensions of the changes in the Arctic through analysis of whale ES.

However, for the sake of comparability of case studies and due to sudden changes in the whale distribution in a part of the study area originally planned by the ARCPATH project, some of the case study locations were altered. The case study location of Tromsø in Norway was thus replaced with Andenes due to the sudden departure of whales from Kaldfjord fjord near Tromsø in the winter of 2017/2018, the reason for which is still not entirely clear but suspected to be the northward shift of herring, according to the interview data. Another reason for the change of the case study was the relative comparability of the town of Andenes in Norway to the town of Húsavík in Iceland in terms of the population size and the role played by cultural whale ES in the local community. Similarly, Ittoqqortoormiit in Eastern Greenland was replaced with Disko Bay in the western part of the country due to limited presence of whales and less developed tourism sector in the former. The fact that the case study locations had to be altered during the course of the four-year research pro-

ject confirms the need for sustainability research to be flexible and adaptable when socio-ecological phenomena are constantly changing.

Whale ES are theorised in this thesis as a result of human-nature interactions within SES, and four such systems in different locations are analysed. Three case study locations — Húsavík in Iceland, Andenes in Norway, and Disko Bay in Greenland — are examined in Publications II and V in relation to whale ES co-production and interactive governance and governability, respectively; the case study of Húsavík is also discussed in Publication III when assessing the local socio-cultural values of whale ES in a community context; and the case study of Faxaflói Bay, near the Reykjavík capital area in Iceland, is used in the monetary valuation of whale ES management regime change in Publication IV.

Húsavík is a town located in Skjálfandi Bay, northeast Iceland, with just over 2,300 inhabitants (Statistics Iceland, 2019). The most typical species in Skjálfandi Bay are humpback (*Megaptera novaeangliae*) and minke (*Balaenoptera acutorostrata*) whales, along with white beaked dolphins (*Lagenorhynchus albirostris*) and harbor porpoises (*Phocoena phocoena*), with blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), sei *Balaenoptera borealis*), northern bottlenose (*Hyperoodon ampullatus*), long-finned pilot (*Globicephala melas*) and killer whales (*Orcinus orca*) making an occasional appearance (Martin, 2012; Rasmussen, 2009). The abundance of these species in the bay has been attracting visitors since the early 1990s, and whale watching has since become the main tourist attraction in town, drawing more than 100,000 visitors per year prior to the COVID-19 pandemic (Icelandic Tourist Board, 2020). Located in Skjálfandi Bay, Húsavík is the self-proclaimed "whale capital of Iceland", and cetaceans play an important role in its economic, social and cultural lives. Even though whaling has never been important in Skjálfandi Bay, the perception of whales as a food source typical to fishing communities in the Arctic quickly changed from "good to eat" to "good to watch", changing how local people relate to and value whales (Einarsson, 2009; Huijbens & Einarsson, 2018). This change and the dependence of the local community on whale watching tourism makes it an interesting case study for assessing the socio-cultural values of whale ES in a community context.

The Norwegian case study community explored in this research is Andenes, a town in the northern region of Vesterålen with around 2,700 inhabitants (Statistics Norway, 2019). The most common species of whales observed in the waters within close vicinity of Andenes are sperm (*Physeter macrocephalus*), minke, and long-finned pilot whales, with orcas, humpback and fin whales being more common in the winter (Cosentino, 2016; Sea Safari Andenes, 2021). Whale watching started in the late 1980s and has since become the main pillar of the region's tourism industry. There are plans to commence The Whale project in Andenes, which will consist of an interactive exhibition, conference venue, and cultural centre, aiming to diversify the tourism industry and lengthen the time that whale watching visitors spend in the town (The Whale, 2019). The community's reliance on whale watching as the main tourist activity attracting visitors from all over Europe and the world, the year-round presence of whales, and its comparability to the other case studies in terms of size and whale ES, determined its selection as a case study in this doctoral research.

The third case study of Disko Bay is the largest open bay in western Greenland, measuring 150 km north to south and 100 km east to west. The main town, Ilulissat, is the third largest settlement in Greenland with just over 4,500 inhabitants (Statistics Greenland, 2019). It has become a popular tourist destination in the years prior to the COVID-19 pandemic, offering various tourist activities, including whale watching and visits the local ice fjord.

The main species of whales in Disko Bay are bowhead (*Balaena mysticetus*), humpback, minke, beluga (*Monodon monoceros*), and narwhal (*Monodon monoceros*). Unlike in the other case studies, Greenlanders in Disko Bay engage in indigenous whaling of minke, fin, humpback, bowhead whales and narwhals, which is important for food security and the cultural identity of the local population (Caulfield, 1997; Suydam & George, 2021). Climate change impacts in Greenland are the most strongly felt of all the case study locations of this research, affecting the ecosystems and accessibility to natural resources. The co-existence of whale watching and indigenous whaling activities and market and subsistence economies in Disko Bay, acutely felt local effects of climate change, as well as somewhat similar development trajectories of the local SES to those in Húsavík and Andenes in terms of expansion of tourism determined the selection of this study case.

Since the presented research concerns multiple benefits that humans receive from whales through ES, it is important to consider their different uses, including whaling, not the least because of the global controversy that surrounds this activity (Asdal & Hobæk, 2016; Mattes, 2017; Parsons & Rawles, 2003; Williams, 2006). All three case study countries — Iceland, Norway and Greenland — are whaling countries. Iceland and Norway engage in commercial whaling, either under objection to the International Whaling Commission's (IWC) 1982 moratorium on whaling, or under reservation to it (Birnie, 1983; IWC, 2020), while Greenland's inhabitants practice indigenous whaling as part of their cultural heritage and subsistence (Caulfield, 1993, 1997; Suydam & George, 2021). These activities are described in more detail in the Publications II and V of this thesis (Chapters 4 and 7).

All three case study countries are subject to international governance by the IWC and the North Atlantic Marine Mammal Commission (NAMMCO) (NAMMCO, 1992). As they are all whaling countries, their annual quota for whaling is set by national agencies in accordance with rules outlined in the procedures of the Scientific Committee of the IWC (Punt & Donovan, 2007) (Appendixes 1, 2 and 3). In terms of whale watching, there are voluntary codes of conduct on how to approach whales in Iceland and Norway, which have been developed by the national whale watching operators' associations of IceWhale and NorWhale. In Disko Bay, the rules for approaching whales are set by the local Avanaata municipality in Ilulissat, according to the interview data. None of the three case study countries have designated marine protected areas (MPAs) for protection of whales in accordance with the International Union for Conservation of Nature's (IUCN) definition as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (IUCN 2016, in CAFF & PAME, 2017, p. 4).

There are two whale sanctuaries and one specialised sanctuary for belugas previously kept in captivity in Iceland, but none of them have a formal MPA status (Cook et al., 2019). Whale ES related to tourism and whaling in Iceland are under the jurisdiction of the Ministry of Industries and Innovation (Appendix A). The annual quota for harvesting minke and fin whales is set by the Marine and Freshwater Research Institute. This quota has not been reached since the recommencement of commercial whaling in the country in 2003, and whaling has not taken place in the Icelandic waters since 2018. The reasons quoted for this are the maintenance costs of the whaling fleet in 2019, the diminishing demand related to the departure of Japan, the biggest export market for fin whale meat, from the IWC, as well as the COVID-19 pandemic, which made whale meat processing almost impossible (Bjarnason, 2020).

In Norway, the governance of provisioning whale ES is mostly under the jurisdiction of the Ministry of Trade, Industry and Fisheries (Appendix B), namely the Norwegian Fisheries' Directorate, which is advised by the Institute of Marine Research. Since the restarting of commercial whaling operations in 1993 under the objection to the IWC Moratorium on Whaling in 1986, Norway has been harvesting minke whales but rarely used up its quota. In 2020, the domestic demand for minke whale meat in Norway rose for the first time in years, which is related to the marketing of whale meat as a sustainable local food resource and the fact that Norwegian citizens travel inside Norway since the introduction of international travel restrictions due to the COVID-19 pandemic (Bjørnseth, 2020). Most whale watching in Norway takes place in the north-western part of the country, especially in Lofoten and Vesterålen, which is the location of the Norwegian case study in this research – Andenes.

In Greenland, most decisions about whale harvesting are made by the Ministry of Fisheries, Hunting and Agriculture following the advice of the Institute of Natural Resources (Appendix C) and consultations with the Organization of Fishermen and Hunters in Greenland – KNAPK. Apart from the whaling quotas set according to the IWC recommendations, there are no official national policy measures or conserving whales in Greenlandic waters. Despite this fact, the local whale populations have been increasing in the decades following the 1986 IWC moratorium on whaling (Heide-Jørgensen et al., 2007; Ugarte et al., 2020).

Due to perceived trade-offs between commercial whaling and whale watching, a whale sanctuary was established in Faxaflói Bay in 2007, following the resumption of commercial whaling in 2003 (Althingi, 2006). The whale species most commonly observed in the bay include minke, humpback and fin whales, along with white-beaked dolphins and harbour porpoises, blue whales make occasional appearances in summer months (Rasmussen, 2014; Sigurjónsson & Víkingsson, 1997). Partly in response to the rapid growth of the Icelandic tourism industry and subsequent expansion of whale watching activities, the sanctuary was enlarged in 2013 and again in 2017 by a change in the regulation 1035/2017, which also declared Skjálfandi Bay a whale sanctuary due to its importance as a whale watching destination (Government of Iceland, 2017). The most recent expansion of the Faxaflói Bay Whale Sanctuary includes the vast majority of the area previously used for whaling, which made whaling operations less profitable as boats have to go farther out to sea, away from the whaling station located in Hvalfjörður in the eastern part of the bay. Some of the implications of this expansion are discussed in more detail in Publication IV, together with a monetary valuation of a hypothetical further expansion of the sanctuary that would likely further reduce provisioning whale ES in the area and increase ES related to tourism and recreation.

1.7 Summary of methods and results

1.7.1 Publication I

Malinauskaite, L., Cook, D., Davíðsdóttir, B., Ögmundardóttir, H., & Roman, J. (2019). Ecosystem services in the Arctic: a thematic review. *Ecosystem Services*, *36*, 100898.[5] https://doi.org/10.1016/j.ecoser.2019.100898

The first paper, a literature review of Arctic ES, sets the background for the rest of the thesis. It was motivated by the limited number of publications focusing on Arctic ES and the fact that there was no literature review on the topic. The article presents the first systematic review of the literature on Arctic ES, highlighting the main themes and research gaps. It aims to answer the first research question of the doctoral thesis by setting the background on the Arctic ES research to date and providing an orientation point for the commencement of future research projects, such as the following papers on whale ES valuation and governance.

The research objectives set out in the paper were as follows:

1) To provide a meta-synthesis of the existing literature that applies the ES concept in an Arctic context.
2) To map out existing publications on the subject from 2005 (when Millennium Ecosystem Assessment was done) to 2018 (when the literature review was executed) and list the main re-emerging themes and gaps in the Arctic ES research to date.

The study applied the Search, Appraisal, Synthesis and Analysis (SALSA) and snowballing methods and used three selection criteria: use of ES concept, locality, and date of publication. The first criterion required that the concept of ES is applied in a meaningful way and not simply as a buzzword, the second criterion – that the content is discussed in relation to the Arctic, and the third — that the date of publication is 2005 or later (up to 2018). The first Search stage involved searching four major academic databases (Science Direct, Scopus, Web of Science and Google Scholar), using relevant keywords and Boolean strings to identify relevant publications that applied the ES concept in an Arctic context within the selected timeframe. Secondly, in the Appraisal stage, the three selection criteria were applied to narrow down the search results to select relevant ones. Thirdly, a snowballing technique was applied to identify more relevant studies. 33 publications were sourced and categorised according to publication types, including peer-reviewed articles, policy papers, and scientific reports in the Synthesis stage, and their content was synthesised, identifying the main analytical focus, methods, and themes related to Arctic ES. In the final Analysis stage, a thematic six-stage analysis was conducted. The stages in this activity were as follows: familiarisation with data, generation of initial codes, searching for themes, reviewing themes, defining themes, and analysis and writing up.

[5] Received 24 September 2018, Revised 23 January 2019, Accepted 14 February 2019, Available online 22 February 2019.

The role of the doctoral student (Laura Malinauskaite) in this paper was to carry out the activities related to the systematic literature review: selection of methodological framework, carrying out the review, synthesising the outcomes, and writing the article. David Cook, Helga Ögmundardóttir, Joe Roman and Brynhildur Davíðsdóttir provided their expertise, guidance and support throughout the research and writing processes.

From the 33 publications sourced for the meta-synthesis, twelve discussed marine biomes, eight – terrestrial, two focused specifically on sea and sea-ice, and eleven examined all three biomes. Even though scarce, the Arctic ES literature has been growing steadily over the last few years. Out of 33 publications identified, 27 were published in 2013 or later. This increased attention can possibly be explained by two influential publications that came out around that time – the Arctic Biodiversity Assessment (ABA) in 2013 and The Economics of Ecosystems and Biodiversity (TEEB) scoping study for the Arctic in 2015, both of which strengthened the ES agenda in the region.

Five key themes were identified during the meta-analysis of the sourced publications: (1) general discussion of Arctic ES, (2) Arctic social-ecological systems, (3) ES valuation, (4) ES synergies and/or trade-offs, and (5) integrating the ES perspective into management. The analysis also revealed that the ES concept is increasingly being applied in the Arctic context in all five themes, but there remain large knowledge gaps concerning mapping, assessment, economic valuation, analysis of synergies, trade-offs and underlying mechanisms, and the socio-economic and socio-cultural effects of ES changes. However, despite the recognition of the relevance of the ES concept for policy and governance, examples of such practical application for management remain few to date. Following this observation, the study points to the need for more primary studies in all five thematic areas identified and the necessity to move from theory to practice in Arctic ES research and governance.

1.7.2 Publication II

Malinauskaite, L., Cook, D., Davíðsdóttir, B., & Ögmundardóttir, H. (2020). Whale ecosystem services and co-production processes underpinning human wellbeing in the Arctic: case studies from Greenland, Iceland and Norway. In *Nordic Perspectives on the Responsible Development of the Arctic: Pathways to Action* (pp. 181–202). Springer International Publishing.[6] https://doi.org/10.1007/978-3-030-52324-4_9

The motivation for the book chapter was to examine ES formation through a social-ecological lens, looking deeper into underlying human-ecosystem dynamics within SES. The chapter sets out to provide a new perspective on ES, their values, and co-production processes that require both natural and non-natural (human, social, manufactured, and financial) capital. Focusing on whale ES in three Arctic coastal communities in Greenland, Iceland, and Norway, the chapter synthesises some of the key ES research to date and develops a whale ES co-production model based on ARCPATH case study research.

The research aims of the book chapter were as follows:

1) To contribute an interdisciplinary discussion of the human dimensions of ES and marine resource management in the Arctic.

[6] First Online: 31 October 2020.

The role of the doctoral student (Laura Malinauskaite) in this chapter included all the research activities, beginning with the concept of the paper, literature review and synthesis, and construction of the theoretical model based on the literature and case studies. David Cook participated in the field work and data collection and provided his insights and expertise in the paper's concept and during the process of writing. Brynhildur Davíðsdóttir and Helga Ögmundardóttir provided guidance and support during the conception of the theoretical model, analysis, writing, and review processes.

2) To develop a co-production model for whale ES based on the literature and case study research.
3) Illustrate the model using practical examples from three ARCPATH case studies of coastal communities in Iceland, Norway and Greenland.
4) Draw some further research and possible governance implications from the model and case studies.

The theoretical model developed in the study is based on the ES cascade model by Haines-Young & Potschin (2010; 2012; 2018) that is widely used in the ES literature and further elaborated by Spangenberg (Spangenberg et al., 2014a; Spangenberg et al., 2014b) who added an ES co-production element to it. A mixed methods approach was applied in the chapter to build a whale ES cascade model that includes co-production processes based on case study research, a literature review, stakeholder mapping, participant and non-participant observations, and semi-structured interviews (the interview guide is enclosed in Appendix D). The interviews were obtained during the fieldwork in Húsavík, Iceland in June 2018, in Andenes, Norway in September 2018, and in Disko Bay, Greenland in August–September 2019. The interview data was analysed qualitatively using the Grounded Theory approach that enabled the elicitation of the key trends and processes related to whale ES co-production in the SES in the case studies.

The resulting model highlights the role that humans play in ES formation as well as the contribution of whale ES to the wellbeing of people in the Arctic. The insights from the case study communities provide some important considerations of social-ecological dynamics and power relations that are important to natural resource use and governance. They also reveal that ES co-production processes are oftentimes as important as the final ES, especially in regard to cultural identity and social cohesion.

In terms of policy relevance, the resulting ES cascade model provides a conceptual bridge between ecosystems and societies when examining ES benefits and values. The ES co-production processes highlighted in the chapter can be targeted to ensure more sustainable use and management of whale ES. It is, however, necessary to acknowledge that the social-ecological dynamics and unpredictable and migratory nature of cetaceans make governance more difficult, requiring adaptiveness and reflexivity on the part of decision makers.

1.7.3 Publication III

Malinauskaite, L., Cook, D., Davíðsdóttir, B., & Ögmundardóttir, H. (2021). Socio-cultural valuation of whale ecosystem services in Skjálfandi Bay, Iceland. *Ecological Economics*, *180*, 106867.[7] https://doi.org/10.1016/j.ecolecon.2020.106867

[7] Received 2 June 2020, Revised 23 September 2020, Accepted 29 September 2020, Available online 13 October 2020.

The role of the doctoral student (Laura Malinauskaite) in this paper was the paper idea and concept, data collection, analysis and article write up. David Cook helped to design the socio-cultural valuation survey, participated in the data collection and guided the statistical analysis of survey data. Helga Ögmundardóttir and Brynhildur Davíðsdóttir provided guidance, support and methodological expertise throughout the research activities and writing process. Two master's students from the University of Iceland's Environment and Natural Resources programme, Sarah Seabrook Kendall and Renée Blankenstein, participated in the socio-cultural valuation survey data collection in Húsavík.

The second paper — a primary, non-monetary whale ES valuation study — was designed in response to one of the research gaps identified in the first journal publication on Arctic ES, namely the need for more primary ES valuation studies in the Arctic context that consider plural values. The study looks into the socio-cultural value domain of whale ES in an Arctic coastal community, Húsavík, which is one of the case studies presented in the book chapter. Being one of the few socio-cultural ES valuation studies to date globally and the first one in the context of Arctic marine ES, it presents a new perspective on marine ES valuation.

The two main aims of the study are:

1. To identify the key ES provided by whales in Skjálfandi Bay and the different place-based values that stakeholders assign to them.
2. To assess the relative importance of key whale ES from a socio-cultural perspective and the factors that influence it.

As there is no one standard set of methods to date for socio-cultural valuation, this type of valuation lends itself to flexibility and innovative methodological approaches. In this study, five different qualitative and quantitative methods were applied to identify the key ES provided by whales and assess their socio-cultural values: a literature review, stakeholder mapping, observations, interviews, and a preference survey. The purpose of the literature review was to gain familiarity with the literature on whale ES and their valuation, the case study background, and other sources that could potentially help in fulfilling the study aims. In addition to that, four experts in the field of whale resources in Iceland were interviewed and the main stakeholders identified through stakeholder mapping. This was an ongoing process, and the stakeholder map (Appendix A) developed in tandem with interview the data collection as interviewees pointed to relevant stakeholders that had been missed.

During the first fieldwork in June 2018, participant and non-participant observations were conducted as well as semi-structured interviews (interview guide in Appendix D) with 16 local stakeholders in Húsavík. During the second part of the fieldwork in August 2019, observations took place at the same time as the socio-cultural preference surveys that were conducted by a team of four researchers. The survey contained a list of ten key whale ES previously identified through analysis of the interviews, literature review, and observations. Respondents were asked to rate their importance on a Likert-type scale from 0 to 5 — 0 being not important at all and 5 being very important — and then answer a set of socio-demographic questions.

The key whale ES identified by the local stakeholders were cultural, with the most frequently mentioned ES linked to whale watching and education. The most commonly identified ES values were related to economic benefits from the whale watching industry in Húsavík. The socio-cultural preference survey revealed that regulating and maintenance ES were most highly valued with a mean score of 4.0 out of 5.0, cultural ES came second with a mean score of 3.5, and provisioning ES in the form of food and raw materials were valued the least with a mean of 0.75. The interview data revealed some marine ES management challenges originating from intensified tourism, marine traffic, industrial development, and climate change.

The socio-cultural perspective explored in this paper adds to the discussion on the plurality of ES values. If combined with monetary and biophysical valuation, it has the potential to reveal the whole spectrum of values associated with whale ES. Its methods are transferable to other species and ecosystems, and the results provide some interesting information about stakeholder perceptions and values assigned to whale ES. The results of the study have the potential to inform marine resource governance in Iceland by highlighting the socio-cultural significance of whales in a community context.

1.7.4 Publication IV

Malinauskaite, L., Cook, D., Davíðsdóttir, B., Ögmundardóttir, H., & Roman, J. (2020). Willingness to pay for expansion of the whale sanctuary in Faxaflói Bay, Iceland: A contingent valuation study. *Ocean & Coastal Management, 183*, 105026.[8] https://doi.org/10.1016/j.ocecoaman.2019.105026

The motivation for the third paper was to explore the monetary value domain of whale ES and start filling in the gap in primary ES valuation studies in the Arctic context identified in Publication I. It aims to elicit monetary values of whale ES in relation to a hypothetical change in a whale ES management regime — expansion of the current whale sanctuary in Faxaflói Bay from the current size to the full extent of the bay, meaning that whaling activities in the bay would be restricted, which would give *de facto* priority to whale watching over whaling. The study utilises the contingent valuation method (CVM) to elicit the preferences of Icelanders and estimate their willingness to pay (WTP) to expand the sanctuary, providing some interesting insights into individual preferences regarding provisioning and cultural whale ES and their management.

The study has two closely related but distinct aims:

1. To contribute to the currently limited body of academic literature on individual preferences and WTP related to management arrangements for marine environments.
2. To inform the public debate on different uses of whale ES in Iceland and their trade-offs.

This study applies the CVM to elicit preferences and estimate WTP in relation to a change in governance arrangements — the expansion of an existing whale sanctuary — which are assumed to imply positive environmental changes in Faxaflói Bay due to the banning of whaling. The CVM survey that was distributed online in collaboration with the University of Iceland's Social Science Research Institute consisted of three sections: attitudinal questions on environmental issues and economic activities related to whale ES in Iceland; a brief description of the current whale sanctuary, questions on participants' familiarity with

[8] Received 29 April 2019, Revised 30 September 2019, Accepted 14 October 2019, Available online 24 October 2019.

The role of the doctoral student (Laura Malinauskaite) in this paper included the contingent valuation survey design, data analysis, and article write up and revisions. David Cook provided guidance in survey design and distribution, which was implemented by the University of Iceland's Social Research Institute, and training of the doctoral researcher in quantitative data analysis. David, Helga Ögmundardóttir and Brynhildur Davíðsdóttir provided guidance, expertise and support throughout the research, writing, and revision processes.

the case study site and a bidding process to elicit WTP; and a set of socio-demographic questions. Participants were asked whether they would be willing to pay a one-off lump-sum tax to expand the whale sanctuary to the proposed limit identified in a map included in the survey, to state their reasoning, and those with WTP were asked to complete the bidding process, in which a double-bounded dichotomous choice approach was applied. Finally, eleven socio-demographic, attitudinal and visitor variables were used in the final logit regression model to determine statistically significant socio-demographic determinants of WTP.

The total number of completed surveys was 684, with a response rate of 45.6%. The mean WTP for expansion of the Faxaflói Bay Whale Sanctuary of the 320 respondents who expressed clear preferences regarding the possible expansion was 5,082 ISK (42 USD in 2018), which, when upscaled to the number of taxpayers in Iceland, amounted to 1.32 billion ISK (10.9 million USD in 2019). In a logit regression analysis, younger people, women, university-educated respondents and those who prioritise the protection of natural areas expressed significantly higher WTP, whereas those who support whaling or live with more people in their household expressed lower WTP for the expansion of the sanctuary. The study results corresponded with the outcomes of recent public opinion polls that Icelanders are divided on the issue of whaling. This information is very timely, with fin and minke whaling in Iceland having been extended until 2023[9] and the public debate on whaling continuing locally and internationally. Moreover, it raises a question about the effectiveness and public perception of whale sanctuaries as whale ES governance tools, which is discussed in the final section of the thesis.

1.7.5 Publication V

Malinauskaite, L., Cook, D., Ariza, E., Davíðsdóttir, B., & Ögmundardóttir, H. (2021). Interactive governance of whale ecosystem services: governability assessment of three case studies in the Arctic. *(Submitted to Ecology & Society Journal)*[10]

The motivation and purpose of the fourth paper was to map out the current governance practices in the case study locations described in the book chapter and connect them to the ES and their values and co-production examined in the previous publications. Through analysis of interactive governance and governability, the study takes a broad view of the governance of whale ES in the three Arctic coastal communities and the extent to which it reflects stakeholder needs and values that they assign to whale ES. The paper is based on ARCPATH case study research in Húsavík, Iceland, Andenes, Norway, and Disko Bay, Greenland, and applies the interactive governance theoretical framework that views governance as a web of multi-layered interactions between formal and informal actors, institutions, and other entities within SES. The study links the interactive governance framework to the ES co-production model developed in Publication II of the thesis, resulting in a new

[9] No whaling took place in Iceland in 2019 or 2020. Some of the reasons quoted were difficulties exporting whale meat, refurbishing of whaling vessels, and Japan's departure from IWC, meaning increased supply of domestic whale meat in the country, which makes imports unnecessary (Bjarnason, 2020).

[10] The role of the doctoral student (Laura Malinauskaite) in this paper was data collection, transcription, and analysis of interviews, synthesis of concepts, and writing of the article. Eduard Ariza suggested the conceptual framework and provided expertise on the topic of marine resource governance. David Cook participated in data collection and helped to structure the paper into its current form. Helga Ögmundardóttir and Brynhildur Davíðsdóttir provided their expertise, guidance, and support in this interdisciplinary inquiry.

conceptual model as a means of analysing the governability of whale ES, which can also be applied in other resource contexts.

The study has three main aims:

1. To outline the main components of the three SES in the case study locations in relation to whale ES and their interactive governance.
2. To assess the governability of whale ES in the three case study communities using an assessment framework developed by interactive governance scholars for marine resources.
3. To discuss the findings in the context of governance needs and values expressed by stakeholders to determine if they are reflected in the current governance of whale ES in the case study locations.

A mixed methods approach including four different methods was applied in the study: a literature review, stakeholder mapping, semi-structured interviews, and participant and non-participant community-based observations. Firstly, a review was conducted of literature available on whale ES, their values and management in the case study countries and the Arctic as a whole. Then the literature review was employed to identify the key actors in the area of interactive governance regarding whales in the three case studies. The resulting stakeholder maps (Appendices A, B and C) were used to identify the potential interviewees with interest or/and expertise in whales in the case studies and the Arctic as a whole. During three fieldwork visits to the case study locations between June 2018 and September 2019, semi-structured interviews with a wide range of actors identified during stakeholder mapping were conducted. Representatives of most stakeholder groups were contacted for an interview to get as diverse a sample as possible, and the final list of interviewees consisted in total of 54 interviews with 57 people representing an array of private and public sector institutions, NGOs, local whale ES users, and other actors. They were designed to elicit the key ES provided by whales and values associated with them as well as governance practices and needs. Parallel to the interviews, participant and non-participant community-based observations took place during the fieldwork. Finally, the governability of whale ES in the three case studies was assessed using a governability assessment framework previously developed by SES scholars for determining the level to which a resource system can be successfully governed based on the qualities of its components and governance interactions.

The paper lists the main components of interactive governance of whale ES, assessing their governability. It finds that there is a high level of socio-ecological dynamics in all three case studies, mostly due to changing economic activities, especially increases in tourism, and environmental changes induced by climate change. The study finds that the common governance vision to all case study locations includes protecting the whale resources while expanding the tourism sector and making it more sustainable, increasing research activities, enhancing cooperation between actors, and introducing stricter whale watching regulations. Due to indigenous whaling, the governance in Greenland is somewhat different as the local hunters are subjected to top-down rules imposed by state and international actors, leaving their needs and values not always sufficiently considered in decision making.

The data analysis suggests that in all three cases much of the whale ES governance takes place through informal institutions as self- and co- governance executed by individuals or groups of resource users. The most common conflicts arising between actors include rival-

ry of actors for harbour space, negative effects of heavy industry and increased marine traffic in terms of noise and pollution, a perception that most tour operators do not give enough back to the communities, conflicts between actors over resources, ES co-production methods, and, in some cases, between their needs and values. According to the governability assessment, the biggest obstacles to governability include a mismatch between the governance vision expressed by actors and the current reality, a high rate of social-ecological change, and the fact that the current formal and informal governance actions are often insufficient to ensure the health of the local marine ecosystems and continuous presence of whales. The latter point highlights the problem of scale, since Arctic SES are affected by the global processes of climate change and globalisation, over which they have little control and are forced to adapt.

2 Summary and discussion

2.1 Summary

This research set out to explore the ES of whales in the Arctic, related co-production processes, values, valuation, and governance. ES are conceptualised here as a resulting from human-nature co-production processes, both cognitive and physical. This conceptualisation has important implications for the ways in which ES are perceived, valued, and governed, as humans in this model are an integral part of a human-environment system rather than being separate from ecosystems. The ES concept has been scarcely applied in the Arctic context to date, so the first part of the thesis provides a review of the existing literature on the topic, identifying the main themes and gaps (Publication I). Following the review results, the second part of the thesis explores one of the themes identified — Arctic SES — and ES formation through human-nature co-production processes in three case study coastal communities (Publication II). The first two steps set the ground for the following empirical whale ES valuation studies.

Recognising the plurality of ES values and distinct value domains, the socio-cultural valuation study explored multiple non-monetary values of whale ES in a community context in Iceland (Publication III). Being the first such ES valuation in this context, the study provides some interesting insights on the role of whales in a coastal community context in Iceland. The study lists the key ES provided by cetaceans and their relative importance, discussing locally based values, trade-offs, and threats. A possible trade-off between provisioning and cultural ES in another Icelandic location where whaling and whale watching coexist is explored in the monetary valuation study (Publication IV). The results of the contingent valuation study reveal divisions among Icelandic citizens regarding their preferences and willingness to pay for a change in the current governance regime that prioritises whale watching over whaling through expansion of the whale sanctuary.

The last part of the research explores the governance of whale ES in the face of rapid social-environmental change, uncertainty and complexity (Publication V). The governance of whale resources in the three case study locations is mapped out according to the interactive governance theoretical framework and their governability assessed through analysis of the governance components and their performance. Following the assessment, it was decided that the governability of whale ES in the case study SES is low to moderate due to high rate of social-ecological dynamics affecting whale ES and often-occurring mismatch between governance vision and needs and actual practices. The final publication also reveals a variety of actors and interactions involved in whale ES governance in the Arctic through formal and informal governance arrangements.

2.2 Discussion of results

In this section, the results of the five publications are discussed in accordance with the research questions outlined in Section 1.5 of the Introduction, following these themes:

- ES values and valuation in relation to the Research Questions 3 and 4
- Social-ecological complexity, especially in the context of Research Question 3
- Resilience of Arctic SES that relates to all Research Questions
- Arctic marine resource governance and the context of Research Questions 4 and 5

2.2.1 ES values and valuation

This doctoral research takes an analytical approach that views humans as an integral part of intertwined human-environment systems rather than being outside of nature, managing ecosystems as a stock of resources. This view resonates with the concepts of deep ecology in environmental ethics (Naess, 2005) and Gaia theory (Lovelock, 2000) that consider humans a part of one planetary system, and comes with certain realisations and responsibilities that may be useful for directing human actions towards sustainability. The notion of SES implies that societies and their surrounding ecosystems are inherently connected and therefore ES are formed through co-production processes rather than being a flow of services from nature to human beneficiaries.

In accordance with the interactive governance literature, it is argued in the concluding paper that natural resource governance begins with a vision, which stems from a set of values (Kooiman & Jentoft, 2009). Values have many definitions and have been at the centre of philosophical and ethical debates from the time of Aristotle (Rescher, 1969). In addition to intrinsic and instrumental ES values, recent literature advocates for a more nuanced understanding of how humans connect to their natural environment through relational values[11] (Kaltenborn et al., 2017; Kumar & Kumar, 2008; Stålhammar & Thorén, 2019). An example of that in this research are some of the non-monetary whale ES values elicited through the socio-cultural valuation in the Publication III, such as community identity, aesthetics, and artistic inspiration.

Brown (1984) distinguishes between held and assigned environmental values. The former indicates underlying values that people find desirable, such as modes of conduct, end states, or qualities; and the latter can be defined as "perceived qualities of an environment that provide material and nonmaterial benefits to people" (van Riper & Kyle, 2014, p. 375). Fig. 3 (ibid.) delineates the spectrum of held and typology of assigned ES values, which were also explored in Publication III on socio-cultural values of whale ES, where the values expressed by the interview respondents in their own words were classified according to the typology in Fig. 3. This is just one way of classifying ES values, but the takeaway message is that recognising, listing and classifying human held values can potentially help to communicate them to and between different groups of people, e.g., resource users and policy makers.

[11] Relational values are defined by Chan et al. (2016, p. 1462) as "preferences, principles, and virtues associated with relationships both interpersonal and as articulated by policies and social norms".

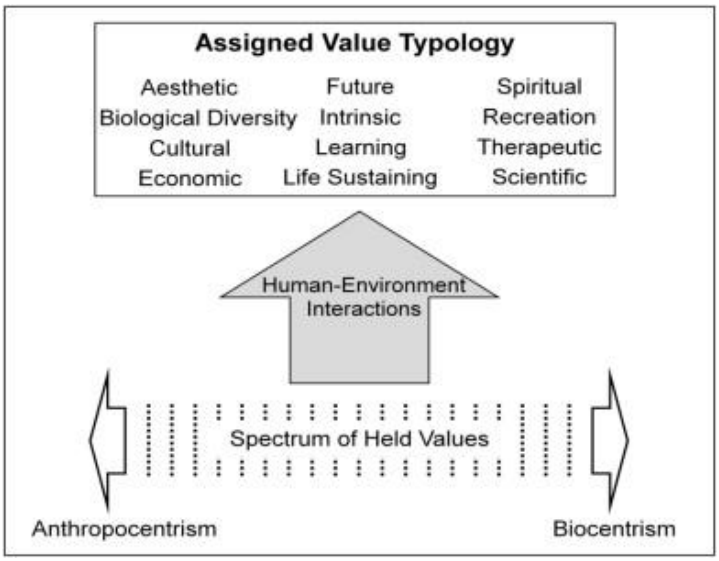

Figure 3 Conceptual framework between held and assigned ES values. Sourced from Van Riper & Kyle, 2014

The value type that modern humans are perhaps most familiar with, especially in relation to public decision making, is economic. It is a metric of exchange that has been used by societies since ancient times, and arguably the most practical one as we have to make economic choices every day. According to Nunes and van den Bergh (2001), monetary ES valuation can be considered as a democratic approach for making public policy decisions, and monetary ES values of biodiversity changes can potentially allow for assessment of damages and for making direct comparisons between alternative options of management. This type of ES valuation was performed in Publication IV concerning two hypothetical whale ES management scenarios.

However, ES valuation is often a target for criticism on the grounds that it fails to take into consideration the intrinsic value of nature that is independent of its use to humans (Jacobs et al., 2016). Another criticism is that ES valuation often reduces ecosystem values to a monetary value that does not reflect its real value and irreplaceability (McAfee, 1999). However, in the context of Fig. 3, economic value is one of twelve types of values assigned by people to ES and should be treated as such. Much of the criticism of monetary ES valuation stems from the misunderstanding of what this type of valuation can and cannot do (Gómez-Baggethun & Martín-López, 2015). The presented doctoral thesis attempts to delineate and consider multiple value domains of whale ES which stem from co-production processes, involving human activities that provide direct wellbeing benefits to those who undertake them as well as final ES that enhance human wellbeing in multiple ways. This is very much in line with the newly published Dasgupta (2021) Review on the Economics of Biodiversity, which, among other things, emphases the embeddedness of human life and wellbeing in ecosystems and biodiversity.

As the title of an article on ES valuation reads: “To value or not to value? That is not the question” (Kallis et al., 2013). Its authors of the paper argue that “monetary valuation is fine if part of socio-political processes that bring more equality and improve the environ-

ment". Like with any tool, its effectiveness depends on where and how it is applied. This doctoral research shows that ES valuation can provide some useful information about human wellbeing benefits sourced from whale ES, but that it is always just a part of a bigger picture. The socio-cultural and monetary value domains covered in Publications III and IV presented how ES values can be elicited, yet there are difficulties with practical application as frameworks for including them in decision making are currently lacking (Chan et al., 2012). The monetary values elicited in Publication IV reveal the preferences of respondents regarding whale ES management, however, they should not be used for policy guidance in isolation from other factors influencing the marine ecosystem and human wellbeing, e.g., when deciding whether to expand the whale sanctuary in Faxaflói Bay, banning whaling in the area. In such cases, the interests of various groups, such as fishing, shipping and transportation companies, individual boat owners, and recreational users of the bay, should also be considered.

2.2.2 Complexity of social-ecological systems

There is no one clear-cut definition of sustainability (Scoones, 2007), but the main question posed by it would be along these lines: 'how should humans act in order to sustain their species on Earth for an indefinite amount of time?' A sub-question explored in this thesis would then be: 'how can we use our resources sustainably and deal with the complexities and uncertainties of social-ecological systems?' One of the ways is by exploring these systems and the role that humans play in them. It is argued throughout the thesis that humans constitute a part of nature, but we have come to the point in evolution where humanity influences the processes on Earth like no species before — the Anthropocene. This fact requires unprecedented action on the part of humans and realisation of huge responsibilities. Through the notions of intertwined SES and whale ES co-production, this research attempts to internalise human agency into the ES concept, opposing a view of humans outside of nature.

Whales are a group of marine mammal species that resonate deeply with many people due to their size and perceived intelligence (Brydon, 2006; Kalland, 1994). Their historical exploitation that brought many species of the largest mammals to have ever lived on Earth to the brink of extinction makes this group of species a symbol for environmental protection and highlights the effects that humans can have on marine ecosystems, globally. This sentiment is expressed in this slogan by the Whale and Dolphin Conservation Society, cited by Einarsson (1993, p. 80): "If we can't save the whale, we can't save anything". However, this research shows that whales mean different things to different people, and that diverse worldviews, values, and contexts need to be taken into consideration when making decisions about their governance. This is especially the case in regard to value attribution to whale ES in their co-production discussed in Publication II, socio-cultural place-based values elicited in Publication III, and the interactive governance and governability assessment discussed in Publication V.

The importance of including different resource contexts and stakeholder worldviews in ES assessments, especially in indigenous settings, has been discussed in the literature in various resource contexts (Solé & Ariza, 2019). Bélisle et al. (2021) describes how consulting indigenous ES users in Northern Canada can help to design landscape valuation methods; Gould et al. (2019) discusses how an indigenous worldview in Hawaii informs local place-based relational and social ES values; Kenter (2016) draws attention to shared, plural and

cultural ES values that are locally-based and collectively formed, drawing on the results of the UK National Ecosystem Assessment; Scholte et al. (2015) and van Riper et al. (2017) advocate for incorporating socio-cultural phenomena, including worldviews, knowledge systems, and place-based values, into ES valuation. In the context of the Arctic and whale ES, the values assigned to whale ES by different stakeholders and communities differ depending on their worldviews, needs, and conceptions of value.

This is evident in the interviews from the case study locations of Húsavík, Andenes and Disko Bay, as discussed in Publications II and V on whale ES co-production and governance. Interviewees representing the whale watching industry emphasised the economic values of whale ES stemming from profits and employment opportunities, the researchers focused on how much there is to learn from these sea giants, and most stakeholders in Greenland, including indigenous hunters, stressed the importance of whale meat for local sustenance and cultural identity. Neither of the views are superior to others and, ideally, they should be all reflected in ES assessments and governance. This is, for instance, illustrated in the feedback loop of the co-production graph depicted in Publications II and V, where ES values and valuation inform decision-making. Another example of including multiple, locally based values into ES analysis is presented in the socio-cultural valuation study in Publication III.

The term "governance" requires recognising the abilities of actors to self-organise and manage natural resources based on their worldviews, values and needs, and in response to existing pressures. This view differs from the traditional top-down approach to natural resource management and also implies complexity that stems from an ever-changing web of governance interactions between formal and informal actors within a governance system (Kooiman, 2008). This high level of complexity is discussed to some extent in this thesis through the analysis of interactive governance and governability of whale ES in the Arctic, and is presented in Publication V. It reveals multi-layered and diverse governance strategies for whale ES in the case study SES that depend on the socio-cultural and socio-economic context as well as outside forces, such as international politics, globalisation, and climate change. When the multiplicity of actors and their needs on local, national, and international levels is taken into consideration, it becomes clear that there is no one solution that fits all but that a common vision and increased inclusiveness in the policy process can make governance more effective (Armitage et al., 2011; Meek et al., 2011).

When we place all these processes within an SES, it all becomes even more complex as natural resources do not just "wait there" to be governed but influence and are influenced by human and biophysical factors. This brings us to the notion of co-evolution of SES that refers to interdependent evolutionary processes between its societal and biotic components, embedded in a dynamic biophysical environment (Gual & Norgaard, 2010; Norgaard, 1994). The original purpose of the ARCPATH project was to explore the human dimensions of climate change through analysis of whale ES (ARCPATH, 2021; Ogilvie et al., 2020). From the co-evolutionary perspective, Arctic coastal communities and marine ecosystems, including whales, co-evolve over time, affecting each other through reciprocal feedbacks (Arctic Council, 2016). Some of the climate change impacts prevalent in the case study locations include changing species of whales following a northward shift of prey, warmer summers, especially in Andenes and Disko Bay, and the increasing unpredictability of winter sea ice in Greenland. In addition, unpredictable weather patterns are prevalent in all locations, which make marine-based economic activities, such as whaling and whale watching, more difficult. On the other hand, the lessening of winter sea ice in

Disko Bay and reduction in hunting facilitated the increase in local fishing activities, which now form the larger part of professional hunters'/fishermen's [12] income. There is a palpable anxiety in the case study communities about the further effects of climate change, but there is also a belief in the communities' ability to adapt and remain resilient that come through in the interviews with stakeholders. This sort of social-ecological co-evolution is ongoing and present in all SES (Kallis, 2007).

Another obvious example of social-ecological co-evolution is whaling, which started as a human response to a need for food and raw materials and apparent abundance of whales, which later resulted in a great reduction in whale populations, some close to extinction, which, in turn, altered human activities and perceptions and values related to whale ES. This, however, had differentiated effects on different resource users, e.g., the Western world was largely able to replace whale oil products with alternatives, e.g., petroleum-based (Coleman, 1995), while the Arctic indigenous people, including the Greenlandic Inuit communities, suffered large reductions in the availability of nutritious and locally available food, which is also a big part of their cultural identity. The IWC moratorium on whaling and global environmental movement to protect whales facilitated the recent increase in whale populations that is now perceived by some actors as excessive, e.g., by the fishermen in Disko Bay that use the polar cod preyed upon by humpback whales as bait for halibut and have been witnessed to shoot at whales to scare them away. Presently, humpback whales are not perceived as desirable food by Greenlanders, at least partly because they were not hunted for a few decades and the younger generations are not used to their meat, according to the interviews.

2.2.3 Resilience of Arctic SES

Social-ecological resilience refers to the capacity of SES to adapt or transform in the face of change, especially abrupt and unexpected, in ways that continue to support human well-being (Biggs et al., 2015; Folke et al., 2016). It is argued throughout the thesis that human-environment systems are closely intertwined through mutual feedback mechanisms (Fig. 1 and 2), such as the co-production of whale ES discussed in Publication II. In the case studies, whale ES provide various human wellbeing benefits that enable the local communities to survive and thrive. Those benefits, however, depend on many factors, such as the presence of humans and whales in a certain location, the environmental conditions that support their existence and, in many cases, the presence of tourism and enabling infrastructure. To remain resilient, SES must be able to persist in the face of shocks, either absorbing them or transforming (Folke, 2006). The examples of reciprocal feedbacks presented through the co-evolutionary lens in the previous section illustrates that.

Olsson et al. (2004) discuss the resilience of an SES in Southern Sweden through social-ecological transformation that was facilitated by adaptive co-management of a wetland, Kristianstads Vattenrike. This is a well-known example in resilience literature of how social transformation through actor cooperation and learning can facilitate a change in ecosystem management towards increased resilience and sustainability. The authors conclude that actor adaptability, knowledge generation on ecosystem dynamics, and capacity to respond to ecosystem feedback by resource users and governing institutions through adaptive co-management play key roles in social-ecological resilience. In this example, a desirable

[12] There is no distinction between the two activities in Greenland.

state of affairs had to be agreed among different actors and the benefit flow from ecosystem to social system utilised in a way that could increase its persistence. However, before any of this could occur, a value had to be put on the persistence of wetland ecosystem. This takes us back to environmental values and preferences: what sort of SES are desirable and resilient and to whom? The stakeholder-centred approach to ES formation, valuation, and governance applied in this research advocates an inclusive and egalitarian governance model, which is often difficult to achieve in real-life situations with many competing interests. This could be seen in the ongoing discussions on the creation of an MPA in Skjálfandi Bay, Iceland that, according to the interviews, have been going on since 2004 but no consensus has been reached between the local actors, let alone between the local community and the government.

If sustainability is to be taken seriously as a governance objective, SES embeddedness in the biosphere needs to be salient in the resilience debate (Folke et al., 2016). The persistence of SES in Húsavík, Andenes, and Disko Bay is determined by ecological and social factors, which has been affected greatly by the global forces of climate change and globalisation. The local ecosystems and societies are changing and co-evolving as is characteristic for SES, yet the recent changes in the Arctic have been taking place at an unprecedented rate, and this is a source of global concern (Arctic Council, 2016; IPCC, 2019). The benefits provided by Arctic marine ecosystems through whale ES explored in this thesis are and will continue to be affected by both globalisation and climate change. The question from the resilience point of view is whether and how whale ES can be sustained and what role do ES values, co-production processes, and governance interactions play in it. Another, perhaps more hypothetical, question is what would happen to these communities should whale ES no longer be accessible? Would they persist and what would happen to the local marine ecosystems if whales were no longer present? This question was asked during the interviews in Disko Bay, Greenland, and most of the respondents replied that they could not imagine such a thing or that they did not think this would ever happen. This indicates that the full extent of values lost with disappearance of whale ES transcend the economic domain and that they are difficult, if not impossible, to assess, especially for individuals and communities whose identity and livelihoods are partly dependent on them.

However, hypothetical questions like this can be explored through scenario building, modelling, and climate change adaptation planning. They involve a high level of uncertainty, and resilience thinking implies living with uncertainty and making use of the constant changes while solving problems and creating new opportunities (Chapin et al., 2010; Folke et al., 2016). In the context of the presented research, it is helpful to draw on the needs, values, and preferences expressed by stakeholders regarding whale ES when identifying problems and opportunities. An example of a problem that came up in the interviews is that whales are affected by warming ocean temperatures and species are moving northwards following the northward shift of prey. This also presents an opportunity as the shift resulted in increased sightings of certain whale species in some locations, e.g., humpback whales in Skjálfandi and Disko bays. Another big force, globalisation, helped to improve the connectivity of the Arctic to the rest of the world, both physically and through modern communication technologies. This has presented Arctic societies with new opportunities but also facilitated a substantial erosion of traditional ways of life and social fabric (Hamilton & Rasmussen, 2010; Huntington et al., 2019; Perry et al., 2011). In the case study communities, the rapid development of the tourism sector, which prior to the COVID-19 pandemic constituted one of the main economic pillars, generated new employment, business and

infrastructure development opportunities, but they were also somewhat overwhelming for the local population not engaged in it, especially in Húsavík and Ilulissat.

Turning crisis into opportunity is not always possible and, in some cases, change inevitably produces losers. This happened in Disko Bay where the historical overhunting of whales by foreign parties and subsequent regulations on local indigenous whaling negatively affected many communities that were dependent on whaling for sustenance and a part of their cultural practices. At the same time, the technological developments and arrival of new species of shrimp and fish in the area, at least partly facilitated by climate change, provided new livelihood opportunities (Hamilton et al., 2003; Hamilton et al., 2000). This is an example of an interplay of various forces at different temporal and spatial scales in an SES that spurred adaptability and partial transformation of the system (Biggs et al., 2015).

While resilience and adaptability are inherent SES features, they more often than not require directing towards more sustainable and desirable pathways (Armitage et al., 2011; Chapin et al., 2015; Olsson et al., 2004). The primary objective of the ARCPATH project, a part of which is this thesis, is to combine research from different scientific fields to inform these pathways. The human wellbeing benefits sourced from whale ES in the Arctic has changed considerably in the 20th century, especially due to the decline in whaling and increase in the tourism sector prior to the COVID-19 pandemic as well as the shift in public perceptions and attitudes towards whales, globally. The results of this research reveal that this has had varying effects on human wellbeing in different locations. Moreover, the governance mechanisms for managing changes in whale ES are, firstly, still forming and, secondly, context dependent. The current scientific knowledge on the actual biophysical and ecosystem effects of climate change, increased industrial activities, and marine transportation in the Arctic is very limited, not the least because of the high rate of change taking place in the oceans. This makes resilience and adaptation planning difficult, putting a lot of emphasis on the need for economic diversification, adaptiveness, and reflexivity in the governance of Arctic SES (Arctic Council, 2015; Berkes & Jolly, 2002; Logerwell & Skjoldal, 2019).

2.2.4 Arctic marine resource governance

Perhaps partly owing to the realisation of complexity and importance of social-ecological context in natural resource management, notably in the work of the Nobel Prize laureate Elinor Ostrom (Ostrom, 2007, 2009), the tendency in recent decades has been to move away from control-and-command to more inclusive policy approaches, such as EBM, marine spatial panning (MSP), and other stakeholder-led management regimes. Since the governance of the Arctic is still developing, its overarching governance body, the Arctic Council, only formed in 1996, and having to adapt to rapid biophysical and social changes in the region, application of these inclusive and responsive management frameworks is becoming increasingly important. The thesis aimed to advance this approach by examining human-nature interactions through the prism of whale ES, elaborating related co-production processes, values, governance interactions and assessment of the governability of whale ES. The final Publication V specifically examines these governance interactions in the context of Arctic coastal communities, deepening the understanding of how these processes related to whale ES play out, in this way exploring the last two research questions of this thesis.

The Arctic Council's stated vision for the Arctic marine environment is "Healthy, productive, and resilient Arctic marine ecosystems that support human well-being and sustainable development for current and future generations." (Arctic Council, 2015, p. 6). This doctoral research focuses particularly on its objectives (2) and (4) outlined in Section 1.5 of the Introduction, firstly, by exploring the values of whale ES in Arctic coastal communities in Publications III and IV, and, secondly, by mapping out the whale ES co-production processes and governance interactions and pointing out to potentially problematic areas where improvements could be made in Publications II and V. The focus of the Arctic Marine Strategic Plan 2015–2025 on human wellbeing and sustainable use of the Arctic marine environment that supports environmental, socio-cultural, and economic values reiterates the importance of examining human wellbeing benefits sourced from Arctic marine ecosystems through ES. It is argued throughout the thesis that defining, describing, and, where appropriate, quantifying the benefits and values attached to them can inform marine ecosystem management in ways that are acceptable to both policy makers and resource users.

In relation to SDG 14 — to conserve and sustainably use the oceans, seas and marine resources for sustainable development — this thesis explores topics related to the targets 14.2 on increasing marine ecosystem resilience and promoting EBM; 14.5 on marine conservation; and 14.c concerned with marine governance, which is the topic of the final Publication V. Both EBM principles and SDG 14 targets emphasise sustainable use of the oceans and sustaining human wellbeing through continuous provision of marine ES. This emphasis gives premise to the Blue Growth Agenda, to which the notion of integrated ocean-human system is central (Burgess et al., 2018; Saviolidis et al., 2020). Marine ES underpin its economic, social and environmental aspects and can potentially inform Blue Growth by helping to navigate synergies and trade-offs between them (Klinger et al., 2018; Lillebø et al., 2017). This can be done through careful MSP that considers various economic activities, interests, and ES synergies and trade-offs within a certain marine area (Guerry et al., 2012; White et al., 2012). MSP involves analysis of trade-offs and prioritisation of activities and ES, and this is where ES valuation can potentially aid (Klain & Chan, 2012; Lester et al., 2013). Some whale ES synergies and trade-offs are explored in Publications III, IV and V, but a more nuanced analysis is needed for the purpose of guiding MSP, such as more primary ES valuation studies, stakeholder consultations and deliberative methods such as multi-criteria decision analysis (Guerry et al., 2012; McKinley et al., 2019).

The Arctic Council (2013; 2015) is committed to an EBM approach to marine ecosystem management, and it is being applied in policy design and implementation in its member countries with varying degree of intensity and success (Arctic Council, 2013a; Hoel, 2009). The EBM definition elaborated in the Kiruna Declaration in 2013 stresses the importance of achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity (Arctic Council, 2013b), which gives premise to the focus of this thesis on whale ES in the Arctic. EBM has been scarcely applied in this context to date, and almost not at all in the case study locations explored in this research. One of the problems encountered in the monetary valuation study in the Publication IV was the lack of any significant conservation objectives in the design and implementation of whale sanctuaries in Iceland, the only limitation within their territories being the absence of whaling.

Cook et al. (2019) explored this issue further and found that whale sanctuaries are generally a very limited whale conservation strategy, unless they adhere to a more holistic framework, such as EBM. The study assessed six whale sanctuaries in Hawaii, Mexico, Canada and Iceland, as well as two IWC oceanic sanctuaries in the Indian and Southern oceans,

using 15 EBM principles developed by Long et al. (2015), and concluded that the Faxaflói Bay Whale Sanctuary in Iceland adhered to only two of the principles fully and another two partially. The other Arctic whale sanctuary analysed in the study, Ninginganiq in Northern Canada, performed much better in terms of EBM principles due to its holistic focus on marine ecosystem conservation and co-management between local actors and scientific bodies. These results suggest that effective marine conservation tools should be employed in a holistic manner and that nomination of a whale sanctuary without a wider EBM strategy has little potential to protect cetacean populations (Hinch & De Santo, 2011; Zacharias et al., 2006). Currently, there seems to be a lack of EBM perspective in whale sanctuary management in Iceland. Another case study of this thesis – Skjálfandi Bay Whale Sanctuary – was not assessed by Cook et al. (2019) but is based on the same legislation as the Faxaflói Bay sanctuary and is therefore likely to suffer from the same pitfalls.

In 2016, 4.7% of Arctic marine areas were classified as Marine Protected Areas. This falls short of the goal set by the SDG Target 14.5 and the Aichi Biodiversity Target 11: to have at least 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ES, under a protection status by 2020, following the IUCN criteria (CAFF & PAME, 2017; CBD, 2016; United Nations, 2016). According to the World Bank (2021), currently 4.52% of marine areas in Greenland have MPA status, 0.83% in Norway, and only 0.38% in Iceland. These statistics indicate that there is room for improvement in marine conservation in these countries, especially through MPAs. The interview data reveals diverging opinions on utilising MPAs as a means for conservation of whales. This is likely to be at least partly due to the lack of experience with MPAs in the case study locations as well as an aversion to top-down marine resource management initiatives, according to the interview data.

It is emphasised in the Aichi Biodiversity Target 11 that MPAs should be "effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes" (CBD, 2016). If EBM principles are followed and an inclusive and holistic approach to marine conservation is applied — unlike in the case of whale sanctuaries in Iceland — MPAs have the potential to enhance marine ecosystem protection in the Arctic. However, establishing an MPA that is co-managed by the local stakeholders, government entities and scientists can be difficult as the case of Húsavík in Iceland has shown, precisely because of the consensus of all parties required. This is discussed by Barry et al. (2020) in the context of Arctic biodiversity conservation and the Arctic Council, where the need for consensus often leads to the lowest common denominator in terms of generating positive environmental change.

The above point relates to some of the difficulties faced by the advocates of MPAs who are met with hostility by marine resource users who are afraid to lose access to marine resources if conservation measures are introduced. This is especially relevant in Arctic coastal communities, which have subsisted on marine resources for millennia with few local food alternatives available. Therefore, if any MPAs should be established in close proximity to these communities and their economic activities, the process has to be inclusive of local stakeholders as resource users and stewards (CAFF, 2015; Fernandez et al., 2016). The information on whale ES co-production, values, and current governance interactions can potentially aid these processes by identifying stakeholders' preferences and values attached to whale ES and helping to facilitate a dialogue between them.

2.3 Contribution to scientific knowledge

The thesis makes several important contributions to the existing literature, especially in the context of Arctic marine ES, using whale ES as a lens. Firstly, the systematic review of the literature on Arctic ES presented in Publication I summarised the current state of knowledge on the topic, delineating the main themes and providing guidance towards research opportunities in this expanding area of research. In this way, it provides a starting point for further research on Arctic ES, which is potentially useful for scholars commencing research on Arctic ES. For instance, this doctoral research was informed by the main themes and gaps uncovered through the systematic literature review presented in the first publication of this thesis.

Secondly, the whale ES co-production model based on the case studies in three Arctic locations in the second publication presents a conceptual model that illustrates the interconnectedness of social-ecological processes involving human and natural capital that enhance human wellbeing through co-creation of whale ES. In this way, it deepens our understanding of ES formation in general and within the particular context of Arctic coastal communities, making a theoretical contribution to the ES literature. The ES co-production model can be applied in other resource contexts, and this has already been done for ES of geothermal areas and glaciers, in which the author of this thesis was involved as the third author (Cook et al., 2020a; Cook et al., 2021).

Thirdly, this doctoral research contributed to scientific knowledge through the first two ES valuation studies on two whale sanctuary locations in Iceland, one concerned with a spatial management arrangement with potential effects on whale ES in Faxaflói Bay and another with socio-cultural values in a community context in Skjálfandi Bay. To the best of the knowledge of the authors, these are the first primary ES valuation studies in this context and were designed in response to the lack of primary ES valuation studies in all ES value domains in the Artic, as had been identified in the first publication of this thesis. The two valuation studies presented here are concerned with the monetary and socio-cultural ES value domains (Martín-López et al., 2014), while the biophysical domain that encompasses underlying ecosystem functions is largely included in the other two value domains (Gómez-Baggethun & Barton, 2013).

Furthermore, the analysis of whale ES governance in the Arctic using the interactive governance framework provides a new perspective on the management of marine mammal resources as it takes into consideration formal and informal governance interactions, considering multiple actors and how the values they attach to whale resources influence their governance. The comparative case study analysis highlights differences and commonalities between the communities, drawing some common issues to light and recognising others as context dependent. This enriches the Arctic governance literature with practical examples from a specific resource context of whale ES. Moreover, this type of analysis differs from usual institutional analysis because it takes a stakeholder-focused perspective to marine resource governance, this way contributing to both the ES and governance literature.

Finally, the variety of methods and theoretical concepts applied in the analysis of whale ES formation, valuation and governance is an example of a transdisciplinary approach to Arctic ES analysis, which was identified as one of the research needs in Publication I and a recommended approach for Arctic sustainability and policy research (Arctic Council, 2016; Falardeau & Bennett, 2019).

2.4 Policy relevance

The doctoral research resonates with one of the key findings of the TEEB scoping study (CAFF, 2015) that an interdisciplinary approach that combines economic and socio-cultural analyses of Arctic ES offers a toolkit for communicating to decision makers the importance of nature to people, evaluating policy options, and integrating stewardship into decisions. The ES valuation data presented in the thesis also responds to Element 5 of the Arctic Council's EBM implementation guidelines (Logerwell & Skjoldal, 2019), Goals 2 and 4 of the Arctic Marine Strategic Plan 2015–2025 (Arctic Council, 2015) and SDG target 14.2 (United Nations, 2016) by providing information on whale ES co-production, valuation, and governance in four Arctic locations. This doctoral research also informs the first and last recommendations for marine mammal management for the 21st Century by Laidre et al. (2015), delineated in Section 1.4 of the thesis by mapping out the interactive governance of whale ES and examining some of the monetary and socio-cultural values and co-production processes associated with them.

The use of ES valuation in policy can be either informative or decisive (Laurans et al., 2013). Informative use means that it is used to contribute to discussions and draw attention to specific resources and/or ES, and decisive — to evaluate trade-offs between different levels and/or types of ES (Milon & Alvarez, 2019). The results of this research are more appropriate for informative rather than decisive use, even though some of the ES valuation results could be fed into decision-making, e.g., through MSP in Faxaflói and Skjálfandi Bays when prioritising economic activities and management tools (Guerry et al., 2012; Lester et al., 2013; McKinley et al., 2019).The exploratory nature of this research means that while it provides some examples of conceptualising and valuing the human wellbeing benefits sourced from whale ES, concrete policy recommendations can only be made in collaboration with natural scientists, whale ES users, and policy makers. The information provided in the results can indeed be relevant for policy making and governance but does not command any particular response.

After conducting literature reviews and a series of interviews with coastal and marine resource users and managers in the Caribbean, Waite et al. (2015) concluded that the conditions for successful inclusion of ES valuation in decision-making include a clear policy question, strategic choice of study area, strong stakeholder engagement, effective communications, access to decision makers, transparency in reporting results, and potential revenue enhancement for the government. If all or some of these conditions are fulfilled, whale ES valuation has a potential to inform policy. For instance, focusing on whale ES can inform specific measures related to human wellbeing effects, and the stakeholder-focused interview approach used in this research facilitates inclusion of different views and values into ES assessments.

Fig. 4 below illustrates how this doctoral research fits into the EBM methodology delineated in the Arctic Marine Strategic Plan (Arctic Council, 2015, p. 10). The circled areas indicate the EBM stages, in which the results of this research could be potentially used. The whale ES and their values identified in Publications II-IV can potentially serve as indicators for setting an EBM agenda and measuring its results. For instance, they could be used in the development of a management plan, which was identified as a necessary key component of the more successful whale sanctuaries with regards to marine EBM by Cook et al. (2019). The human activities affecting whale ES formation, availability and governance

in the case study locations examined in Publications II and V correspond to the second circled area from the top in Fig. 4; the conceptual models for ES co-production and interactive governance in Publications II and V correspond to the third circled area; and the two whale ES valuation studies presented in Publications III and IV link to the point on collecting relevant data for informing EMB.

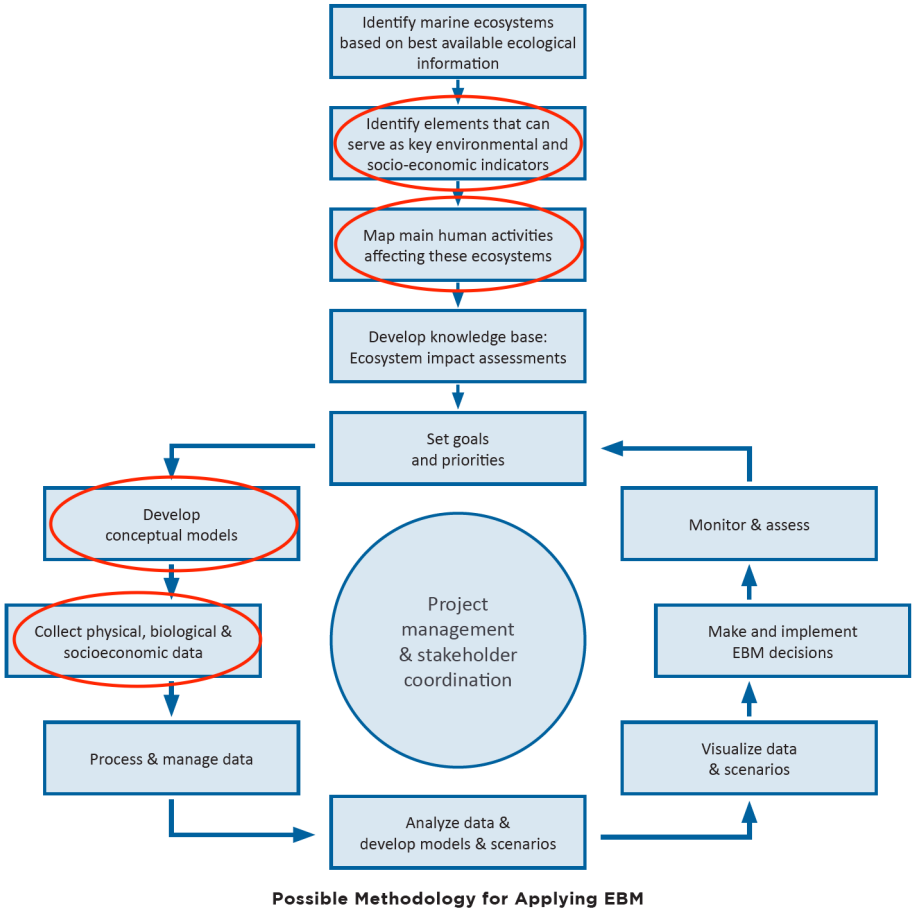

Figure 4 EBM stages that can be potentially informed by the in results of the doctoral research. Adapted from the Arctic Marine Strategic Plan 2015-2025.

2.5 Limitations and further research

2.5.1 Limitations of ES concept and valuation

The ES concept has been criticised by scholars for being anthropocentric and for serving as a tool for the commodification of nature (Gómez-Baggethun & Ruiz-Pérez, 2011; Kosoy & Corbera, 2010; McAfee, 1999). However, as was argued earlier, this is only the case if ES valuation methods are used inappropriately and out of context. While ES valuation meth-

ods are far from being perfect, they provide some useful information on human preferences related to the benefits sourced from ecosystems (Kallis et al., 2013; Nunes & van den Bergh, 2001), in this case — whales.

One of the biggest challenges in the course of the doctoral research and the ARCPATH project in general was combining the different research methods and approaches (King and Ogilvie 2021). While this enabled a multifaceted view of whale ES in the Arctic, integrating these different perspectives was somewhat challenging because they were concerned with different aspects of whale ES and, in some cases, different locations. The literature on integrative ES assessment suggests that combining biophysical, socio-cultural and monetary ES valuation brings a more nuanced understanding than can be gained from the individual approaches alone, method choice and implementation strongly affects the results obtained (Hattam et al. 2015, Dunford et al. 2018). In this research, no biophysical analysis of whale ES was done, implying a focus on the demand side of whale ES and inevitably overlooking some important aspects of whale ES. Having said that, it provides a more nuanced view of whale ES than a single method approach would have done, implying opportunities for further research where the biophysical aspects of the supply side of whale ES is better integrated.

While the research attempts to address the social-ecological complexity through elaborating whale ES co-production processes in the cascade model presented in Publication II, it still presents a simplification of SES complexity and puts a lot of emphasis on commodification and exchange value. An attempt was made to mitigate this risk through the emphasis of the socio-cultural values and the co-production processes that represent a part of the ES value in terms of livelihoods, cultural practices, self-determination, and co-creation. For instance, the socio-cultural valuation study of whale ES in Skjálfandi Bay reveals non-monetary relational values concerning community identity.

A limitation of survey-based ES valuation methods is that some of the important regulating and maintenance whale ES in the remote parts of the Arctic are potentially undervalued as survey respondents often lack awareness of them. These ES are likely to produce important human wellbeing benefits and have rather high biophysical values (International Monetary Fund, 2019), yet they are likely given no value in decision-making if there are no direct human beneficiaries. Another potential problem is presented by the fact that the presented research singles out whale ES from the marine ecosystem as a whole. While whale ES would not be possible without the Arctic Ocean marine ecosystem and the value of direct experiences, such as whale watching, cannot be separated entirely from the wider aesthetics of the surrounding landscape and ecosystem, focusing on the functional group of whales has its merits, especially when it comes to practicality and simplifying ES assessments for trade-off analysis in decision-making (Riisager-Simonsen et al., 2020).

Even though the thesis discusses the potential role of economic ES values in policymaking, no direct monetary valuation of whale ES was conducted within it, but rather a contingent valuation of a hypothetical change in a management regime related to provisioning and recreational whale ES in Publication IV. Generally, there are few primary monetary valuation studies of marine ES to date and they cover limited geographic areas (Pendleton et al., 2007). Moreover, estimating values of some of the regulating and maintenance ES provided by marine and coastal ecosystems involves high levels of uncertainty due to limited information on the mechanisms underlying them and the links between different groups of ES (Milon & Alvarez, 2019). In the case of whale ES, the estimates of ES values – monetary or otherwise – do not reflect the relationships and feedbacks between whales and the

rest of the Arctic and the global ocean ecosystems. The monetary and socio-cultural information resulting from the presented research is, therefore, exploratory rather than definite, and can be used to draw attention to the multiple aspects of human wellbeing benefits sourced from whale ES.

The limitations specific to the socio-cultural valuation study in Publication III were, firstly, that the list of whale ES used in the preference survey was informed by local stakeholders while the majority of survey respondents ended up being visitors; secondly, that the survey design allowed for giving high scores to all ES without having to prioritise them; and thirdly, that there could have been a potential positive bias when valuing less straight-forward whale ES, such as regulating and maintenance that required more explanations by the researchers, and therefore they were potentially perceived as relatively more important. However, some cultural ES, such as spiritual enrichment and inspiration for arts, also required explanations, yet were given relatively lower scores, so the presence of bias is not certain. Efforts were made to alleviate the first limitation by consulting the wider literature on whale ES, and the second limitation could be addressed in future studies by improving the survey in a way that requires prioritisation.

The limitations specific to the contingent valuation study presented in Publication IV are the high proportion of protest voters and their exclusion, no option for negative WTP, and the fact that the preferences of visitors, to whom a large part of whale ES benefits go, were not taken into consideration. These limitations can be alleviated by improving the contingent valuation survey design to allow for more accurate determination of protest voters, inclusion of visitors in surveys, and having more value options for willingness to pay.

2.5.2 Limitations related to research methods

Table 3 lists the limitations of the research related to the methods used, along with the descriptions of the attempts on the part of the research team to mitigate them.

Table 3 Limitations related to research methods used in the doctoral research

Method used	Limitations	Mitigation Efforts
Literature review	Overlooking relevant publications that do not explicitly use ES terminology but refer to ES and that are not written in English; publication selection bias and researcher subjectivity in thematic analysis and choice of Boolean strings	Use of additional search keywords; "snowballing" technique in publication selection; application of rigorous and reproduceable methodology with clearly defined themes
Case study method	Researcher subjectivity in case study selection and comparison	Setting clear criteria for case study selection; recognising context dependency of social-ecological phenomena and avoiding big generalisations
Stakeholder mapping	Incomplete information, researcher subjectivity when listing the key stakeholders	Use of the best practice guides; consultations with experts and stakeholders; progressive revision of maps according to new information
ES co-production model design	Oversimplification of social-ecological complexity; reductionist approach to social-ecological phenomena by focusing solely on whale ES	Recognising the limitations and the scope of the model; emphasis on whale ES as a part of SES; putting the research into context

Semi-structured interviews	Interviewee selection and availability bias; researcher subjectivity when interpreting the results; possible interviewee fatigue in the communities which have been subject to a lot of research studies	Following the best practice guides in case study research; following rigorous data analysis methodology; consulting previous research undertaken in case study communities to avoid duplication
Observations	Lack of depth due to short time frames of observations; potential researcher subjectivity when interpreting the observational data	Using observations as supplementary research method; avoiding broad generalisations; consulting stakeholders and experts
Socio-cultural preference surveys	Subjectivity and potential researcher bias when choosing the key whale ES; high scores allowed for all ES without trade-offs; lack of familiarity by respondents with some ES	Recognising that the socio-cultural values present only a part of whale ES values; recognising that the study represents a snapshot in time and is exploratory
Contingent valuation	Hypothetical bias; payment vehicle bias	Making sure that the valuation scenario is as realistic as possible; choosing a payment vehicle that respondents are familiar with

The limitations and their mitigation efforts are described in more detail and referenced in each publication.

2.5.3 Other research limitations

Even though the research is concerned with different locations in one part of the Arctic, its results are not necessarily generalisable to all whale ES in the circumpolar north. It is emphasised throughout the thesis that the valuation results present a snapshot in time in a certain SES location based on the information that was gathered. There is no doubt that some aspects of whale ES have been left out, but the efforts were made to gather as much relevant data from as diverse sample of respondents as possible. For instance, in Greenland, three full time hunters were interviewed. Access to these hunters, as well as translation services from Greenlandic to English, were made available by a local facilitator, but all of them represented the older generation of hunters (all male), only one part of the local hunting community. Gender dimensions of whale ES were mostly left out of the analysis. This was not intentional but determined by the lack of apparent gender dimensions in the data, which could be further examined by a focused gender-based analysis of ES co-production. Same could be said about the cultural minorities due to the lack of access to and information about them. Moreover, the fieldwork took place between June and September, typically the busiest months of the tourism season in the case study locations. The results of this research might have been very different if the data was collected at another time in the year, and likely even more so if collected after the commencement of the COVID-19 pandemic.

One of the main limitations of this research is related to the lack of analysis of the biophysical value domain of whale ES. However, the biophysical ES value domain is argued to underlie the other value domains and in this way be included in ES valuation without making it explicit (Gómez-Baggethun & Barton, 2013). The lack of natural science research concerning marine ecosystem dynamics and whale distributions in the Arctic, and the unpredictability of whale ES due to their migratory nature, was found to be a strong limitation for ES valuation, governance, and analysis of co-production processes. As the case of Tromsø demonstrated, place-based whale ES valuation loses a big part of its relevance if they are no longer present in certain locations due to changes in marine ecosystem. This

limitation can be potentially reduced by conducting more research in this area, as is discussed in the next section on the avenues for further research.

Even though it is argued throughout the thesis that analysing whale ES separately has practical value in terms of simplicity and applicability, it is impossible to separate ES from their context (Milon & Alvarez, 2019). This limitation is inherent to this research as it focuses on whale ES, but attempts have been made put its results into a wider context and recognise this limitation. Another limitation related to the whale ES co-production cascade model developed in Publication II is the danger of overlooking non-use and intrinsic ES values. Then there is a question about how to value regulating and maintenance ES provided by whales when they are not present in a certain location. In this case, inclusion of different spatial and temporal scales may be required. Moreover, ES co-production does not happen in a socio-political vacuum and involves social power relations (Berbés-Blázquez et al., 2016), which were largely left out of the co-production analysis in Publication II, but discussed briefly in relation to governance in Publication V.

2.5.4 Ethical and language issues

The ethical issues of this research are mostly related to incomplete information obtained through short fieldwork in the case study locations. In qualitative research, this presents a significant limitation that can lead to a distorted image of reality and inappropriate generalisations (Flick, 2008). This is especially relevant in indigenous communities, whose worldview may differ significantly from that of the researchers' and the dominant "Western" worldview in the academic environment (Ermine et al., 2004; Martin & Mirraboopa, 2003).

Language is central to qualitative research as it is the medium in which participants communicate their experiences and researchers interpret those experiences based on the research framework used and their own experience and cognition (Polkinghorne, 2005; Potter & Hepburn, 2005). There are several issues related to language in the research. Firstly, only entries written in English were considered in the literature review, as is discussed in Publication I. This potentially narrows the search results significantly as non-English language research related to Arctic ES was left out. Moreover, the researchers that were involved in the fieldwork data collection in the case study locations lacked knowledge of the local languages — Norwegian in Norway, Greenlandic and Danish in Greenland, and, to a certain extent, Icelandic in Iceland (neither of the researchers who participated in the fieldwork are native Icelandic speakers). This posed the biggest obstacle in Greenland, where English literacy is the lowest of the three countries where fieldwork was done and local people are used to speaking their native tongue and use Danish rather than English when interacting with foreigners. This fact made it necessary to hire an interpreter for the interviews with the Greenlandic hunters and to record one interview with a local government official in Danish for it to be translated later by one of the members of the research team who speaks Danish. Moreover, language also posed a significant barrier when contacting potential interviews that did not speak English and when designing the stakeholder map, necessitating reliance on the available English sources and expert consultations of researchers that had previously done research in Greenland.

2.5.5 Further research

The lack of primary ES valuation studies in all value domains in the Arctic identified in Publication I remains, despite the ES valuation studies presented in this thesis. More valuation studies on an ecosystem and species level are needed to assess the human wellbeing benefits and their changes in the Arctic that could be fed into policy approaches, such as EBM (CAFF, 2015). More research on social power relations and equity implications of Arctic ES co-production, use and distribution is also needed to provide sound advice for just and equitable natural resource governance in the region (ibid.). This is especially relevant for gender issues, and future studies could include gender-focused analysis of ES co-production, access, and governance. Additionally, more emphasis should be put on the views of less powerful and therefore less often heard sectors of society, such as cultural minorities, people with disabilities, migrant workers, and the elderly, in future studies to ensure that all groups of stakeholders are represented in ES research.

Furthermore, there is a need for clear strategies on how to integrate ES research into policy and governance as estimating human wellbeing effects alone is not sufficient to improve sustainability. Estimating ES synergies and trade-offs as well as their bundles is another important avenue for further research concerned with Arctic ES and marine ES in general. Their assessment is especially important if the results are used to inform MSP, as it involves prioritising some economic activities and ES over others (Ehler & Douvere, 2009; Guerry et al., 2012). For this purpose, it is also necessary to further develop and refine ES valuation techniques in order to make their methods more robust and results more reliable and comparable between cases.

The limitations presented by the lack of understanding the biophysical processes behind the changes in whale distribution observed in the case study locations, as well as the mechanisms behind the accumulative anthropogenic effects on cetaceans, including whales, call for more research in this area. One of the objectives of the ARCPATH project – to connect climate data to the effects of climate change on whale populations – remains largely unmet at the present moment due to the lack of studies connecting these biophysical processes. The task at hand is not easy as it involves a lot of uncertainly, yet there are innovative multiple-input modelling tools, such as Atlantis, which could be utilised for this purpose (Fulton et al., 2011; Weijerman et al., 2016). Estimated biophysical changes and their effects on marine species could then be translated into human wellbeing effects through assessment of ES and valuation.

The Arctic Council is a strong advocate of the EBM approach in Arctic ecosystem and biodiversity governance, which implies a holistic view of people and ecosystems as SES, requiring transdisciplinary research efforts and all-ecosystem approach to analysis. The presented research zooms into the whale ES in the Arctic, but an Arctic Ocean ecosystem needs to be studied as a whole from a multidisciplinary angle in order to make sound and holistic governance recommendations (PAME, 2013).

Finally, it is impossible to ignore the impact that the COVID-19 pandemic has had since the beginning of 2020. The abovementioned research avenues will have to be studied in this context, taking into consideration the new dynamics impacting Arctic SES, as well as the rest of the world. Future research could explore the effects of the pandemic on Arctic coastal communities, examining the social-ecological changes it caused, the coping mechanisms of the communities, as well as their resilience or lack thereof.

2.6 Conclusion

To the best of the knowledge of the author, this thesis presents the first attempt to study the human wellbeing benefits sourced from whales from the ES perspective in an interdisciplinary manner in the context of the Arctic. The research analysed the social-ecological dynamics associated with co-production, valuation and governance of whale ES using a diverse set of qualitative and quantitative methods. The literature review on Arctic ES identified the main themes and gaps in this area of study, including the increasing focus on Arctic SES and a lack of primary ES valuation studies. Following these findings, a conceptual model was constructed to include human co-production components into the ES cascade based on examples of whale ES in three Arctic SES. The resulting model conceptualises the ways in which human wellbeing benefits are formed throughout different stages of the ES cascade from biophysical structure to ES valuation, potentially helping to identify the areas where social and ecological sustainability could be improved.

The doctoral research also presents the first two primary valuation studies of whale ES in the Arctic context, to the best of the knowledge of their authors. The socio-cultural valuation study, based on qualitative and quantitative data, sheds light on how stakeholders value whale ES in the local context of a coastal community in Iceland and concludes that the regulating and maintenance ES and cultural benefits related to tourism and recreation, education and existence values were given most importance by the survey respondents. A monetary ES valuation study in another whale sanctuary location in Iceland, Faxaflói Bay, reveals a division among the Icelandic population on the issue of whaling versus whale watching and a mean WTP of 5.082 ISK (42 USD in 2018) by the 324 respondents (around 47% of the sample) with clear preference regarding the sanctuary expansion.

The governability assessment of whale ES in three Arctic SES sheds light on some of the SES properties that determine whale ES governability. This exercise, based on qualitative analysis of interviews, observations, literature review and stakeholder mapping, connects the interactive governance and ES literature and brings to light the multiple values and co-production processes related to whale ES, in this way making a theoretical contribution to both fields. The assessment of whale ES governability in three coastal communities reveal high levels of complexity and dynamics in the SES studied, which are partly addressed by actors' ability to self-govern in the areas where formal institutional arrangements are lacking, e.g., in whale watching. However, this ability varies between the case studies owing to differences in actors' capacities, needs, and values, necessitating dialogue and co-governance efforts on behalf of formal and informal institutions and stakeholders at all levels. The governance visions and needs expressed by stakeholders are only partly reflected in the existing instruments and institutions, indicating a limited fit between governance elements. The results of this stakeholder-focused assessment indicate the heterogenous, multi-scale and multi-actor governance interactions that require an inclusive and reflective approach in efforts to improve it.

The thesis explored social-ecological dynamics through the concept of whale ES, which serve as a lens for exploring natural resource utilisation and governance issues in the Arctic. Much of these resources are marine-based and are being affected by climate change, globalisation and other anthropogenic factors at an unprecedented scale. Therefore, the relevance of the focus of this research on the relationship between human societies and marine species such as whales is more important than ever before.

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3 Publication I: Ecosystem services in the Arctic: a thematic review

Ecosystem Services 36 (2019) 100898

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

Ecosystem services in the Arctic: a thematic review

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ARTICLE INFO

Keywords:
Arctic
Ecosystem services
Literature review
Meta-synthesis
ES valuation
Social-ecological systems

ABSTRACT

The study presents the first systematic review of the existing literature on Arctic ES. Applying the Search, Appraisal, Synthesis and Analysis (SALSA) and snowballing methods and three selection criteria, 33 publications were sourced, including peer-reviewed articles, policy papers and scientific reports, and their content synthesised using the thematic analysis method. Five key themes were identified: (1) general discussion of Arctic ES, (2) Arctic social-ecological systems, (3) ES valuation, (4) ES synergies and/or trade-offs, and (5) integrating the ES perspective into management. The meta-synthesis of the literature reveals that the ES concept is increasingly being applied in the Arctic context in all five themes, but there remain large knowledge gaps concerning mapping, assessment, economic valuation, analysis of synergies, trade-offs, and underlying mechanisms, and the social effects of ES changes. Even though ES are discussed in most publications as being relevant for policy, there are few practical examples of its direct application to management. The study concludes that more primary studies of Arctic ES are needed on all of the main themes as well as governance initiatives to move Arctic ES research from theory to practice.

1. Introduction

The concept of ecosystem services (ES) presents a useful way of thinking about the relationship between human welfare and nature, with the literature on ES having grown exponentially since the 1990s (Costanza et al., 2017; Costanza and Kubiszewski, 2012; Droste et al., 2018; McDonough et al., 2017). The popularity of the concept grew further through the publication of the seminal Millennium Ecosystem Assessment (2005) and research platforms such as The Economics of Ecosystems and Biodiversity (TEEB) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which have sought to mainstream ecosystem service valuation into decision-making. The fact that the number of scientific peer-reviewed articles containing the words 'ecosystem services' in their title have grown from less than 10 in the 1990s to 2800 in 2016 alone (Costanza et al., 2017), illustrates this point. This rapidly-growing body of literature contains analysis from all types of ecosystems and includes a wide range of topics, including ecological analysis, valuation, biodiversity conservation, and management (Abson et al., 2014; Droste et al., 2018).

Despite the growing attention to ES and its practical applications, the concept has, in certain remote parts of the planet, failed to attract widespread public attention. One such region is the Arctic, also known as the 'refrigerator of the world', referring to the global importance of climate regulation services that it provides together with the Antarctic region (Chapin et al., 2005; Walker, 2007). The extent and importance of the vast array of services that Arctic sea ice, marine and terrestrial ecosystems provide on global, regional and local scales was not recognised until fairly recently. Scientific research, changing weather patterns and improved understanding of Earth's geological cycles in the twentieth century made apparent that not only the four million Arctic inhabitants depend on Arctic ecosystem services, but so do the rest of the Earth's inhabitants. As natural resources become scarce globally, the attention of political leaders has turned to the Arctic, where climate change makes some more accessible. Like everywhere else in the world, trade-offs occur when extracting natural resources in the Arctic and

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https://doi.org/10.1016/j.ecoser.2019.100898
Received 24 September 2018; Received in revised form 23 January 2019; Accepted 14 February 2019

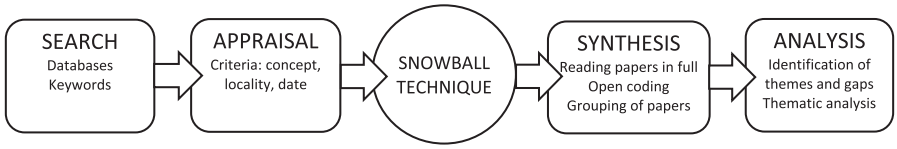

Fig. 1. Framework used for the meta-synthesis: a combination of SALSA and snowballing technique.

increasing global interest in the region means that this is no longer an Arctic-only issue. Global forums, such as the Arctic Circle Assembly, which involve actors from a wide array of sectors and geographical locations outside of the Arctic, and the fact that global powers like China and the European Union have their own Arctic policies, are indicative of this impression (Young, 2010, 2016).

In few places on Earth are the consequences of climate change more apparent than in the Arctic (Arctic Council, 2004; Viñas, 2018; Wang and Overland, 2012). A warming climate has left increasingly large areas of the Arctic Ocean ice-free in summer, which, together with thawing of permafrost and rising temperatures on land and water, is changing the ecosystems in unprecedented and unpredictable ways (IPCC, 2014; O'Garra, 2017; Wang and Overland, 2012; Whiteman et al., 2013). With landscape and ecosystems, societies that depend on them are also changing: Arctic populations are confronted with challenges as well as opportunities presented by climate change, having to adapt to changes quickly to remain resilient (Arctic Council, 2013b, 2016; Chapin et al., 2015; Kaltenborn et al., 2017). The notion of ecosystem services, with its perspective focused on the benefits derived from human-ecosystem interactions, provides a platform for examining the impacts of changes that are taking place in the Arctic (Arctic Council, 2016; Costanza et al., 2017; Potschin and Haines-Young, 2017). However, literature connecting the ES concept, especially its practical applications to Arctic policy-making, is still scarce. This paper provides a meta-synthesis of the existing literature that applies the ES concept in an Arctic context. Its principal objective is to map out existing publications on the subject since 2005 and list the main re-emerging themes and gaps in the research so far. To the best of the authors' knowledge, this meta-synthesis is the first attempt to provide a comprehensive overview of the existing literature on Arctic ES, and its outcomes will represent an orientation point for the commencement of future Arctic ES research projects.

The paper is organised as follows. Section 2 presents the methods used in the literature review, including publication sourcing techniques, article selection rationale, and thematic analysis. Section 3 lays out the synthesis of the main findings according to the five recurring themes identified in the literature. Section 4 presents the discussion of the results, and Section 5 concludes the paper by outlining the practical implications of this review with regards to research and sustainable development policy in the Arctic.

2. Methods

2.1. SALSA framework

In order to locate and synthesise the existing literature on ecosystem services in the Artic to date, the meta-synthesis method (Cronin et al., 2008; Polit-O'Hara and Beck, 2006) was applied using the Search, Appraisal, Synthesis and Analysis (SALSA) framework (Cronin et al., 2008; Grant and Booth, 2009) (Fig. 1). 'Meta-synthesis involves analysing and synthesising key elements in each study, with the aim of transforming individual findings into new conceptualisations and interpretations' (Grant and Booth, 2009, p. 6). SALSA framework has its roots in health sciences but is applicable to any discipline due to its simplicity and logical sequence of steps for conducting a literature review. It is an approach that has frequently been applied in ES research without a specific reference to the SALSA framework (Mastrangelo et al., 2015; Yang et al., 2018). Due to a small number of identified relevant scientific articles, a 'snowballing' method (Creswell, 2007) was applied between the Appraisal and Synthesis stages to expand the list of publications relevant to the topic.

2.2. SALSA and snowballing steps

2.2.1. Step 1: search

Four academic databases – Science Direct, Scopus, Web of Science and Google Scholar – were searched to identify relevant publications that applied the concept of ecosystem services in an Arctic context between 2005 and 2018. Firstly, the search keywords 'Arctic' and 'ecosystem services' were used to find the relevant literature using a Boolean search string 'Arctic AND 'ecosystem service$[1]'", with entire texts interrogated in all four databases. All the resulting publications from Scopus (n = 121) and Web of Science (n = 107) were then taken to the Appraisal stage. The pool of results from the Science Direct and Google Scholar academic search engines were initially very large – 2686 and 13,000 respectively – and the overwhelming majority were not relevant for this Arctic-specific ES literature review. To narrow these down, the term 'ecosystem services' was replaced in both search engines with the terms 'environmental services', 'nature's services' and 'natural capital' and complemented with additional search words 'valuation', 'mapping', 'economics' and 'subsistence resources', using Boolean search string: 'Arctic AND ('nature's services' OR 'natural capital') AND ('valuation' OR 'mapping' OR 'economics' OR 'subsistence resources'). This new search sourced four additional publications from Science Direct and five from Google Scholar. Some articles appeared in more than one academic search engine and these were not counted twice. Overall, two hundred and thirty-seven papers were sourced from the four databases.

2.2.2. Step 2: appraisal

The abstracts of all the papers sourced from the four databases in the Search phase were read in full to determine their suitability to be included in the review using three criteria: use of ES concept, locality, and date of publication. The first criterion required that the concept of ES is applied in a meaningful way and not simply as a buzzword, the second criterion – that the content is discussed in relation to the Arctic, and the third – that the date of publication is 2005 or later. The reason for the latter criterion is that the seminal Millennium Ecosystem Assessment (MEA) synthesis report was published in 2005 containing a chapter on Polar Systems, and it has been credited for spawning multiple lines of ES research due to its popularisation of the concept (Chapin et al., 2005; Chaudhary et al., 2015; MEA, 2005). After reading the abstracts, eighteen of the two-hundred and thirty-seven publications were deemed suitable for this literature review.

2.2.3. Additional step 3: snowballing technique

An additional step was added to the SALSA framework to identify more relevant articles. 'Snowballing technique' refers to pursuing references provided in citations of selected publications, a method that has proved to be particularly useful for 'identifying high-quality sources

[1] "$" stands for zero or one character in Boolean search (Malkamäki et al., 2017)

in obscure locations' (Greenhalgh and Peacock, 2005, p. 1065). Its successful applications range from literature reviews in health sciences (ibid.), social science and education (Tess, 2013), computer science (Radjenović et al., 2013), and environmental science and policy studies (Binder et al., 2013; Spruijt et al., 2014). Applying this technique resulted in 15 additional articles and allowed for the inclusion of a wider range of publications, such as intergovernmental bodies (e.g. the Arctic Council and its expert working groups) and non-governmental organisations (e.g. the World Wildlife Fund). It also enabled the triangulation of data sources and representation of the viewpoints of different stakeholders. Appendix 1 presents the final list of 33 publications sourced from each search engine and using the snowballing technique in the chronological order of sourcing.

2.2.4. Step 4: synthesis

All the papers sourced in the first three steps using a combination of SALSA framework and snowballing technique were read in full and analysed with a purpose of identifying the main analytical focus, methods and themes related to Arctic ES. The papers were categorised according to publication types: academic peer-reviewed articles (n = 20), reports and studies published by inter-governmental forums, such as the Arctic Council and the Nordic Council of Ministers (n = 10) and other sources – an NGO publication, a book chapter and a conference proceeding (n = 3). Then the publications were grouped according to the Arctic biomes discussed: terrestrial, sea-ice and marine (O'Garra, 2017).

2.2.5. Step 5: analysis

The thematic analysis was conducted in accordance with the six-stage framework outlined by Braun and Clarke (2006), which has been applied in a wide variety of qualitative research contexts. This process has its methodological foundations in grounded theory (Guest et al., 2012; Strauss and Corbin, 1990), whereby coding and the formation of identified research themes involve a bottom-up inductive process that is emergent from the data. The six phases in the framework are as follows: (1) familiarisation with data; (2) generation of initial codes; (3) searching for themes; (4) reviewing themes; (5) defining themes; and (6) analysis and writing up. With regards to the initial generation of codes in stage 2, an open coding approach was applied, ensuring that codes were developed and modified as the coding process progressed. Initially, the coding of the 33 selected articles was carried out manually, before utilising qualitative data analytic software MAXQDA. In stage 3, the codes were grouped into five distinct themes, which were then reviewed for consistency in stage 4 to ensure that there was no or very limited overlap between them, and then each theme was defined in stage 5. Stage 6 involved a quantitative appraisal of the extent to which each theme appears in the Arctic ES literature, from which research gaps emerged. In this paper, observations of research gaps made by the authors of the respective Arctic ES publications are also referred to as a reinforcement of our own conclusions.

3. Results

3.1. General findings

Arctic ecosystems and ES are typically classified into three biomes: terrestrial, sea-ice and marine (O'Garra, 2017). From the 33 publications sourced for this meta-synthesis, eleven discuss all three biomes, eight – terrestrial, two – sea-ice and ice, and twelve – marine ecosystems. Appendix 1 contains more detailed information about each paper, including the publication type and date, themes and biomes discussed, and methods used. As Table 1 indicates, most of the literature is concerned with the marine biome or discusses all three biomes, whereas terrestrial and sea-ice biomes receive relatively less attention. The tendencies are similar in peer-reviewed academic literature, with terrestrial and marine ES being more widely discussed than the Arctic sea-ice biome.

Table 1
Number of publications concerned with Arctic ES in different biomes

Biome	Terrestrial	Sea-ice	Marine	All three	Total
Number of publications	8	2	12	11	33
Number of peer-reviewed articles	6	2	5	3	16

Even though scarce, the literature on Arctic ecosystem services has been growing steadily over the last few years. Out of 33 publications identified for this review, 27 were published in 2013 or later. One possible explanation for this increased attention is that two influential publications came out around that time – the Arctic Biodiversity Assessment (ABA) in 2013 and The Economics of Ecosystems and Biodiversity (TEEB) scoping study for the Arctic in 2015 – which strengthened the ES agenda in the region. At the same time, Arctic issues started to be discussed with increased frequency in international forums, such as the Arctic Circle Assembly and global climate negotiations (Duyck, 2015), and Arctic-focused research programmes are growing in number as a result of this increased attention.

Despite the relatively large number of documents found on academic search engines that contain the words 'Arctic' and 'ecosystem services', only a few of them actually focus on ES. For example, the total number of such documents on the Scopus database (on April 15, 2018) was 121; among them only seven had Arctic ES as their main topic, but in 68 articles the term 'ecosystem services' was used in the abstract, most often in relation to threats of their loss if Arctic ecosystems are further degraded by the changing climate and human activities. This observation exposes the tendency in the ES literature to use the term as a buzzword for sustainability research justification but without exploring it in any real depth (Abson et al., 2014; Droste et al., 2018).

3.2. Main themes

Five key themes emerged through the thematic analysis: (1) general discussion of Arctic ecosystem services; (2) Arctic social-ecological systems; (3) economic (monetary and non-monetary) valuation of ES and/or potential for it; (4) identification and general discussion on ES synergies and/or trade-offs; (5) integrating the ES concept into Arctic resource management. The main themes are listed in Table 2, together with brief explanations and numbers of corresponding publications. The themes are discussed in more detail in the remainder of this section with references to the literature. The themes discussed in each publication sourced for this review are listed in Appendix 1, along with a brief outline of their analytical approach.

3.3. General discussion on Arctic ES

More than half of the publications (17 out of 33, or 52%) include general discussions on Arctic ES, in addition to explanations concerning the concept and its relevance for the Arctic. This fact indicates that there is a perception of novelty in this research area and a need to provide some background. The main focus points of each publication that includes this theme are listed in Table 3. Publications are listed in the same order as in Appendix 1.

The discussion starts with general attempts to apply the ES concept, list and classify Arctic ES using the most common typologies, such as the Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) (Arctic Council, 2013b, 2016; CAFF, 2015; Chapin et al., 2005; Gundersen et al., 2016; Huntington, 2013; WWF, 2015). The Economics of Ecosystems and Biodiversity (TEEB) scoping study by the Biodiversity Working Group of the Arctic Council Conservation of Arctic Fauna and Flora (CAFF) (CAFF, 2015) gives an extensive overview of Arctic ES and indicates the potential for

Table 2
Five main themes emerging from the literature on Arctic ES

Theme	Explanation	Number of publications
1. General discussion on Arctic ES	General discussion of Arctic ES up to the point of (but not including) spatial mapping.	17
2. Arctic social-ecological systems	Social-ecological systems as a conceptual model for thinking about nature-human interactions in the Arctic.	12
3. Valuation of Arctic ES	Discussion and application of ES monetary and non-monetary valuation methods in the Arctic.	18
4. Synergies and/or trade-offs between Arctic ES	Discussion and/or assessment of synergies and/or trade-offs between different Arctic ES.	10
5. Integrating ES into management	Application of ES concept into the management of Arctic natural resources and socio-ecological ecosystems.	23

spatial mapping, valuation and application in the management of natural resources. The Arctic Biodiversity Assessment (ABA) (Huntington, 2013) reviews four provisioning and one cultural ES, providing an overview of the key stakeholders, trends and future concerns. The MEA (Chapin et al., 2005) provides a general discussion on the status, trends, and drivers of change in the Arctic ES as well as implications for human well-being. The stated purpose of these Arctic-wide studies is to prepare the ground for future ES research and its conceptual application in Arctic sustainable development policy.

Some of the more focused studies also provide a general discussion of the ES concept before applying it to a specific context. They attempt to list, describe and discuss its potential applications in the research and management practices of different Arctic biomes, e.g. coastal ecosystems and kelp forests (Gundersen et al., 2016; Smale et al., 2013), cold water corals (Armstrong et al., 2014), sea-ice ecosystems (Eicken et al., 2009; Euskirchen et al., 2013), boreal forests in Arctic Finland (Vihervaara et al., 2010) and Alaska (Chapin et al., 2006), and a combination of biomes (Chapin et al., 2015; Jansson et al., 2015). In some cases, the ES concept is applied in relation to other sustainability concepts, such as ecosystem stewardship and resilience. Chapin et al. (2015) discuss the applicability of the ES concept to Arctic conservation through an ecosystem stewardship framework that integrates social and ecological dimensions of conservation across different spatial scales. Similarly, the Arctic Resilience Report (Arctic Council, 2013b, 2016) conceptualises the occurrence of ES as an interplay between social and ecological systems, using the term to discuss the resilience of ecosystems and communities to fast-paced environmental and social change. The ES concept in these studies provides a framework for conceptualising, quantifying and managing human-nature interactions in the Arctic.

3.4. Arctic social-ecological systems

In relation to sustainability, the term 'social-ecological system' (SES) is used to highlight the interdependence of humans and nature and diminish boundaries between social and natural sciences in sustainability research and management (Berkes et al., 2000). SES is defined by the Arctic Council (2016, p. 17) as 'an integrated system that includes human societies and ecosystems. The functions of such a system arise from the interactions and interdependence of the social and ecological subsystems. Its structure is characterised by reciprocal feedbacks.' As Table 4 indicates, the term is predominantly used in a conceptual way to emphasise the need for a holistic inter- and transdisciplinary approach to Arctic sustainable development.

The SES concept is discussed in relation to ES in 12 publications out of 33 (36%), and it has been applied to the whole of the Arctic (Arctic Council, 2016; CAFF, 2015; Chapin et al., 2015), separate biomes (Eicken et al., 2009; Jansson et al., 2015), regions (Jansson et al., 2015) and species (Mosbech et al., 2018). The SES concept lies at the heart of the Arctic resilience debate, being used to study how changes in one part of a system affect its resilience and to emphasise the interdependence of social and natural domains. The Arctic Resilience Report (Arctic Council, 2013b, 2016) discusses in depth how different components of these sub-systems are affected by the physical changes in the Circumpolar North and what policy actions have a potential to enhance their resilience. This holistic approach resonates with the Sustainable

Table 3
Main points of focus in general discussion on Arctic ES.

Publication	Focus
O'Garra, 2017	Discusses the importance of Arctic ES globally, presents a framework for ES valuation and identifies the threat that many services may soon be lost due to climate change.
Armstrong et al., 2014	Presents the ES concept and applies it to the management of a cold-water coral reef.
Chapin et al., 2015	Provides ES definition and briefly discusses it in relation to an ecosystem stewardship conservation framework.
Anisimov et al., 2017	Aims to improve understanding of climate change effects on societies in the Arctic through changes in ES supply.
Eicken et al., 2009	Discusses ESs of the sea-ice biome, referring to them as sea-ice system services (SISS) and classifies them using the MEA framework.
Mosbech et al., 2018	Presents ES concept and applies it to a single species of Little Auk to highlight the multiple ways, in which Arctic communities benefit from ES.
Chapin et al., 2006	Integrates ES in a framework for analysing directionally changing social-ecological systems, applying this approach to Alaskan boreal forests.
Jansson et al., 2015	Presents the ES concept and uses it to estimate the societal effects of future climate change in northernmost Europe in terms of changes in terrestrial and freshwater ES.
Vihervaara et al., 2010	Presents, discusses and applies the ES conceptual tool in analysis of human-environment systems in Finnish Forest Lapland.
Smale et al., 2013	Applies the ES notion to highlight the ecological and societal importance of kelp forests and the threats of climate change.
Huntington, 2013	Discusses four provisioning and two cultural ES in the Arctic using available data.
Arctic Council, 2016	Provides a theoretical analysis of links between ecosystem properties and attributes of social systems with a resilient supply of ES, beginning to examine possible impacts of climate change on Arctic ES.
Gundersen et al., 2016	Uses MEA classification to list and explore ES of four defined coastal ecosystems: kelp forests, eelgrass meadows, blue mussel beds, and shallow bays and inlets.
Chapin et al., 2005	Provides a wide-ranging and detailed review of polar ES according to the MEA classification, and considers ES contribution to human wellbeing, possible climate change effects and management interventions.
CAFF, 2015	Presents a scoping and thematic study of main Arctic ES and provides guidance and policy focus areas that could be further refined and assessed using TEEB methodology.
Magnussen and Kettunen, 2013	Through scoping study, highlights the socio-economic importance of the marine ES in the Barents Sea and Lofoten Islands and how they might be affected by oil and gas drilling in the area.
WWF, 2015	Provides a summary and professional review of the TEEB scoping study by selected contributors, highlighting the multiple values of Arctic ES.

Table 4
Main points of focus on social-ecological systems.

Publication	Focus
Chapin et al., 2015	Discusses how the warming climate in the Arctic interacts with socio-economic changes to reduce subsistence activities in rural communities; examines the contribution of Arctic ES to human well-being and identifies the main drivers of ES changes.
Eicken et al., 2009	Describes sea ice as a geophysical phenomenon within a social-ecological system and draws out a framework for identifying and meeting the information needs of sea-ice users in Arctic Alaska.
Mosbech et al., 2018	Examines the ES provided by the little auk in Northwest Greenland from ecological, socioeconomic and cultural perspectives, highlighting the variety of reciprocal interactions of a single species with multiple components of a SES.
Chapin et al., 2006	Using a case study of Alaskan boreal forests, draws on the dynamics of social-ecological systems that are subject ed to directional changes to identify policy strategies for addressing their sustainability.
Jansson et al., 2015	Uses the SES concept for analysing the occurrence of and projected changes in ES provision in northernmost Europe, concluding that adaptation strategies must take into account the complexities of social and ecological responses to change.
Vihervaara et al., 2010	Using the case study of Finnish Forest Lapland, introduces a methodology and databases for the sustainable management of ES.
Arctic Council, 2013b	Presents an Arctic resilience framework as an integrative approach for assessing SES changes across spatial and temporal scales, identifying the risk of threshold effects and building response capacity.
Koenigstein et al., 2016	Integrates stakeholder perceptions of ES changes with available scientific information to study climate change effects on SES in the Barents Sea region and identify appropriate adaptation actions.
Kaltenborn et al., 2017	Explores through an ES lens human-nature interactions and local notions of human well-being in the SES of a small community in the Lofoten Islands.
Huntington, 2013	Discusses interdependence of social and ecological subsystems of SES in the Arctic through the supply of provisioning and cultural ES.
Arctic Council, 2016	Bases the concept of Arctic resilience on reciprocal feedbacks between social and economic SES components and their ability to bounce back from shocks and adapt to change.
CAFF, 2015	Uses SES to describe reciprocity between Arctic societies and ecosystems, providing examples from different biomes. Suggests applying the SES concept for analyses of ES provision and change.

Development Goals (SDGs) of the United Nations that address human and ecological dimensions simultaneously. For instance, promotion of sustainable communities in the Arctic (SDG 11) through climate action (SDG 13) and responsible use of natural resources that enhance the sustainability of marine (SDG 14) and terrestrial (SDG 15) ecosystems (Nilsson et al., 2016; UN, 2016). The all-encompassing nature of the SES concept and its applicability to policy-making, guided by the SDGs, at least partly explains its fast-growing popularity.

Not unlike the SDGs, despite its seemingly high applicability for policy, the SES debate in the literature remains somewhat ambiguous and conceptual, which is a common difficulty with broad concepts. Having said that, there are examples of how the SES notion has been employed to provide concrete management suggestions. In focused studies, it enables researchers to model and quantify the interactions and flows of ES between components of SESs, bringing forward policy needs in specific contexts. Eicken et al. (2009) describes sea ice as a geophysical phenomenon within an SES and refers to the benefits derived from it by people as sea-ice system services (SISS). Regulating, provisioning and cultural SISSs are co-created and utilised by different user groups who constantly observe sea-ice, adjusting their activities accordingly. To identify the priorities of different SISS users and meet their information needs, the study suggests a consortium-based approach, where scientists and resource users work closely together. Chapin et al. (2006) present a framework for assessing the sustainability of SESs undergoing directional changes and apply it to boreal forest management in Alaska. Using criteria based on human-ecosystem interactions and resulting ES, the authors highlight the policy strategies that are most likely to enhance the sustainability of this SES. Vihervaara et al. (2010) translate different land uses of Finnish Forest Lapland into relevant ESs, map them and assess the impacts of different land uses on ES provision and SES, combining ecological, economic and sociological data. A similar approach was applied by Jansson et al. (2015), who analyse feedback mechanisms between SES components to project future changes in ES supply in the European Arctic.

Arctic societies and ecosystems have coexisted in a relative balance for millennia, but the climatic and physical conditions are changing more rapidly now than ever, threatening species, landscapes and ways of life in the region. The SES concept presents a new approach to conservation and environmental management as it removes the nature-culture separation, focusing instead on the synergies between human well-being and environmental protectionism. Chapin et al. (2015) propose an 'ecosystem stewardship' approach to Arctic conservation, whereby human activities are considered to be an integral part of ES co-production and management. On the same note, Koenigstein et al. (2016) advocate an integrated approach to research that involves stakeholder-informed ecosystem modelling.

The SES notion underpins the multiplicity of values resulting from interactions between humans and nature. The literature includes examples of how one component of SES, e.g. a single species, can influence multiple aspects of social, economic and cultural life in Arctic communities. Mosbech et al. (2018) look into the ES provided by the little auk, a small seabird with breeding grounds in Northwest Greenland, and describe it as a social and ecological 'engineer' that has influenced the livelihoods and cultural practices of local communities and functioning of local ecosystems for millennia. Other 'social engineers' in the literature include the walrus, a keystone species in Alaskan Inuit communities (CAFF, 2015, p. 38), reindeer in Arctic Eurasia, and caribou in North America; the species that are central to the cultural identities of communities expressed through traditional art and storytelling (CAFF, 2015, p. 89; Huntington, 2013; Jansson et al., 2015). Marine resources, including fish and marine mammals, play a dominant role in many Arctic coastal communities' social and cultural lives through monitoring, harvesting and sharing activities (CAFF, 2015; PAME, 2013). Kaltenborn et al. (2017) describe the relationship between communities and local ecosystems as important in terms of provisioning ES, but also as components of what constitutes a 'good life' – a sense of well-being.

3.5. Valuation of Arctic ecosystem services

Putting the ES concept into practice often implies carrying out an ES valuation, the results of which can be communicated to decision-makers in monetary (Cook et al., 2016; Costanza et al., 2017; Hauck et al., 2013) or non-monetary (Kelemen et al., 2014; Maestre-Andrés et al., 2016; Castro Martínez et al., 2013) terms. Few primary valuation studies of Arctic ES have been carried out to date, despite the increasing attention to ES globally and the efforts of the TEEB scoping study for the Arctic in this regard (CAFF, 2015). Table 5 lists 13 publications from the literature that are concerned with monetary valuation and 5 that provide non-monetary analyses of Arctic ES values.

A recent study by O'Garra (2017) provides a preliminary assessment of the quantity, distribution and economic value of the key Arctic ES and geological resources using the benefit transfer method and total economic value (TEV) framework. The author combines secondary

Table 5
Main points of focus on valuation of Arctic ES.

Publication	Focus
Monetary perspective	
O'Garra, 2017	Application of benefit transfer approach for estimation of the economic value of key Arctic ES.
Aanesen et al., 2018	Using discrete choice experiments (DCE), reveal households' preferences related to commercial developments and recreational activities in coastal zones in Northern Norway.
Hasselström et al., 2017	Cost-benefit analysis of reducing the probability of a major oil spill in Lofoten-Vesterålen in northern Norway, finding that improving maritime safety is economically profitable for society in terms of the avoided costs of ES loss.
Goldstein et al., 2014	Provides a replacement cost calculation for the subsistence harvest of northern pintail by indigenous communities in North America.
Euskirchen et al., 2013	Attempts to monetise the climate regulation ES of the Arctic cryosphere by examining how physical changes and feedback mechanisms may affect global CO2 emissions up to the year 2100 and, using the social cost of carbon, calculates the expected economic damage.
Noring et al., 2016	Contingent valuation study of ES at risk from potential oil spills in the Lofoten Islands, finding a high perception of risk and preference for preventive over reactive measures for reducing the ecological damage of oil spills.
Aanesen et al., 2015	Uses a discrete choice experiment (three protection scenarios) to elicit the economic values of ES provided by cold water corals in Northern Norway.
Hasselström et al., 2012	Background desk-based study using secondary sources to estimate the threats to and values of ES in the Lofoten Islands and the Barents Sea likely to be affected by an oil spill in the area.
Huntington, 2013	Cites different valuation studies of Arctic ES, stressing the need for value pluralism and need for primary studies.
CAFF, 2015	Cites ES valuation studies from around the Arctic, giving examples of methods and different types of ES values.
Magnussen and Kettunen, 2013	Cites economic valuation studies of provisioning and cultural ES provided by Norwegian fisheries.
WWF, 2015	Reviews the TEEB scoping study, outlining examples of different ES values and emphasising plurality.
Navrud et al., 2017	Presents a contingent valuation study of coastal ES potentially lost due to oil spills in Arctic Norway.
Non-monetary perspective	
Mosbech et al, 2018	Applies an interdisciplinary perspective, assessing in non-monetary terms the economic, socio-cultural and ecological importance of the little auk in Northwest Greenland.
Koenigstein et al., 2016	Uses stakeholder consultation to inform ecosystem modelling in terms of the socio-economic impacts of ocean warming and acidification in the Barents Sea region.
Kaltenborn et al., 2017	Examines the role of ES and cultural values in the well-being of a small community in Northern Norway.
Brinkman et al., 2016	Uses qualitative data from semi-structured interviews with subsistence resource harvesters in four indigenous communities in Alaska to identify their perceptions of climate change effects on the availability of provisioning ES.
Alessa et al., 2008	Provides analysis of the perceptions of change in the quality and availability of freshwater provisioning ES in a remote community in the Steward Peninsula, Alaska, and the role of Traditional Ecological Knowledge for resilience.

biophysical and economic data from existing studies (not all Arctic-based) and arrives at an aggregate estimate of around $281 billion (in 2016 prices) worth of ES per year derived from food, mineral extraction, oil production, tourism, hunting, existence values, and climate regulation. The paper sends a strong message, comparable to those of Costanza et al. (1997) and Costanza et al. (2014), drawing public attention to the economic value of ecosystem services and the costs of their loss if climate change predictions for ice-free summers in the next two decades turn out to be accurate (IPCC, 2014; Wang and Overland, 2012; Whiteman et al., 2013).

In an attempt to monetise the cost of lost climate regulation services in the Arctic by combining climate modelling and the social cost of carbon, Euskirchen et al. (2013) arrive at an estimate that between 2010 and 2100 the annual costs from extra climate warming add up to a societal cost ranging from USD 7.5 trillion to USD 91.3 trillion, with the large range resulting largely from the choice of discount rate. For comparison, the highest estimate exceeds global GDP in 2013, which was around USD 77 trillion, and the low estimate is in excess of every nation's GDP that year apart from the US (USD 16.7 trillion) and China (USD 9.6 trillion) (World Bank, 2018).

Several ES valuation studies in the literature translate concerns over possible oil spills in the Arctic into economic values, arguing for a precautionary approach in hydrocarbon exploration. They reveal significant negative effects of potential oil spills on individual well-being through loss of ES, warning that the costs of such spills are much higher than preventive measures (Hasselström et al., 2012, 2017; Magnussen and Kettunen, 2013; Noring et al., 2016) and, in some cases, even the economic gains from drilling (Kotchen and Burger, 2007; Magnussen and Kettunen, 2013). A contingent valuation study estimated that US households' willingness to pay (WTP) to prevent a similar oil spill to the Exxon Valdez in 1989 aggregated to $2.8–7.16 billion (1990 USD) (Carson et al., 2003) and to USD 10.87 billion (2005 USD) according to a later estimate by Kotchen and Burger (2007). In Norway, a nation-wide pilot contingent valuation study on hypothetical oil spills in Northern Lofoten reveals significant non-use values attached to coastal ES, with an average WTP per household per year for a ten-year period to avoid marine and coastal ecosystem service (ES) loss/damage from an oil spill ranging between NOK 1165 and NOK 1192 nationally and NOK 1330 and NOK 2387 by Lofoten residents (Navrud et al., 2017). Another study estimated that people were willing to pay between EUR 274 and EUR 287 to avoid a loss of ES provided by cold water corals (Aanesen et al., 2015).

There are, as of yet, very few valuation studies focusing on ES of a single species in the Arctic. Focused studies, however, have the potential to improve understanding of nature-human interactions and values that are generated through them in different place-specific contexts. In one such study, Goldstein et al. (2014) use a replacement cost method to estimate the cost of replacing a year's worth of subsistence harvest of northern pintail by indigenous communities in North America using chicken as the most viable alternative. The authors determine a mean estimate of the total replacement cost for the annual subsistence harvest of ~15,000 pintails to be ~$63,000 per year (2010 USD), with sub-regional values ranging from $263 yr^{-1} to $21,930 yr^{-1}. Mosbech et al. (2018) apply a non-monetary analysis of the value of the little auk in Inughuit communities in Northwest Greenland and find multiple ecological, socio-cultural and economic aspects, in which the species help to sustain the socio-ecological systems in the region.

Socio-cultural analyses of non-monetary ES values address the main criticism of monetary valuation of ES – that it fails to capture the multiple values and valuation languages (Huntington, 2013; Kumar and Kumar, 2008; Martinez-Alier et al., 1998). For Inupiat communities in the Seward Peninsula in Alaska, this mismatch, combined with the loss of traditional knowledge transfer systems, means that the younger generations are less aware of the extent of ES changes and, therefore, less able to adapt to them (Alessa et al., 2008). A study by Brinkman et al. (2016) adds a socio-cultural dimension to climate change projections by integrating the perceptions of local subsistence resource users in four Alaskan indigenous communities. A study by Koenigstein et al. (2016) also attempts to integrate stakeholders' perceptions into ES

models for the Barents Sea region by combining preference assessment surveys with predictive ecosystem modelling. The authors argue that their process-based integrated ecosystem model captures ecological complexity and place-specific societal values of ES and is, therefore, better-equipped to inform adaptive governance than models based on only physical data. An evaluation by Kaltenborn et al. (2017) examines the contribution of cultural and provisioning ES to human well-being in the small Røst community in northern Norway through local stakeholders' narratives, which they later synthesise into the localised concept of a 'good life'. This approach highlights the importance of scale and context in socio-cultural assessments of ES as they provide the basis for social cohesion and shared values in communities.

3.6. Synergies and trade-offs

An important topic in the ES literature that transpires in the Arctic context is the discussion of synergies and trade-offs between different ecosystem services. According to Openness' (Operationalisation of Natural Capital and Ecosystem Services) project definition, an ES trade-off is 'a situation where the use of one ES directly decreases the benefits supplied by another' and a synergy is 'a situation where the use of one ES directly increases the benefits supplied by another service' (Turkelboom et al., 2016, p. 2). Synergies and trade-offs are addressed in only 10 out of 33 publications (20%) as there are few primary ES assessments and valuation studies to date that could inform this discussion. They are, however, important to consider as no ES exists in isolation and use of one service is likely to impact on the availability of others (Arctic Council, 2016; Jansson et al., 2015; Martín-López et al., 2014; Martín-López et al., 2012). The publications that report on synergies and trade-offs are listed in Table 6.

The supply of ES is not necessarily one-directional or static and may form multiple and multidirectional synergies and trade-offs at the same time, depending on the local ecological, social and cultural context (de Groot et al., 2010; Koenigstein et al., 2016; Martín-López et al., 2012). For instance, some Arctic studies show clear trade-offs between provisioning and cultural services in marine, sea-ice and terrestrial biomes (Aanesen et al., 2018; Gundersen et al., 2016; Huntington, 2013; Vihervaara et al., 2010), while others point to an important synergy linking regulating, provisioning and cultural ES (Chapin et al., 2005). The cold climate in the Arctic resulted in limited industrial activity, which forced local populations to adapt to the harsh conditions through harvesting provisioning ES and preserving traditional ways of life through cultural ES, such as spiritual enrichment and aesthetics. These two categories of ES are reported as being closely interlinked as subsistence harvesting activities play an important role in many communities' social and cultural lives and identity (Huntington, 2013; Kaltenborn et al., 2017; Koenigstein et al., 2016; Mosbech et al., 2018).

Some studies point out the fundamental trade-off between industrial development in the Arctic and ES bundles associated with environmental protection (Aanesen et al., 2018; Armstrong et al., 2014; Chapin et al., 2005). Jansson et al. (2015) briefly consider trade-offs between the cultural, provisioning, and regulating ES of terrestrial and freshwater ecosystems in Northern Europe and find that they are numerous and multidirectional, especially when climate change effects and adaptation strategies are taken into consideration. Another common trade-off identified in the literature is between regulating and provisioning marine ES: important fish habitats provided by cold water corals and kelp forests in the Northeast Atlantic are often degraded by the harvesting of marine resources, notably commercial fishing (Aanesen et al., 2015; Armstrong et al., 2014; Smale et al., 2013). A trade-off that causes considerable tension among groups of Arctic ES users is between provisioning and cultural services provided by marine mammals, e.g. through whaling and whale-watching in the town of Húsavík in northern Iceland (Arctic Council, 2016).

Although abiotic flows are not typically counted as ES, significant trade-offs between biotic and abiotic flows are important to consider in environmental management (O'Garra, 2017; van der Meulen et al., 2016). This is reflected in the literature on ES in the Arctic, where hydrocarbon exploration is discussed as an important driver of change. Trade-offs between Arctic ES and hydrocarbon exploration are central to an ongoing debate and have been observed between oil and gas drilling and cultural, regulating and provisioning ES in North America (Carson et al., 2003; Kotchen and Burger, 2007) and the Barents Sea (Hasselström et al., 2012, 2017; Magnussen and Kettunen, 2013). While considering synergies and trade-offs between different ES reduces the risk of double-counting benefits in valuation studies and allows for better modelling of multiple socio-ecological interactions, it makes the picture of Arctic ES much more complex (Arctic Council, 2016; Jansson et al., 2015; Vihervaara et al., 2010).

3.7. Integrating ES concept into Arctic natural resource management

Even though it could be argued that all ES research is aimed at informing policy, it is debatable when the ES concept is integrated into management and when it is merely discussed. In this review, the criteria for inclusion of papers in this category is that (i) integration of the ES concept into the management of Arctic environmental policy is discussed in some detail and (ii) concrete suggestions for policy are

Table 6
Main points of focus on synergies and trade-offs between Arctic ES.

Publication	Focus
Aanesen et al., 2018	Applying DCE, reveals trade-offs between cultural and provisioning coastal ES in northern Norway.
Hasselström et al., 2017	Touches upon potential trade-offs between hydrocarbon exploration and ES provision in Northern Norway, which are partly preventable if appropriate safety measures against oil spills are applied.
Jansson et al., 2015	Discusses cause and effect relationships between ES under changing climate conditions, without using the specific terms of synergies and trade-offs.
Vihervaara et al., 2010	Identifies trade-offs between provisioning and cultural ES in the Finnish Boreal Forest.
Koenigstein et al., 2016	Identifies synergies between provisioning and cultural ES in the Barents Sea region, where harvesting of marine resources is central for social cohesion and the sense of local identity.
Kaltenborn et al., 2017	Discusses synergies and trade-offs between cultural and provisioning ES that are important for human well-being.
Aanesen et al., 2015	Briefly describes the trade-off between provisioning ES (commercial fishing) and regulating ES (fish habitat provided by cold water corals).
Huntington, 2013	Gives examples of synergies and trade-offs between provisioning and cultural ES in the Arctic, especially through indigenous subsistence and commercial harvesting, and how they form additional synergies with regulating ES and identifies trade-offs between provisioning ES and extraction of non-renewable resources.
Arctic Council, 2016	Reflects on trade-offs between the cultural and provisioning services of marine mammals. ES synergies and trade-offs are considered as a result of multiple interactions within a SES.
Chapin et al., 2005	Describes synergies between regulating, provisioning and cultural ES, synergies and trade-offs between subsistence and cash economies in ES utilisation, as well as synergies and trade-offs between industrial development and cultural ES.

Table 7
Main points of focus on integrating the ES concept into management.

Publication	Focus
Armstrong et al., 2014	Proposes ES-based management of cold-water corals.
Chapin et al., 2015	Proposes an ecosystem stewardship framework that integrates social and ecological processes and ES for Arctic conservation.
Hasselström et al., 2017	Assesses the economic costs of oil drilling and potential oil spills, and how these should be considered when making decisions about new hydrocarbon exploration in the Arctic.
Anisimov et al., 2017	Analyses projected changes in ES provision due to climate change, providing guidance for land use planning in the Arctic.
Eicken et al., 2009	Proposes a framework for addressing the information needs of sea-ice users based on the concept of sea-ice services.
Chapin et al., 2006	Proposes an ES-based framework for management of Alaskan boreal forest.
Jansson et al., 2015	Sets out possible strategies for climate change adaptation based on changes in ES provision and societal responses.
Vihervaara et al., 2010	Outlines an ES-based framework for Finnish boreal forests.
Arctic Council, 2013a	Proposes Ecosystem-Based Management (EBM) as a preferred environmental management model for the Arctic.
Arctic Council, 2013b	Suggests taking a participatory approach and including traditional knowledge of SES and ES into Arctic governance.
Koenigstein et al., 2016	Integrates stakeholder perspectives of ES use into ecosystem modelling to improve governance.
Kaltenborn et al 2017	Includes social and built capital and their dependence on local natural capital into ES management frameworks.
Brinkman et al 2016	Includes perceptions of ES users into adaptation strategies to ensure access to resources.
Huntington, 2013	Proposes integration of ES and stakeholder perspectives into Arctic environmental management.
Arctic Council, 2016	Proposes a holistic and systematic approach for enhancing the resilience of Arctic SES, where ES flows are a result of human-ecosystem dynamics and can be used for diagnosing as well as addressing system disturbances and shocks.
Gundersen et al., 2016	Provides a conceptual model of the effects of human activities on ES and management actions to mitigate them.
Chapin et al., 2005	Gives an overview of the treaties governing Arctic ES, identifies some institutional trade-offs and opportunities for stakeholder-focused ES management.
CAFF, 2015	Discusses various Arctic ES governance and valuation aspects, providing examples of policy focus areas where the TEEB methodology can be applied.
Magnussen and Kettunen, 2013	Discusses the impact of prior ES assessments on marine planning policy in Norway, e.g. establishment of the Norwegian Ecosystem Service Expert committee, and argues for better integration of ES values in environmental management decisions, e.g. through cost-benefit analysis.
PAME, 2013	Recommends monitoring Arctic marine ecosystems, valuing their ES and managing human activities to minimise negative effects on ES provision.
PAME, 2015	Proposes an EBM framework for the management of the Arctic Ocean.
WWF, 2015	Calls for the inclusion of ES values in decision-making, using examples from around the Arctic.
Navrud et al., 2017	Suggests ES valuation as a method for making environmental management decisions more transparent.

made. 23 out of 33 (70%) publications include suggestions of how to apply the ES concept in management, offering varying levels of practical policy guidance. These contain mainly general discussions of the applicability of the concept to management, as Table 7 indicates. The seminal reports – the MEA (2005), TEEB Scoping Study (2015) and Arctic Resilience Report (2016) – discuss the relevance of ES for management of Arctic natural resources and promote an integrated approach to ES governance, where ecological objectives and interests of different stakeholder groups are reflected in environmental policy planning and implementation (Arctic Council, 2016; CAFF, 2015; Chapin et al., 2005; Chapin et al., 2015; Huntington, 2013).

The overarching recommendation in the literature is that human activities should be considered a part of socio-ecological system dynamics rather than operating separately from nature. Ecosystem-based management is one such approach, defined by the Arctic Council (2013a, p. 1) as a 'comprehensive, integrated management of human activities based on best available scientific and traditional knowledge about the ecosystem and its dynamics, in order to identify and take action on influences that are critical to the health of ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity'. In the literature, EBM is most extensively discussed in the context of marine management. The Arctic Council's Working Group on Protection of the Arctic Marine Environment (PAME) applies an ecosystem approach in their proposed framework for the management of marine protected areas (MPA[2]) in the Arctic and stresses the importance of 'long-term conservation of nature with associated ecosystem services and cultural values' (PAME, 2015, p. 11). Arctic Ocean Review (PAME, 2013) provides recommendations for identifying and monitoring Arctic marine ecosystems, valuing their ES and managing human activities that may affect them. Gundersen et al. (2016) suggest that employing the ES approach in the management of the Nordic coastal zones, part of which are in the Arctic, would enable policy-makers to combine social preferences and ecological principles, and Smale et al. (2013) advocate EBM of kelp forests in the northeast Atlantic.

Focused ES assessments and valuation studies provide policy recommendations based on their outcomes. In the terrestrial biome, Anisimov et al. (2017) assess the projected effects of the warming climate on permafrost and terrestrial vegetation in the first half of the 21st century using mathematical models, foreseeing that this information would be useful for land use planning and management in the region. ES-based frameworks were proposed for the management of Alaskan and Finnish boreal forests (Chapin et al., 2006; Vihervaara et al., 2010), adaptation to climate change in terrestrial and freshwater ecosystems in the European north (Jansson et al., 2015), conservation of migratory species in the Arctic and sub-Arctic North America informed by economic values of ES provided by northern pintails (Goldstein et al., 2014), and future research and protection of the little auk in northwest Greenland (Mosbech et al., 2018).

Another key issue that transpires in the literature is the role of resource users in Arctic ES management. Including stakeholder perspectives and Traditional Ecological Knowledge (TEK) in environmental policy frameworks is being increasing widely advocated worldwide (Gómez-Baggethun et al., 2013; Reed et al., 2009). Scale and context are of great importance here as panaceas are rarely effective in environmental governance (Ostrom, 2007; Young et al., 2018). Localised ES assessments that combine scientific information and traditional knowledge are suggested as a climate adaptation strategy in the Arctic. Eicken et al. (2009) analyse how different stakeholders perceive, measure and use sea ice in Arctic Alaska, and how this knowledge can be used in climate adaptation. Socio-cultural analyses of Arctic ES suggest including the perspectives of local ES beneficiaries in research, monitoring and management, and adjusting the spatial and temporal scales so that they are relevant to stakeholders (Alessa et al., 2008;

[2] MPA is 'A clearly defined geographical space recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.' (PAME, 2015, p. 11)

Huntington, 2013; Kaltenborn et al., 2017; Koenigstein et al., 2016).

A major purpose of economic valuation of ES is to inform policy decisions. This information can be incorporated into decision-making when determining which set of actions is likely to be most beneficial in a particular socio-ecological context. Some of the monetary valuation studies provide an economic rationale for the sustainable management of Arctic ES from a cost-benefit analysis perspective, demonstrating that welfare losses are associated with unsustainable management practices (Aanesen et al., 2015; Armstrong et al., 2014; Goldstein et al., 2014; Hasselström et al., 2012, 2017; Navrud et al., 2017). Other studies contend that the loss of vital regulating Arctic ES may be irreversible, leading to dire and unpredictable consequences and that these losses should be prevented through strict environmental policies (Anisimov et al., 2017; Euskirchen et al., 2013; O'Garra, 2017).

4. Discussion

4.1. Research gaps

During the synthesis of the main themes in the literature on Arctic ES, some significant research gaps emerged. The most frequent were as follows:

(i) a need for a better inventory of Arctic ES through collection of biophysical, socio-cultural and socio-economic data;
(ii) a dearth of detailed and focused analysis of mechanisms and feedbacks of social-ecological interactions;
(iii) a lack of primary monetary and non-monetary Arctic ES valuation studies;
(iv) a shortage of analysis of interactions between ES bundles in terms of synergies and trade-offs;
(v) a lack of examples of concrete strategies for integrating ES into Arctic policy and natural resource management.

Given the novelty of the subject, it is unsurprising that most of the literature addresses general discussions of how the ES notion could be applied in an Arctic context. The first step towards addressing the gaps in Arctic ES research demand a comprehensive inventory and classification of ES in all biomes (Aanesen et al., 2015; CAFF, 2015; Chapin et al., 2005; Huntington, 2013; Smale et al., 2013). This work was started by the MEA and the scoping study by TEEB, but large gaps remain. Secondly, spatial mapping of Arctic ES on different scales containing bio-physical as well as socio-cultural and economic information is necessary for analysing and modelling the effects of rapidly changing climate conditions on ecosystems and societies (Armstrong et al., 2014; CAFF, 2015; Eicken et al., 2009; Huntington, 2013; WWF, 2015).

The SES concept is discussed predominantly on conceptual and theoretical levels, with a few exceptions where interactions between social and ecological components are described in detail using case studies. There is a general consensus that the SES concept is useful for examining human-nature interactions, yet its practical application is lacking. There is a need for in-depth primary studies exploring risks, causalities and feedbacks between societies and ecosystems that could provide guidance for effective policy interventions (Arctic Council, 2016; Hasselström et al., 2017; Kaltenborn et al., 2017; Koenigstein et al., 2016; Vihervaara et al., 2010). This kind of research requires a transdisciplinary approach, collaboration between different disciplines and inclusion of local perspectives, such as TEK. Future studies on SES resilience in the Arctic should include analysis of different ES management and governance regimes, allowing for comparisons and cross-regional learning (Aanesen et al., 2018; Chapin et al., 2006; Chapin et al., 2015). Social sustainability, equity and gender-related effects of Arctic ES changes and distribution across stakeholder groups are also under-researched (Arctic Council, 2016; CAFF, 2015; Hasselström et al., 2017; Jansson et al., 2015).

As Arctic ES is a relatively new area of research, there is a lack of primary ES valuation studies in all biomes, and it is important that a pluralistic view is applied when interpreting results and using them to inform policy (Alessa et al., 2008; Arctic Council, 2016; Huntington, 2013). The aim of this perspective is to ensure that relevant value domains are accounted for in each case. A worry shared by many ES researchers is that monetary ES valuation techniques are not equipped to capture the full value of environmental services, especially in indigenous contexts (Chan et al., 2012a,b; Kumar and Kumar, 2008; Martín-López et al., 2014; Satz et al., 2013). There is a danger that non-use values and cultural ES are omitted or poorly captured in one-dimensional monetary ES valuations that do not account for the multiplicity of values and valuation languages (Chan et al., 2012b; Huntington, 2013; Kotchen and Burger, 2007; Castro Martínez et al., 2013). This problem is not unique to the Arctic and has been discussed in other contexts (Chan et al., 2012a; Kelemen et al., 2014; Maestre-Andrés et al., 2016). The literature on Arctic ES calls for more primary economic (CAFF, 2015; Gundersen et al., 2016; Magnussen and Kettunen, 2013; O'Garra, 2017), socio-cultural (Alessa et al., 2008; Huntington, 2013; Kaltenborn et al., 2017; Vihervaara et al., 2010) and integrated (Brinkman et al., 2016; Huntington, 2013; WWF, 2015) valuation studies.

Utilisation of one ES often affects the availability of others, and while some synergies and trade-offs are identified in the literature, the discussion of the underlying mechanisms is largely missing. To eliminate this knowledge gap, interactions between different Arctic ES and ES bundles need to be studied together with human activities that affect their provisioning. A prerequisite for that is filling in the first two gaps in research – mapping and inventory, and assessment of feedback mechanisms between SES components and ES valuation. The literature highlights the need for dynamic modelling that would facilitate analyses of trade-offs and synergies between different uses of Arctic ecosystems on varying spatiotemporal scales (Arctic Council, 2016; CAFF, 2015; Gundersen et al., 2016; Huntington, 2013; Jansson et al., 2015; Navrud et al., 2017; O'Garra, 2017; Vihervaara et al., 2010). This requires a good understanding of the different uses of Arctic ES and advanced technical skills on the part of researchers, as well as improved models and software. Provisioning and cultural ES form a synergy with climate regulating ES in the Arctic and are sensitive to climate change, so better modelling and, ultimately, conservation policies that produce climate regulation benefits are likely to enhance provision across all three types of ES (Chapin et al., 2005; Huntington, 2013; Jansson et al., 2015; Watson et al., 2003).

Despite the widespread discussion in the literature on mainstreaming ES into Arctic sustainability policies, description of concrete policy tools and strategies is largely missing. In most papers, the ES concept is applied in a general way with no step-by-step practical guidance. This observation coincides with one made by McDonough et al. (2017), who suggest that ES-based management strategies should recognise their limitations of applicability, e.g. to one research field, to prevent bias in quantification as knowledge is shared. The next steps, following the initial description of Arctic ES and scoping exercises presented in this synthesis review, involve filling in the research gaps and integrating that knowledge into resource management. For this purpose, additional resources, expertise and governance mechanisms are required, as well as inclusive decision-making frameworks. An example of such improvements is the European Union's effort to develop ES research and mainstream it into policy, such as through the EU Biodiversity Strategy 2020 and Mapping and Assessment of Ecosystems and their Services (MAES).

4.2. Comparison to other ES literature reviews

The research gaps identified in this literature review on Arctic ES coincide with some of the previous observations of similar globally focused reviews of ES research, such as the recent study by Costanza et al. (2017) that highlights the need for integrated ES inventory and valuation, analysis of trade-offs and dynamic modelling, and context-specific bundling and scaling of ES to address local management needs. Balvanera et al. (2012) find similar knowledge gaps in ES research in Latin America, pointing to a need for better ES inventory, assessment and modelling of synergies and trade-offs that are relevant to resource users. Malinga et al. (2015) emphasise the global need for improved mapping of heterogeneous landscapes with multiple ES on all scales, since this would enable researchers to assess spatial-temporal dynamics of human-nature interactions as well as ES bundles, synergies and trade-offs. The interdisciplinary necessities in ES research and evolving recognition of multiple perspectives and types of values associated with ES observed in this meta-synthesis was also noted by Droste et al. (2018). The tendency for descriptive rather than normative and action-oriented analysis of human-nature interactions in ES literature was pinpointed by Abson et al. (2014) and Milcu et al. (2013), corresponding with the observation in this study that discussion of Arctic ES at this stage remains rather conceptual, lacking scientific detail and practical guidance for application to management and policymaking.

The emphasis on the need to move away from single-point ES valuation towards integrated approaches and non-economic deliberative techniques highlighted in this study is also reported in the global ES literature (van den Belt and Stevens, 2016), particularly in the context of cultural ES (Dickinson and Hobbs, 2017; Droste et al., 2018; Milcu et al., 2013). This would be a welcome development towards comprehensive assessment of Arctic ES, ensuring the inclusion of different worldviews and value domains, especially when valuing cultural ES. A pitfall to look out for in future ES research is the tendency to focus on the most obvious and quantifiable cultural ES that fit neatly into utilitarian value frameworks, such as recreation and tourism, while less tangible ES, such as the sense of identity and spiritual enrichment, receive less attention (ibid.). Another common concern, which coincides with the observations of this study, is over-prioritisation of economic ES values over socio-cultural and ecological ones (Chaudhary et al., 2015; van den Belt and Stevens, 2016).

The ES concept presents an opportunity for a holistic approach to Arctic sustainable development that integrates social and natural sciences. Involvement of a wider array of social science researchers, activists and policy makers is required to bridge knowledge gaps and increase policy relevance (ibid.). However, it is also important that they work together to avoid compartmentalising ES research into separate disciplines or policy agendas (Abson et al., 2014; Droste et al., 2018; Milcu et al., 2013). Having been dominated by ecology and economics since its conception, the ES literature has under-emphasised social issues. The involvement of social science and humanities in shaping the ES discourse is essential, so that the issues of development, social justice, equity, gender equality, welfare of future generations, governance, ethics, social-environmental interactions and co-production of ES are addressed (Chaudhary et al., 2015; Daw et al., 2011; Dickinson and Hobbs, 2017; Fisher et al., 2013; van den Belt and Stevens, 2016).

4.3. Limitations

This study presents the first reproducible attempt to assess the current state of knowledge on Arctic ES using research methods commonly applied in meta-syntheses of literature. It is not, however, without limitations. Firstly, as noted by Milcu et al. (2013) in the context of cultural ES, there is likely to be a parallel body of research that is concerned with the topic without using ES terminology. We included a few publications sourced through 'snowballing' technique that examine nature-human interactions and associated values through an ES lens (Alessa et al., 2008; Kaltenborn et al., 2017; Mosbech et al., 2018), but there are likely to be more studies in the Arctic that examine similar issues without specifically referring to ES. The second limitation is associated with qualitative aspects of the methodology – publication selection bias and subjectivity when interpreting the results of the thematic analysis. Finally, the ES research environment is rapidly changing with new research constantly being published through various outlets and in different languages, e.g. Russian research focused on Arctic issues that did not come up in our academic database search, and it is unavoidable that some relevant publications were overlooked.

5. Conclusions

To the best of our knowledge, this thematic review is the first attempt to systematically review the literature on Arctic ecosystem services to date. This synthesis of 33 publications on Arctic ES indicates that the ES concept is being applied in the Arctic with potential implications for research and policy, although it is limited in scope and depth at the moment. The number of publications sourced for this review went from an average of 0.75 per year between 2005 and 2012 to around 4.5 between 2013 and the beginning of 2018. That the vast majority (27 out of 33, or 82%) of publications sourced for this review were published in 2013 or later suggests that the body of literature on Arctic ES is growing rapidly, as are general academic, economic and political interests in the region. As the global focus shifts to the Arctic, owing to rapid climate change with resulting environmental challenges and economic opportunities, this trend is likely to continue. Many of the reviewed publications cross the boundaries of scientific disciplines and contain multiple themes, which confirms that ES research continuously crosses disciplinary boundaries, bringing about new opportunities for cooperation as well as methodological challenges. Discussion of Arctic ES research is still relatively novel and limited, and there is an apparent need for further research in all thematic areas identified in this literature review.

With intensifying climate change and its uncertain effects on Arctic ecosystems and societies, it is particularly important to estimate trade-offs between different ES and conduct primary valuation studies (monetary and non-monetary) in order to estimate those effects and determine appropriate policy responses. Moreover, a closer examination of human-ecosystem dynamics and various natural resource management scenarios is needed to enable incorporation of Traditional Ecological Knowledge and other locally-based strategies into climate change resilience planning in the Arctic. The broad areas of future study identified in this meta-synthesis will require resources and innovation as well as the willingness of scientists, policy makers and communities to cooperate. Even more importantly, future research on Arctic ES should be aimed at informing policy and incorporating the ES perspective into the management of natural resources, as is required by the EBM framework favoured by the Arctic Council.

Appendix 1. Sourced publications on Arctic ecosystem services

Appendix 1
Sourced publications on Arctic ecosystem services (in chronological order of sourcing).

Nr.	Source	APA Reference	Type	Methods and type of data	**Biome**	**Themes**
1.	Science Direct	O'Garra, T. (2017). Economic value of ecosystem services, minerals and oil in a melting Arctic: A preliminary assessment. *Ecosystem Services*, 24, 180-186.	Article	Economic ES valuation; benefit transfer method; secondary data.	all	1,3
2.	Science Direct	Aanesen, M., Falk-Andersson, J., Vondolia, G. K., Borch, T., Navrud, S., & Tinch, D. (2018). Valuing coastal recreation and the visual intrusion from commercial activities in Arctic Norway. *Ocean & Coastal Management*, 153, 157-167.	Article	Economic ES valuation; discreet choice experiment with three scenarios; primary data.	marine	3,4
3.	Science Direct	Armstrong, C. W., Foley, N. S., Kahui, V., & Grehan, A. (2014). Cold water coral reef management from an ecosystem service perspective. *Marine Policy*, 50, 126-134.	Article	Desk-based review of literature and management; draws policy implications.	marine	1,5
4.	Science Direct	Chapin, F. S., Sommerkorn, M., Robards, M. D., & Hillmer-Pegram, K. (2015). Ecosystem stewardship: A resilience framework for arctic conservation. *Global environmental change, 34*, 207-217.	Article	Desk-based overview of the concept; discussion of its applicability for Arctic ES management.	all	1,2,5
5.	Scopus	Hasselström, L., Håkansson, C., Noring, M., Soutukorva, Å., & Khaleeva, Y. (2017). Costs and benefits associated with marine oil spill prevention in northern Norway. *The Polar Journal, 7*(1), 165-180.	Article	Cost-benefit analysis of two scenarios using secondary data.	marine	3,4,5
6.	Scopus	Anisimov, O., Kokorev, V., & Zhiltcova, Y. (2017). Arctic Ecosystems and their Services Under Changing Climate: Predictive-Modeling Assessment. *Geographical Review, 107*(1), 108-124.	Article	Predictive mathematical modelling ES changes using secondary data.	terrestrial	1,5
7.	Scopus	Goldstein, J. H., Thogmartin, W. E., Bagstad, K. J., Dubovsky, J. A., Mattsson, B. J., Semmens, D. J., Diffendorfer, J. E. (2014). Replacement Cost Valuation of Northern Pintail (Anas acuta) Subsistence Harvest in Arctic and Sub-Arctic North America. *Human Dimensions of Wildlife, 19*(4), 347-354.	Article	Primary economic ES valuation using replacement cost method.	terrestrial	3
8.	Scopus	Euskirchen, E., Goodstein, E. S., & Huntington, H. P. (2013). An estimated cost of lost climate regulation services caused by thawing of the Arctic cryosphere. *Ecological Applications, 23*(8), 1869-1880.	Article	Calculation of added warming effects of thawing Arctic ice and associated economic costs of ES loss to year 2100 using integrated assessment models and secondary data.	sea-ice	3
9.	Scopus	Eicken, H., Lovecraft, A. L., & Druckenmiller, M. L. (2009). Sea-Ice System Services: A Framework to Help Identify and Meet Information Needs Relevant for Arctic Observing Networks. *Arctic, 62*(2), 119-136.	Article	Framework for addressing information needs of ES users based on primary data from case studies.	sea-ice	1,2,5
10.	Web of Science	Mosbech, A., Johansen, K. L., Davidson, T. A., Appelt, M., Grønnow, B., Cuyler, C. & Flora, J. (2018). On the crucial importance of a small bird: The ecosystem services of the little auk (Alle alle) population in Northwest Greenland in a long-term perspective. *Ambio, 47*(2), 226-243.	Article	Analysis of sociocultural and ecological ES values applying a multi-method approach; primary and secondary ecological and ethnographic data.	terrestrial	1,2,3
11.	Web of Science	Noring, M., Hasselström, L., Håkansson, C., Soutukorva, Å., & Gren, Å. (2016). Valuation of oil spill risk reductions in the Arctic. *Journal of Environmental Economics and Policy, 5*(3), 298-317.	Article	Primary ES valuation using contingent valuation method and two scenarios.	all	3
12.	Web of Science	Chapin, F. S., Lovecraft, A. L., Zavaleta, E. S., Nelson, J., Robards, M. D., Kofinas, G. P., Naylor, R. L. (2006). Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate. *Proceedings of the National Academy of Sciences, 103*(45), 16637-16643.	Article	Sustainability policy framework developed and applied to the case study, uses secondary data to draw policy strategies.	terrestrial	1,2,5
13.	Web of Science	Jansson, R., Nilsson, C., Keskitalo, E. C. H., Vlasova, T., Sutinen, M.-L., Moen, J., Aspholm, P. E. (2015). Future changes in the supply of goods and services from natural ecosystems: prospects for the European north. *Ecology and Society, 20*(3).	Article	Analysis of projected changes in ES via expert panels and literature review.	terrestrial	1,2,4,5
14.	Google Scholar	Vihervaara, P., Kumpula, T., Tanskanen, A., & Burkhard, B. (2010). Ecosystem services–A tool for sustainable management of human–environment systems. Case study Finnish Forest Lapland. *Ecological Complexity, 7*(3), 410-420.	Article	Development of methodology for ES research; examples of various primary and secondary data sources.	terrestrial	1,2,4,5
15.	Google Scholar	Smale, D. A., Burrows, M. T., Moore, P., O'Connor, N., & Hawkins, S. J. (2013). Threats and knowledge gaps for ecosystem services provided by kelp forests: a northeast Atlantic perspective. *Ecology and Evolution, 3*(11), 4016-4038.	Article	Extensive literature review synthesising existing knowledge and drawing recommendations.	marine	1
16.	Google Scholar	Arctic Council, A. (2013). Summary for policy-makers. Arctic Resilience Interim Report 2013.	Report	A brief summary of the report for policy makers.	all	2,5
17.	Google Scholar	Koenigstein, S., Ruth, M., & Gößling-Reisemann, S. (2016). Stakeholder-informed ecosystem modeling of ocean warming and acidification impacts in the Barents Sea region. *Frontiers in Marine Science, 3*, 93.	Article	Combination of stakeholder perceptions and ecosystem modelling to evaluate societal effects of ES changes.	marine	2,3,4,5

(*continued on next page*)

Appendix 1 (*continued*)

Nr.	Source	APA Reference	Type	Methods and type of data	**Biome**	**Themes**
18.	Google Scholar	Kaltenborn, B. P., Linnell, J. D., Baggethun, E. G., Lindhjem, H., Thomassen, J., & Chan, K. M. (2017). Ecosystem Services and Cultural Values as Building Blocks for 'The Good life'. A Case Study in the Community of Røst, Lofoten Islands, Norway. *Ecological Economics*, *140*, 166-176.	Article	Analysis of ES cultural values through ethnographic observations, in-depth interviews, and a participatory scenario workshop; primary data.	all	2,3,4,5
19.	Snowball Method	Aanesen, M., Armstrong, C., Czajkowski, M., Falk-Petersen, J., Hanley, N., & Navrud, S. (2015). Willingness to pay for unfamiliar public goods: Preserving cold-water coral in Norway. *Ecological economics, 112*, 53-67.	Article	Economic ES valuation – discreet choice experiment using three scenarios; primary data.	marine	3,4
20.	Snowball Method	Brinkman, T. J., Hansen, W. D., Chapin, F. S., Kofinas, G., BurnSilver, S., & Rupp, T. S. (2016). Arctic communities perceive climate impacts on access as a critical challenge to availability of subsistence resources. *Climatic Change*, *139*(3-4), 413-427.	Article	Semi-structured interviews eliciting local perceptions of ES changes linked to climate predictions; primary and secondary data.	all	3,5
21.	Snowball Method	Alessa, L., Kliskey, A., Williams, P., & Barton, M. (2008). Perception of change in freshwater in remote resource-dependent Arctic communities. *Global environmental change, 18*(1), 153-164.	Article	Primary qualitative and quantitative data from semi-structured interviews and questionnaires used to elicit stakeholders' perceptions of ES changes in the case study area.	terrestrial	3
22.	Snowball Method	Hasselström, L., Cole, S., Håkansson, C., Khaleeva, Y., Noring, M., & Soutukorva, Å. (2012). *The value of ecosystem services at risk from oil spills in the Barents Sea.* Paper presented at the The ISEE conference, Rio de Janeiro.	Conference paper	Discussion of ES values based on secondary economic data.	marine	3
23.	Snowball Method	Huntington, H. P. (2013). Provisioning and cultural services. Chapter 18 of the Arctic Biodiversity Assessment (ABA). Status and trends in Arctic biodiversity. *Conservation of Arctic Flora and Fauna (CAFF), Akureyri, Iceland*, 593-626.	Report	General overview and case study approach; a mixture of desk studies and comprehensive literature review.	marine	1,2,3,4,5
24.	Snowball Method	Arctic Council. (2016). *Arctic Resilience Report.* Stockholm Environment Institute and Stockholm Resilience Centre.	Report	Literature review and stakeholder engagement, leading to case study approach. Case studies selected and data coded by experts using qualitative comparative analysis.	all	1,2,4,5
25.	Snowball Method	Gundersen, H., Bryan, T., Chen, W., & Moy, F. E. (2016). *Ecosystem Services: In the Coastal Zone of the Nordic Countries*: Nordic Council of Ministers.	Report	General overview and case study approach; mixture of desk studies and comprehensive literature review.	marine	1,5
26.	Snowball Method	Chapin, F. S., Berman, M., Callaghan, T. V., Convey, P., Crépin, A.-S., Danell, K., McGuire, A. D. (2005). Polar Systems. In *Millennium Ecosystem Assessment.*	Report	Broad overview of polar ES and their management using wide range of secondary data and case studies.	all	1,4,5
27.	Snowball Method	CAFF. (2015). Conservation of Arctic Flora and Fauna (CAFF). The Economics of Ecosystems and Biodiversity (TEEB) for the Arctic: A Scoping Study. Stockholm Environment Institute and Stockholm Resilience Centre.	Scoping study	Scoping study synthesising the existing knowledge through lit. review, case study approach, and development of research and policy frameworks.	all	1,2,3,5
28.	Snowball Method	Magnussen, K., & Kettunen, M. (2013). Marine ecosystem services in the Barents Sea and Lofoten Islands, a scoping assessment. *Nordic Council of Ministers, Copenhagen.*	Scoping assessment	Scoping assessment of ES values using secondary data from previous studies.	marine	1,3,5
29.	Snowball Method	Arctic Council, A. (2013). *Ecosystem-based management in the Arctic.*	Report	An overview report by an expert group using secondary data, outlining research and policy needs.	all	5
30.	Snowball Method	PAME. (2013). *The Arctic Ocean Review Project, Final Report.*	Report	Desk-based review of policy instruments; recommendations for future management.	marine	5
31.	Snowball Method	PAME. (2015). *Framework for a Pan-Arctic Network of Marine Protected Areas.*	Report	An overview of ES values and management needs; MPA framework.	marine	5
32.	Snowball Method	World Wildlife Fund (WWF). (2015). Valuing Arctic Ecosystems and Biodiversity. WWF Global Arctic Programme. Ottawa, Canada.	Magazine	Professional review of TEEB Scoping Study and commentary by selected contributors.	all	1,3,5
33.	Snowball Method	Navrud, S., Lindhjem, H., & Magnussen, K. (2017). Valuing Marine Ecosystem Services Loss from Oil Spills for Use in Cost-Benefit Analysis of Preventive Measures. *Handbook on the Economics and Management of Sustainable Oceans*, 124-137.	Book chapter	Presents non-market ES valuation and its implications for policy using an example of a primary contingent valuation study with three scenarios.	marine	3,5

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4 Publication II: Whale ecosystem services and co-production processes underpinning human wellbeing in the Arctic: case studies from Greenland, Iceland and Norway

Chapter 9
Whale Ecosystem Services and Co-production Processes Underpinning Human Wellbeing in the Arctic: Case Studies from Greenland, Iceland and Norway

Laura Malinauskaite, David Cook, Brynhildur Davíðsdóttir, and Helga Ögmundardóttir

Abstract The concept of ecosystem services (ES) has only just begun to be applied in the Arctic, and to an even lesser extent to marine mammals, such as whales. This chapter develops an ES cascade model and related ES co-production processes as they apply to whale resources in the Arctic. The result is a new conceptual model demonstrating the interconnectedness of social-ecological processes involving natural and human capital that enhance human wellbeing through the co-creation of whale ES. An ES cascade model is presented for whale ES, which connects the five linked stages of such ES production: the biophysical structure, functions, ecosystem services, the benefits to human wellbeing, and associated values. They are further expanded to include the co-production processes of whale ES as well as its main stages, inputs, and flows. These processes are illustrated using examples from ARCPATH case studies of coastal communities dependent on whale resources: Húsavík in Iceland, Andenes in Norway, and Ilulissat/Disko Bay in Greenland. The chapter aims to improve the understanding of the human dimensions of ES and the underlying processes that enable Arctic coastal communities to benefit from whales. It provides a starting point for further analysis of possible research and management approaches regarding whale resources in the Arctic.

Keywords Ecosystems services · Co-production · Marine mammals · Arctic coastal · Communities · Social-ecological systems

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D. C. Nord (ed.), *Nordic Perspectives on the Responsible Development of the Arctic: Pathways to Action*, Springer Polar Sciences,
https://doi.org/10.1007/978-3-030-52324-4_9

9.1 Introduction

Interdisciplinary inquiry, synthesis of information from different scientific fields, and the articulation of community perspectives in the face of rapid social and environmental change are central to the ARCPATH project. In that sense, the interests of the ARCPATH project shares some key characteristics with the concept of ecosystem services (ES), commonly defined as the benefits that people obtain from natural capital that has become an important part of the global sustainability debate (Millennium Ecosystem Assessment (MEA) 2005). The ES concept is interdisciplinary in nature and links biophysical structures and processes to human values, benefits, and wellbeing. However, human agency in ES production has rarely been discussed in a way that makes a meaningful contribution to the understanding of the processes underlying ES (Fischer and Eastwood 2016). This has resulted in gaps in our understanding of how natural and non-natural capital inputs contribute to ES (Outeiro et al. 2017). This undermines, somewhat, the potential usefulness of the concept for analysing social perspectives on climate change within the ARCPATH project.

Having said that, this knowledge gap is being gradually filled as socioecological dimensions of ES receive increasingly more attention in the ES literature. This has been particularly the case with respect to one of the most commonly used ES classification systems, the Common International Classification of Ecosystem Services (CICES). To conceptualise how human beings, benefit from ecosystems, Haines-Young and Potschin (2010) designed an ES cascade model that follows a value chain-like sequence, defining and describing the different stages of ES formation from biophysical structure to human wellbeing benefits and values. The model has been used extensively in ES research, yet discussion of marine ES in this context remains limited.

One area of marine ES that is just starting to be explored is how marine mammals contribute to human wellbeing. This is being done by identifying and classifying whale ES (Cook et al. 2020; Roman et al. 2014). Whales continue to play an important ecological, sociocultural and economic role in Arctic coastal communities (Caulfield 1997; Roman et al. 2014). The region's historical reliance on marine resources for survival and the simultaneous existence of market and subsistence economies (Vammen Larsen et al. 2019) makes it an interesting study area to investigate the generation of benefits from whale ES. Most of the whale ES discussed in this chapter are co-created by human activities using different types of capital: natural, human, social, manufactured, and financial (Palomo et al. 2016).

Yet our understanding of the linkages between ecological functions, human inputs and the marine ES effects on human wellbeing within the Arctic continues to be somewhat limited. This is largely due to the existing disconnect between social and natural sciences that tend to study Arctic societies and ecosystems separately (Malinauskaite et al. 2019).

This chapter seeks to contribute an interdisciplinary discussion of the human dimensions of marine resource management. It applies the five-stage ES cascade

model (Potschin and Haines-Young 2016) to whale ES. The stages – biophysical structure – function – service – benefit – valuation – are explained as human-nature co-production processes using examples from three ARCPATH case studies of coastal communities in Iceland, Norway and Greenland. In each instance whale ES provides an important contribution to human wellbeing in terms of livelihoods, cultural identity and social cohesion.

This chapter's inquiry is structured in four sections that complement this introduction. The first of these presents a theoretical framework. The next describes the research methods of the study and the location of its case studies. The third section provides both an analysis of whale ES in the Arctic and the utilization of an ES cascade model for those whale ES that include co-production processes. Finally, the last section of the chapter discusses possible policy implications and limitations of the model as well as areas for future research.

9.2 The Theoretical Framework

As mentioned above, the Haines-Young and Potschin (2010) ES cascade model distinguishes between the different stages in the formation and valuation of ES, including supply and demand-side occurrences (Martín-López et al. 2014). As indicated in Fig. 9.1, biodiversity and ecosystem functions are located within an ecosystem, while human wellbeing and values are located within a different social system, and ES are located at the intersection between the two. The conceptual framework of the ES cascade model distinguishes between different stages of the ES formation process and between biophysical, sociocultural and monetary value domains.

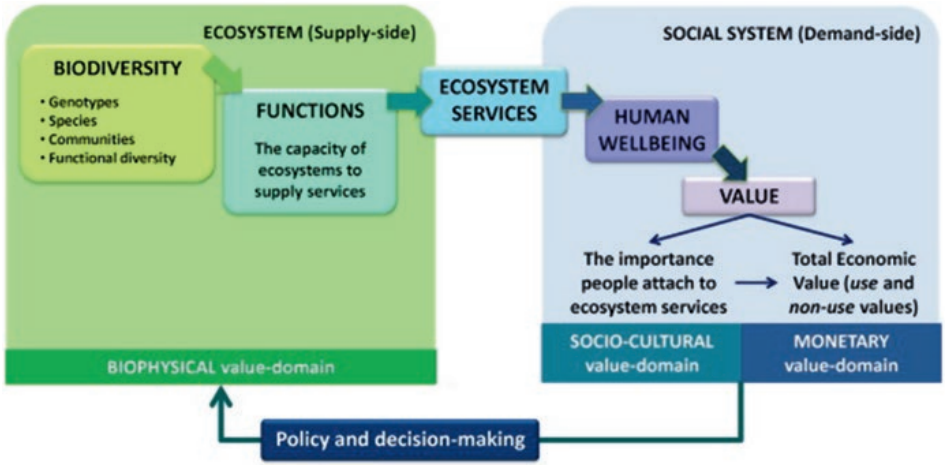

Fig. 9.1 Conceptual framework of ES cascade model and value domains embedded in social-ecological systems. (Sourced from Haines-Young and Potschin (2010) and Martín-López et al. (2014))

Figure 9.1 illustrates the flow of processes involving the five core stages of biodiversity, functions, ES, human wellbeing benefits, and value. An additional stage in the model, policy and decision-making, is presented at the bottom of Fig. 9.1 and represents the feedback coming from the social system, where human wellbeing benefits and values link into the biophysical domain through ES management.

Every stage of the ES cascade model requires inputs of natural capital and, in many cases, built and human capital. First, for a species of whales to be able to supply ES, their natural environment has to be relatively intact and well-functioning. Secondly, a decision has to be made about which characteristics of a whale have potential to increase human wellbeing, and this requires cognitive human inputs. Thirdly, built capital, such as whale watching boats or tracking equipment, is often required to mobilise whale ES. Finally, to measure ES values, human wellbeing is translated into some kind of metric, which requires human capital inputs (Spangenberg et al. 2014). This expanded the original ES cascade model of Haines-Young and Potschin (2010) to include social processes and human agency at every stage of the cascade process. The amended model focuses predominantly on the formation of ES with use values that require human and built capital inputs. The individual ES co-production processes as defined by Spangenberg et al. (2014) are listed and explained below.

Value attribution 'can be characterised as an intellectual act defining an ecosystem service potential, as a potential supply for an assumed societal (and thus group and culture specific) demand' (Spangenberg et al. 2014, p. 25). This implies a recognition by a group or an individual that a particular part of an ecosystem has a potential to enhance human wellbeing and therefore has value from an anthropocentric point of view. Value attribution is the first step towards co-production of ES and involves cognitive[1] and physical co-production on behalf of humans (Palomo et al. 2016). It is essentially a social construct that depends on human needs, preferences and values in a given natural resource context.

Mobilisation of ES potential (ESP) in the ES cascade model implies transformation of ecosystem services potential, which can be defined as a possibility for a certain group of individuals to enhance their wellbeing through its utilisation. Contrary to a portrayal of ES as free-flowing gifts of nature, they are similar to other production processes and have been described as 'anthropogenically defined and produced, the results of socio-technical systems activating the potentials offered by nature's functions' (Spangenberg 2014, p. 25). As in value attribution, ESP mobilisation requires cognitive and/or physical inputs.

ES appropriation is the process of getting access to ES that enables its users to receive benefits from them. It is at this stage of the cascade model that human wellbeing benefits from ES are generated. ES are appropriated when the products of ES

[1] It is important to distinguish between two types of ES co-production by humans here: physical and cognitive (Palomo et al. 2016). Physical co-production implies processes within material ES flows and measurable physical changes in ES supply, while cognitive co-production implies inherent cognitive processes and perceptions of an individual or a group related to the benefits of a given ES, either through direct or indirect interactions.

mobilisation are enjoyed by those who have access to them. It is usually, but not necessarily, the same group of individuals who facilitate ES mobilisation through investment of human, physical and financial capital that gain this use right (Spangenberg et al. 2014). ES appropriation in this model only accounts for ES with use values.

ES commercialisation occurs when appropriated ES are sold in markets, i.e. when those who mobilise and/or appropriate ES decide to exchange at least a part of them for money or other goods. A relatively high demand for ES increases its exchange value and gives an incentive for a higher rate of mobilisation and, at the same time, for the protection of the biophysical structure/function through management interventions and sustainable use. ES commercialisation is applicable to those ES that can be exchanged in markets.

This chapter combines the conceptualisation of the ES cascade framework depicted in Fig. 9.1 with the co-production theory by Spangenberg et al. (2014), seeking to overcome some of the latter's shortcomings, i.e. its failure to account for the full spectrum of ES values. The chapter thus seeks to make a contribution to ES theory by proposing an all-encompassing model of ES co-production specific to whale ES. This is then illustrated by outcomes from ARCPATH's case studies in three Arctic coastal communities.

9.3 Research Methods and Case Study Locations

9.3.1 Research Methods

This chapter builds a cascade model of whale ES that includes underlying co-production processes using examples from case studies in the Arctic. For this purpose, a mixture of research methods was used: a literature review, stakeholder mapping, participant and non-participant observations, and 49 semi-structured interviews. All interviews were conducted by the authors using best practice guidelines in qualitative research methods (Hennink et al. 2020). Grounded theory method was then applied in qualitative analysis of the interview data, with a purpose of eliciting the key ways in which respondents co-create and benefit from whale ES (Strauss and Corbin 1990). The fieldwork for the case study research took place in Húsavík, Iceland in June 2018, in Andenes, Norway in September 2018, and in Disko Bay, Greenland in August 2019.

9.3.2 Case Study Locations

Húsavík is a medium-sized town in Northeast Iceland with just over 2300 inhabitants (Statistics Iceland 2019). The most typical whale species in Skjálfandi Bay are humpback, minke, and blue whales and harbour porpoises. The abundance of these

species in the bay has been attracting visitors since the 1990s, and whale watching has since become the main tourist attraction in town, drawing more than 100,000 visitors per year (Nicosia and Perini 2016). Húsavík is the self-proclaimed 'whale watching capital of Iceland', and cetaceans play an important role in its economic, social and cultural lives.

Andenes in northern Norway is a medium-sized town with around 2700 inhabitants (Statistics Norway 2019). The main species of whales are sperm, humpback, minke and orcas. Whale watching started in the late 1980s and has since become very important for the tourism industry in the Vesterålen region and for the town's economy in general. There are plans to soon commence 'The Whale' project in Andenes, which will consist of an interactive exhibition, conference venue and cultural centre (The Whale 2019).

Disko Bay in Greenland is the largest open bay in western Greenland, measuring 150 km north to south and 100 km east to west. The main town, Ilulissat, is the third largest settlement in Greenland with around 4500 inhabitants (Statistics Greenland 2019). The town has become a popular tourist destination in recent years, offering various tourist activities, including whale watching. The main species of whales in Disko Bay are bowhead, humpback, minke, beluga and narwhal. Unlike the residents of other case study sites, Greenlanders engage in indigenous whaling, which is important for the food security and cultural identity of the local population (Caulfield 1997).

The three case study locations were chosen because of their proximity to the Arctic Circle as well as their social, cultural, and economic similarities. They are all located on Arctic or sub-Arctic coastlines and share other geographical features that encourage the presence of whales. Furthermore, they have all experienced a shift in economic activities from extractive use of marine resources to service-based economic activities, especially tourism, and all three communities depend on whale ES for their livelihoods and wellbeing to some extent.

9.4 An Analysis of Whale ES in the Arctic and the Utilization of the ES Cascade Model

9.4.1 Whale ES in the Arctic

Quite recently, a literature review-based inventory of whale ES in the Arctic was conducted by Cook et al. (2020) where, following the CICES classification system (Haines-Young and Potschin 2018), whale ES were grouped into three types: provisioning, regulation and maintenance, and cultural ES. The examples of whale ES listed in the inventory and other literature are summarized below. These are complemented with examples from the ARCPATH case studies.

9.4.1.1 Food Products (Meat, Blubber, Skin and Intestines)

Whale food products, such as whale skin (mattak) and whale meat, contribute significantly to food security in many Arctic coastal communities (Cook et al. 2020), including those in Disko Bay, where they are used for sustenance and traded in both barter and market economies. Whale food products are sourced through local hunting restricted by nationally determined quotas. In Iceland and Norway, whale food products are also available, albeit to a lesser extent, and sourced through commercial whaling which is also regulated by quotas.

9.4.1.2 Whale Bones, Teeth and Baleen

Raw materials from whales – bones, teeth and baleen – have been historically important in all three case study countries before the introduction of petroleum-based alternatives (Cook et al. 2020). Some of these raw materials are still used by craftsmen in the case study locations to produce souvenirs, jewellery, traditional tools and other artefacts.

9.4.1.3 Enhanced Biodiversity and Evolutionary Potential

There is evidence in the context of whales that more biodiverse environments are more ecologically productive. Roman et al. (2014) discuss the pump and conveyor belt functions of whales, which lead to the vertical (via diving and surfacing) and horizontal (via migration) transfer of nutrients from areas of high to lower productivity. This ES is also discussed by Wilmers et al. (2012), indicating biodiversity decline in some areas that have suffered significant losses of great whales, which are associated with trophic cascades.

9.4.1.4 Climate Regulation (Carbon Sequestration)

The submergence of whale carcases contributes to the organic content of the deep sea and carbon sequestration, providing a limited but important role in global climate regulation (Roman et al. 2014; Smith and Baco 2003). A recent study estimates that a whale stores a mean of 33 tonnes of carbon dioxide in its carcass, which most often gets buried in the deep sea for centuries when a whale dies (International Monetary Fund 2019).

9.4.1.5 Tourism (Whale Watching)

Whale watching is the single most important tourist activity in both Húsavík and Andenes, and is emerging fast as a lucrative branch of tourism in Ilulissat. Over 100,000 visitors come to Húsavík every year to go whale watching (Icelandic Tourist Board 2020), generating direct and indirect income, boosting employment and ensuring a steady flow of visitors throughout the year. The same is true in Andenes but the interview data suggests that here visitor numbers are lower and that there are actually two whale watching seasons – summer and winter. There are no official statistics regarding the numbers of whale watching passengers in Disko Bay, but interviews and observations indicate that the sector is growing rapidly, generating livelihoods and adding to the overall development of the tourism sector in the area.

9.4.1.6 Music and Arts (Entertainment)

Whale-inspired art is found in Húsavík in artwork by local artists, photographs, books and whale song recordings in the town's Whale Museum. In Andenes, most of whale-related art can be found in the souvenir shop of the main tour operator, Whale Safari. This whale ES has another dimension in Ilulissat, where whales and other marine mammals play an important part in traditional art, including fine arts, storytelling and entertainment. There are multiple traditional tales and legends about whales in Greenland, some of which have been adapted into children's stories and translated into foreign languages (Futtrup 1996). Whale songs have been a part of Inuit culture for centuries, still inspiring music today (Sakakibara 2009).

9.4.1.7 Sacred and/or Religious

Whales play an important role in people's connection to nature in all three case study countries. In Greenland, it has to do with spirituality and subsistence hunting, while our interviews in Iceland and Norway suggest that the presence of whales is considered as a sign of healthy ecosystems and can facilitate a way to connect to them. It has been reported by whale watching guides and operators that seeing a whale for the first time can be a highly emotional and even spiritual experience due to the rarity and sheer size of these animals. This type of impact was mentioned during interviews in all three case studies, yet it appears to be most prominent in Greenland where spirituality before Christianity was nature-based, and being a part of the surrounding ecosystems is still very deeply felt among the local population (Caulfield 1997).

9.4.1.8 Education

The presence of whales, combined with the growth of whale watching, facilitated the increase in formal educational activities related to whales, targeting visitors, researchers and the local population in Húsavík and Andenes. The Húsavík Whale Museum and the local primary schools, together, organised a Whale School for the local schoolchildren, while the University of Iceland Research Centre in Húsavík attracts researchers and students from all over the world. In Andenes, there are plans to open a museum, research and information centre entitled 'The Whale', aimed at educating visitors and locals about whales and marine environment. In Ilulissat, educational whale ES are apparent in the local museum's exhibitions. Moreover, stories about whales are still very much an integral part of the Greenlandic culture. This means that educational whale ES are co-produced and enjoyed in informal settings through daily cultural practices.

9.4.1.9 Aesthetics

Whales have been described as 'charismatic megafauna', being large and majestic animals that appeal to the public (Kalland 1994). The size, rarity, physical appearance and apparent intelligence of whales are sources of great enjoyment for people around the world, making whales very popular species among visitors. Interviews with whale watching guides and operators affirm that wishing to appreciate the beauty and majesty of whales is a major motivation behind choosing to go on a whale watching trip.

9.4.1.10 Community Cohesiveness and Cultural Identity

In both Húsavík and Andenes, whales have become new symbols of these towns as a result of both the expansion of whale watching and the concurrent decline of previous employment opportunities such as fishing in the Húsavik and the military in Andenes. In both places, whale watching constitutes an important economic pillar, providing a basis for expanding tourism and counteracting a 'brain drain' of the younger generation. Whales are important for these communities' outside image and socially formed identity as whale watching is the main visitor attraction. In Greenland, the cultural identity aspect is deeply rooted as whales have been the basis of subsistence and cultural practices for Greenlanders since their settlement (Caulfield 1997). Most Greenlandic interviewees, when asked what would happen to their community should the whales disappear from their area, said they could not imagine it because whales represent a part of what they are as people.

9.4.1.11 Existence

Some of the ecosystem services of whales described above, such as inspiration for the arts, the provision of educational values or simply aesthetic enjoyment, do not necessarily involve direct interactions between whales and people in an environmental setting. For many people, just knowing that whales exist and are conserved provide wellbeing benefits, which are often labelled as non-use value (Harris and Roach 2017).

9.4.1.12 Bequest

Bequest is also an aspect of non-use value that may not be regularly considered. It is related to expectations that future generations will be able to enjoy whale ES. Neither bequest nor existence values are addressed by Spangenberg et al. (2014) model but they are discussed in the CICES classification outlined by Cook et al. (2020).

It is evident from the list above that whales provide people in the ARCPATH case study communities with multiple benefits through ES. It is also clear that even though whales and their habitat are the primary sources of ES, most of these benefits require active human involvement. The next section of this chapter presents a framework for theorising how it happens.

9.4.2 An Expanded Whale ES Cascade Model Including Co-production Processes

Table 9.1, below, follows the same CICES classification system of ES (Haines-Young and Potschin 2018) used above to list whale ES. It employs the Total Economic Value (TEV)[2] framework to identify different types of use and non-use values that are later presented in Fig. 9.2 below. It adds the value domains outlined in Fig. 9.1, and elaborates ES co-production processes involved in each whale ES as per the approach of Spangenberg et al. (2014). It is important to note that human co-production activities do not occur in all whale ES. The regulating and maintenance types of ES do not require active human involvement as they originate entirely in ecological structures and processes.

[2] 'A widely used framework to disaggregate the components of utilitarian value in monetary terms, including direct use value, indirect use value, option value, quasi-option value, and existence value' (Potschin et al. 2014). TEV framework is used to classify ES according to their type of utilisation and determine appropriate valuation methods. Use value includes direct use, indirect use and option value, and non-use value is derived from the knowledge that a resource is preserved intact for the future.

Table 9.1 ES cascade model specific to whale ES including co-production activities

Biophysical structure/ process/function (subject to pressures)	Ecosystem services (subject to co-production)	Co-production activity	Benefit	Values (ES value domains and types of TEV values)
Harvested whale	Food products	Hunting	Nutrition	Economic and sociocultural; direct consumptive use
Harvested whale	Bones, teeth, baleen	Hunting	Raw materials for arts and culture	Economic and sociocultural; direct consumptive use
Harvested whale	Blubber products	Hunting	Energy	Economic; direct consumptive use
Whale carcass	Enhanced biodiversity/ evolutionary potential	None	Maintenance/enhancement of life-supporting systems	Biophysical; indirect use
Whale carcass	Climate regulation	None	Regulation of geophysical environment	Biophysical; indirect use
Living whale	Tourism (whale watching)	Whale watching	Recreation, enjoyment and health	Economic and sociocultural; direct non-consumptive use
Living whale	Music and arts	Creation of art	Aesthetic experiences, entertainment and inspiration	Sociocultural, economic; direct non-consumptive use
Living whale	Education	Educational/research activities	Education and training	Sociocultural; direct non-consumptive use
Living whale	Sacred and/or religious	Human/whale interaction Contemplation	Spiritual enrichment	Sociocultural; direct non-consumptive use
Living whale	Aesthetics	Human-whale interaction/ contemplation	Aesthetic experiences	Sociocultural; direct non-consumptive use
Living whale	Community cohesiveness and cultural identity	Community/ecosystem interaction	Cultural heritage, source of social cohesion and identity	Sociocultural; direct non-consumptive use
		Social/cultural activities		
Living whale	Existence	Cognitive co-production: knowing/ contemplating/having certain values	Sense of satisfaction and security	Sociocultural; non-use
Living whale	Bequest	Cognitive co-production: knowing/ contemplating/having certain values	Expectation of security for future generations	Sociocultural; non-use

The table above sets forth the biophysical structures and functions that provide the basis for ES, along with corresponding co-production activities, resulting benefits, and values.

The whale ES co-production model presented in Fig. 9.2, below, stems from the elaboration of whale ES noted above. The schematic, based on the ES cascade model by Haines-Young and Potschin (2010), was designed to incorporate involvement of whale ES producers and users into ES formation, following Spangenberg et al. (2014). It presents all the main stages of whale ES formation as well as the social-ecological processes that lead to them. Despite being based largely on the ARCPATH case studies, the model is generalisable and can potentially be applied to ES co-production in other contexts.

Figure 9.2 sets out to illustrate how people benefit from whales through co-production of ecosystem services. In the model, the anthroposphere, where these processes happen, overlaps with the biosphere, highlighting the dependence of humans on ecosystems. The different parts of the model are described in the next section using examples from the ARCPATH case studies.

9.4.3 The Stages of Whale ES Cascade Explained

The five stages of the whale ES cascade model in Fig. 9.2 – biophysical structure/process/function, ecosystem service potential, co-produced ES, benefits, and values – are explained in the following paragraphs. They represent the products of the co-production processes that occur between each stage and ultimately lead to human wellbeing and associated values.

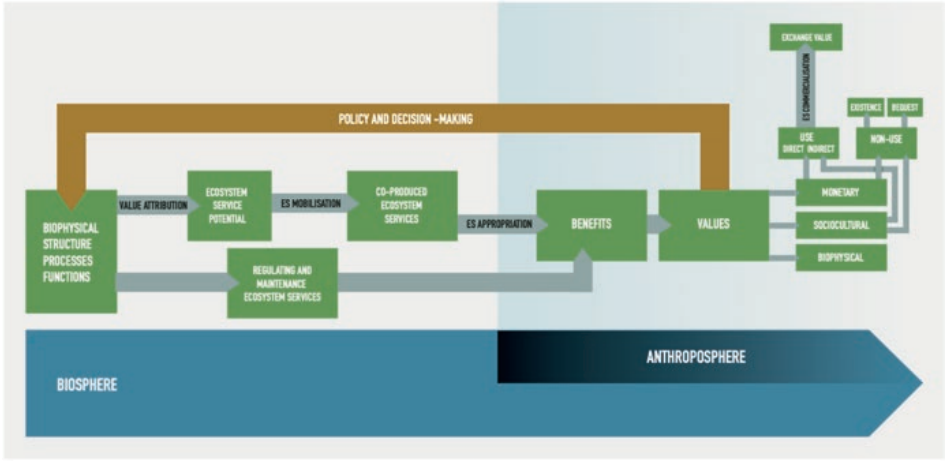

Fig. 9.2 Whale ES cascade model for whale ES. (Adapted from Haines-Young and Potschin (2010), Spangenberg et al. (2014), and informed by ARCPATH case study research)

9.4.3.1 Biophysical Structure/Process/Function

The schematic in Fig. 9.2 shows different stages of the expanded ES cascade model. A whale, its life cycle (living whale, dead/harvested whale, and whale carcass) and its biophysical processes and functions constitute the ecological infrastructure[3] of whale ES. Biophysical functions include the processes that make the whale ES possible. Whale feeding and breeding in different parts of the world provides people with possibilities to observe them in their natural habitat and gain recreational and other benefits. The whale pump facilitates nutrient cycling. Finally, whale carcasses enable carbon sequestration and enhance evolutionary potential in the deep ocean floor (Roman et al. 2014).

9.4.3.2 Ecosystem Service Potential

According to Spangenberg et al. (2014), ESP occurs as a result of recognition of the potential of ecosystems to enhance human wellbeing through value attribution. ESP is the midpoint between ecological infrastructure and the ES that require co-production. At this stage of the ES cascade (Fig. 9.2), potential users with the power and resources to do so, decide upon the ecosystem structures and functions which are valuable in a particular social, cultural and economic context, reflecting societal needs.

9.4.3.3 Co-produced Ecosystem Services

In the expanded model, there are two ways in which ES are supplied: either as regulating and maintenance ES, or as ES that require human co-production (Fig. 9.2). The model recognises that most whale ES (except regulating and maintenance) require active human involvement. For instance, for any of the provisioning ES to be enjoyed by humans, a whale has to be harvested, certain value has to be attributed to its products, and conditions provided for a whale to be hunted, and whale harvesting has to take place. Regulating and maintenance services, on the other hand, imply indirect use value and do not require any additional sourcing effort by humans. Cultural ES usually involve direct or indirect interaction between humans and whales and value attribution to the existence of a whale.

[3] [An ecosystem's] 'natural capital, its properties; and support functions that underlie other ecosystem services and are in a dynamic relationship with [that ecosystem's] processes and natural capital' (Jónsson and Davíðsdóttir 2016).

9.4.3.4 Benefits

Benefits denote an enhancement of human wellbeing. These can be direct or indirect benefits experienced individually or collectively and can occur as a result of direct or indirect human-nature interactions or market exchange with those who have access to ES. For instance, meat resulting from whale hunting in Greenland provides nutritional benefits, and the act of hunting itself – sociocultural and social benefits from the cultural practice and preserving of traditional way of life. These benefits differ between Iceland and Norway where whale meat is less significant for local food production and whaling is carried out by commercial companies. When considering benefits, one must ask the important question: Benefits for whom? This raises an array of issues concerned with needs, perceptions, conceptions of a good life, equity, and the distribution of power relations related to ES appropriation and commercialisation.

9.4.3.5 Value

In Fig. 9.2, above, the ES values are divided into the three domains first delineated in Fig. 9.1: biophysical, sociocultural, and monetary. The latter, in turn, is divided into use and non-use values, following the TEV framework (Cook et al. 2020). Non-use values can be accounted for in non-monetary terms through sociocultural valuation or in monetary terms through non-market valuation techniques. Use values can be accounted for in sociocultural or monetary terms. Given the anthropocentric nature of the ES concept, the biophysical value domain relates to the underlying ecosystem functions that translate into economic and sociocultural values (Gómez-Baggethun and Barton 2013). An example of how the value of whale ES can reside in all three of these value domains is subsistence whaling in Greenland, where some whale meat is sold or exchanged through bartering but most of it is consumed without any exchange of money. As it provides very important nutritional and sociocultural benefits, the monetary value of whale meat in Ilulissat alone is a poor indicator of the its contribution to the provisioning and the wellbeing of local communities.

The five stages of the whale ES cascade model represent the sequential transformation of certain characteristics of the ecological infrastructure into human wellbeing benefits. The processes that enable this transformation are described in the following paragraphs.

9.4.4 ES Co-production Processes, Actors and Power Relations: Case Study Examples

It has been argued above that various physical and cognitive co-production processes have to take place for ES to be possible: value attribution, mobilisation of ecosystem services potential, ES appropriation, and commercialisation (Fig. 9.2).

These processes enable transformation of different features of whales into the progressive stages of whale ES. They are heavily dependent on the context in which ES are co-produced. For this reason, ES co-production processes differ somewhat in each study location and generalisations are only appropriate to some extent.

9.4.4.1 Value Attribution

Value attribution is a context-dependent process, and it matters who participates in it and whose values and needs are represented. For example, carbon sequestration in whale carcasses is only attributed value by people if there is a perceived threat of climate change to human wellbeing. If this were not the case, there would be no perceived human wellbeing improvement from sequestering more carbon. Similarly, whale food products have a potential to enhance human wellbeing in those societal and economic contexts where whale meat is a desirable form of nutrition. One such example is found on Disko Island in Greenland where the demand for whale products is high. However, it is much less in Andenes and Húsavík, according to our interview data.

When considering the cognitive co-production process of value attribution within ES, it is important to consider who assigns values to different parts of the ecological infrastructure. Power relations between stakeholder groups in each case are also important because different ESPs often compete with one another. For instance, in the perceived trade-off between whaling and whale watching in Iceland, whose value attribution matters: citizens, scientists, the tourism sector or whaling companies? In Greenland, the whaling quotas are set by the National Institute of Natural Resources based in Nuuk, where most scientists are non-native. According to the interview data, even though the Greenlandic Hunters' Association is consulted, the hunters do not take ownership of management decisions on which their livelihoods depend, nor do they feel that their interests and values are given sufficient consideration.

9.4.4.2 Mobilisation of ESP

For whale watching to happen, first, whales have to be present and, second, a decision has to be made that whales are worthwhile seeing (cognitive process). Then, specific infrastructure is necessary to facilitate whale watching activities and make it possible for those interested to enjoy this recreational activity (physical process). ES mobilisation requires different types of capital and happens in an institutional setting where different rules can apply. The most prominent cultural whale ES in Húsavík and Andenes – whale watching – requires natural capital (whales and marine ecosystem), human and social capital (manpower, compliance with regulations, knowledge, etc.), and built capital (boats, harbour, security equipment, etc.) that is mobilised using financial capital.

The institutional settings that regulate activities related to whale resource utilisation dictate what is allowed in a certain context. In the case of whale watching within each of our study locations, there are very few formal institutional limitations. On the other hand, whaling is controlled by a number of strict rules. Social context and power relations also play significant roles at this stage of the ES cascade model. Those who provide the most inputs during the ES mobilisation processes – e.g. through human labour – do not necessarily reap the most human wellbeing benefits. An example that could be cited here are the whale watching guides. According to our interview data, they are often highly qualified, but tend to receive a relatively low wage that is characteristic of the hospitality industry.

9.4.4.3 ES Appropriation

To be able to hunt whales and get access to the provisional whale ES, requires whaling equipment that comes at a considerable cost. Whale watching operators in both Húsavík and Andenes have been able to repurpose some existing fishing boats or to secure new rib boats. This requires certain upfront investments and prevents some potential whale watching operators from entering the market. In Greenland, whale watching is conducted using either small privately-owned boats that have permits to carry up to ten passengers or bigger specialised vessels usually owned by larger foreign tourism companies. Greenlandic whaling is also operated using mostly small privately-owned boats and obtaining a recreational or professional hunting license is relatively straightforward. However, the whaling quotas tend to be rather small in number when compared to demand, which increases competition between hunters.

Who gets to enjoy the excludable whale ES is determined by those who have the use right (Felipe-Lucia et al. 2015). Those who mobilise ES gain use rights and benefits from ES, which they can choose to enjoy themselves, share for free, or exchange with others. Here the questions of equity, fairness and social power relations arise. For example, whale watching and whaling vessel owners are generally the only ones who can access provisioning and recreational whale ES, while others have to get access by purchasing them in markets. The relatively high market price of whale watching may price out low income visitors from the recreational benefits of whale watching.

9.4.4.4 ES Commercialisation

Use values of whale ES become exchange values through ES commercialisation as set forth in Fig. 9.2. This is when those who mobilise and/or appropriate ES decide to exchange all or a part of them for money or other goods. High demand for ES increases its exchange value and provides an incentive for higher rates of mobilisation and, at the same time, protection of the ecological infrastructure through management interventions and sustainable use. (Note the uppermost arrow in Fig. 9.2).

In Húsavík, there are relatively few whales compared to the amount of whale watching boats. However, the number of whale watching trips has grown almost exponentially since the 1990s. The potential negative effects of whale watching on whale populations (Christiansen et al. 2013) raise questions about whether they should be regulated. Responding to such concerns, the Icelandic Whale Watching Association created a code of conduct to provide whale watching operators with guidelines (IceWhale 2015).

Other examples of whale ES commercialisation can be seen when Greenlandic part-time hunters[4] decide to sell their catch in a local market instead of keeping it all for themselves and their families, or when small-boat owners start taking passengers out to sea and charge money for such tours. In both cases, those who mobilise ESP decided to exchange the resulting ES, which then becomes a market commodity. Commercialisation of education and related whale ES occurs through sales of whale watching tours, educational materials, and entrance fees to museums.

9.5 Discussion and Conclusion

9.5.1 Possible Policy Implications

The expanded model outlined above conceptualises human involvement in the co-production of whale ES. It challenges an existing view of ES as a one-directional flow of benefits from ecosystems to societies. Our alternative perspective that has been introduced in this chapter portrays humans as active co-producers of many whale ES through value attribution, mobilisation, appropriation, and commercialisation. Such findings have the potential to inform policy tools targeted at influencing these processes from ecological structures to market exchange. An example of this can be seen in the Icelandic Code of Conduct in Whale Watching where private actors with economic interest in recreational whale ES cooperate to protect the underlying ecological infrastructure.

The analysis of ES co-production processes reveals some power and equity issues that are also relevant for policymaking. For instance, in ecosystem-based management, they present a way of accounting for the human dimensions of marine ecosystem management (Christie et al. 2017). These dimensions play out through ES co-production processes as uneven influence over value attribution, differentiated access to capital that is necessary for ES mobilisation and appropriation, and disproportionate influence on ES management. This is apparent in the policy area of whaling within Greenland where those who depend the most on whale ES have little influence over the rules regarding their harvesting.

Of the three value domains highlighted in this chapter (Figs. 9.1 and 9.2), exchange values are the most commonly used in ES valuation, often detracting from

[4] There are two types of hunting licences in Greenland: for full-time and part-time hunters.

the biophysical and sociocultural value domains. However, in many Arctic coastal communities, whale ES constitute important biophysical and sociocultural values as they play a central role in local social-ecological systems. This is especially true with respect to Greenland's heritage where the relationship between humans and marine mammals is of great sociocultural significance. Some of these values cannot be accounted for by monetary valuation alone (Cook et al. 2020) and require alternatives, such as sociocultural valuation and deliberative ES valuation methods (Martín-López et al. 2014). The analysis of whale ES formation and evidence-gathering process via interviews in this chapter promote a stakeholder-focused approach to marine resource utilisation.

Focusing on whale ES and their contribution to human wellbeing alone is not sufficient, in itself, to ensure the protection of marine ecosystems and their necessary functions underpinning whale ES. The functioning of entire ecosystems need to be taken into account. Hence, a wider approach is needed to consider different aspects of socio-ecological systems, in particular sustainability, ecosystem dynamics and multi-species interactions (Granek et al. 2010).

Ecosystem-based management is an approach that fits well with the discussion of ES in this chapter because it includes ecological, economic and societal objectives in marine ecosystem management (Long et al. 2015). It is a preferred approach to marine ES management that is encouraged by the Arctic Council (2013). The view of society as an integral part of a social-ecological system rather than something external to nature accommodates the consideration of actors and processes outlined in this chapter.

9.5.2 Uncertainties, limitations and research needs related to whale ES cascade.

Unpredictability of whale resources is an important issue to consider in whale ES analysis and management. In all three case study locations, whale species and populations have been fluctuating in tandem with biophysical conditions, not least due to observed climate change. Whales are highly migratory species, and any changes in natural conditions and the distribution of prey species can cause them to leave their usual feeding areas. Data gained from interviews with experts in Norway indicate that this happened in Tromsø in 2018, leading to the near-total collapse of whale watching in the area and causing concern that something similar might happen in other Arctic locations. Therefore, improved knowledge of biophysical changes and anthropogenic activities affecting whale behaviour is crucial for reducing this uncertainty.

The ES cascade model presented in Fig. 9.2 was adapted to include sociocultural and biophysical value domains as well as non-use values. However, even when included in the model, the non-use values can be difficult to account for in policy making. Non-market valuation techniques have been applied in certain attempts to

monetise non-use values of marine ES, but their results should be supplemented with information on other types of values for more comprehensive assessment (Chan et al. 2012). Multiple value domains might be affected simultaneously following impacts to whale ES in each of the case study communities. Value pluralism would have to be addressed through integrated ES assessment methods to account for these changes.

The ES cascade model has also been criticised for failing to take into consideration power relations and the socio-economic realities of ES co-production, access and use (Berbés-Blázquez et al. 2016). This chapter has strived to address these concerns in the context of whale ES in the Arctic. Moreover, even though the ES cascade model acknowledges the presence of synergies and trade-offs between ES, its ability to quantify them is rather limited due to many uncertainties and complexities that are at play between the different uses of marine ecosystems (Granek et al. 2010).

Another challenge relates to conducting ES valuation using methods that can be hard to apply in policy (de Groot et al. 2010). Monetary ES valuation methods often involve surveys that might not be able to reach a representative sample of a given population. Results might be affected by budget constraints or limited by an aversion to paying additional fees for environmental protection. For instance, the contingent valuation study on expanding the whale sanctuary in Faxaflói Bay, Iceland (Malinauskaite et al. 2020) captures some of the preferences of Icelanders regarding its size and reveals public division on the subject of whaling. However, it remains to be determined what this means explicitly for management of whale ES. Sociocultural valuation reflects non-monetary values, but their implications for management are harder to quantify due to complicated metrics that decision-makers are not familiar with in many cases.

Finally, considering that whales are highly migratory species that cannot be confined to one marine ecosystem, the ES approach has a limited ability to account for some of their regulating and maintenance and provisioning forms of ES during periods of time when they are not present in a given location. The question of whether whale ES are still valuable when not present in a certain location relates to perhaps the biggest philosophical limitation of the ES concept – its limited capacity to account for intrinsic ES values in the absence of a human presence.

9.6 Concluding Thoughts

In this chapter, an ES cascade model was developed for whale ES and expanded to account for co-production processes. The inventory of whale ES was informed by a literature review and illustrated using empirical examples from three ARCPATH case study coastal communities in Iceland, Greenland and Norway. The purpose of this exercise was to highlight the role that humans play in ES formation and to further our understanding of the contribution of whale ES to the wellbeing of people in the Arctic. The resulting model conceptualises where and how in the whale ES

cascade human co-production occurs. It also includes some considerations of equity and power relations that are crucial to any analysis of natural resource use.

The purpose of ARCPATH has been to connect climate science to on-the-ground societal effects, highlighting community perspectives and possible pathways to action. The first link that ARCPATH has explored is that between climate change and environmental impacts (see Chap. 8 in this volume). The second link, which is the focus of this chapter, is between environmental change and human wellbeing (see also Chap. 10 in this volume). The conceptual framework for studying human-nature interactions presented here is a first step towards analysing how changes in marine ecosystems may affect local communities and how these effects might be best addressed. Whale ES represent an understudied area in Arctic and ES research, and the focus on co-production processes helps to identify much-needed local community perspectives within these fields.

The ES cascade model provides a conceptual bridge between ecosystems and societies that is needed for effective policy advice. The processes highlighted in this chapter can be targeted to ensure more socially and ecologically sustainable use of whale resources. Albeit, the unpredictable nature of these marine mammals and the scale of social-environmental change in the Arctic makes management more difficult and require adaptiveness and reflexivity on the part of policy makers.

In the context of rapid change in the Arctic and diverse uses of whale ES, there is a need for more primary ES valuation studies covering the full spectrum of value domains. Likewise, more research is needed on the biophysical and co-production processes that underpin ES values, and better understanding of power relations, determining who participates in co-production. Additionally, more attention needs to be directed toward who experiences whale ES benefits, and who has the decision-making power regarding their management. These research directions combined hold a potential to build better linkages between the disciplines in their inquiries into social-ecological change in the Arctic.

Acknowledgement The work in this chapter is supported by and contributes to the NordForsk funded Nordic Centre of Excellence project (Award 766654) Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH).

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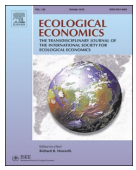
5 Publication III: Socio-cultural valuation of whale ecosystem services in Skjálfandi Bay, Iceland

Ecological Economics 180 (2021) 106867

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon



Analysis

Socio-cultural valuation of whale ecosystem services in Skjálfandi Bay, Iceland

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ARTICLE INFO

Keywords:
Socio-cultural ES valuation
Whale ecosystem services
Non-monetary valuation
Multi-method approach

ABSTRACT

The study examines the socio-cultural values of multiple ecosystem services (ES) sourced from whales in Skjálfandi Bay, North Iceland, with many beneficiaries living in and visiting the town of Húsavík. The study begins to address the research gap in non-monetary valuation of marine ecosystem services. Based on a multi-method approach, it elicits stakeholders' perceptions of the contribution of whale ES to human wellbeing using stakeholder mapping, semi-structured interviews, observations, and socio-cultural preference surveys. The key whale ES identified by the local stakeholders were cultural, most frequently mentioned being recreation and education. The most commonly mentioned ES values were related to economic benefits from the whale watching industry. The preference survey reveals that regulating and maintenance ES were valued most highly with a mean score of 4.0 out of 5.0, cultural ES were second with a mean score of 3.5, and provisioning ES in the form of food and raw materials were valued the least with a mean of 0.75. Interview data also reveals some marine ES management challenges originating from intensified tourism, industrial development, and climate change. The results of the study have the potential to inform marine resource management in Iceland by including socio-cultural values associated with whale resources.

1. Introduction and case study background

Ecosystem services (ES) can be valued in biophysical, economic and socio-cultural terms (Martín-López et al., 2014; Pascual et al., 2010). The biophysical value domain is concerned with physical characteristics of ecosystems and their components, the economic – with monetary values of ES, and the socio-cultural – with preferences and principles held by people towards nature (Pascual et al., 2017). The latter are expressed by socially formed and personally held values that cannot be measured in monetary or biophysical terms (Maestre-Andrés et al., 2016). These values describe the importance, worth or usefulness of ES to people and can be instrumental, intrinsic or relational depending on the context (Chan et al., 2016; Walz et al., 2019).

A variety of methods are available for assessing socio-cultural values of ES. They are continuously being developed and refined (Martínez et al., 2013; Pascual et al., 2017) and include observational approaches and expert-based approaches, document research, in-depth interviews, focus groups, and surveys (Santos-Martín et al., 2017; Scholte et al., 2015). Despite this fact, socio-cultural values have often been overlooked in ES valuation, potentially obscuring human-nature relationships and hampering mainstreaming of the ES concept in policy and management (Chan et al., 2012a; Santos-Martín et al., 2017).

Humans source multiple benefits from whales, including food, tourism, ecosystem regulation, aesthetic enjoyment and artistic inspiration (Cook et al., 2020; Malinauskaite et al., 2020a; Roman et al., 2014). Despite this fact, the ES of marine mammals have been lightly explored in the academic literature. Notably, Roman et al. (2014) and Cook et al. (2020) formed inventories of whale ES, outlining their biological importance. There have also been attempts at economic valuation to assess the recreational value of whale watching (O'Connor et al., 2009; Parsons et al., 2003; Robertsen, 2013). However, whale ES have not yet been assessed from a socio-cultural perspective. Adding this dimension to ES valuation has the potential to deepen the understanding of their role in human wellbeing (Calvet-Mir et al., 2012; de Souza Queiroz et al., 2017).

The uses of whale resources in Iceland have changed considerably in the second half of the twentieth century, with the decline of commercial whaling and increase in whale watching tourism, requiring communities to adapt and change their economic activities accordingly (Einarsson, 2009; Martin, 2012). A community that has so far successfully adapted to the decline of the local fishing industry and increased tourism industry is

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https://doi.org/10.1016/j.ecolecon.2020.106867
Received 2 June 2020; Received in revised form 23 September 2020; Accepted 29 September 2020

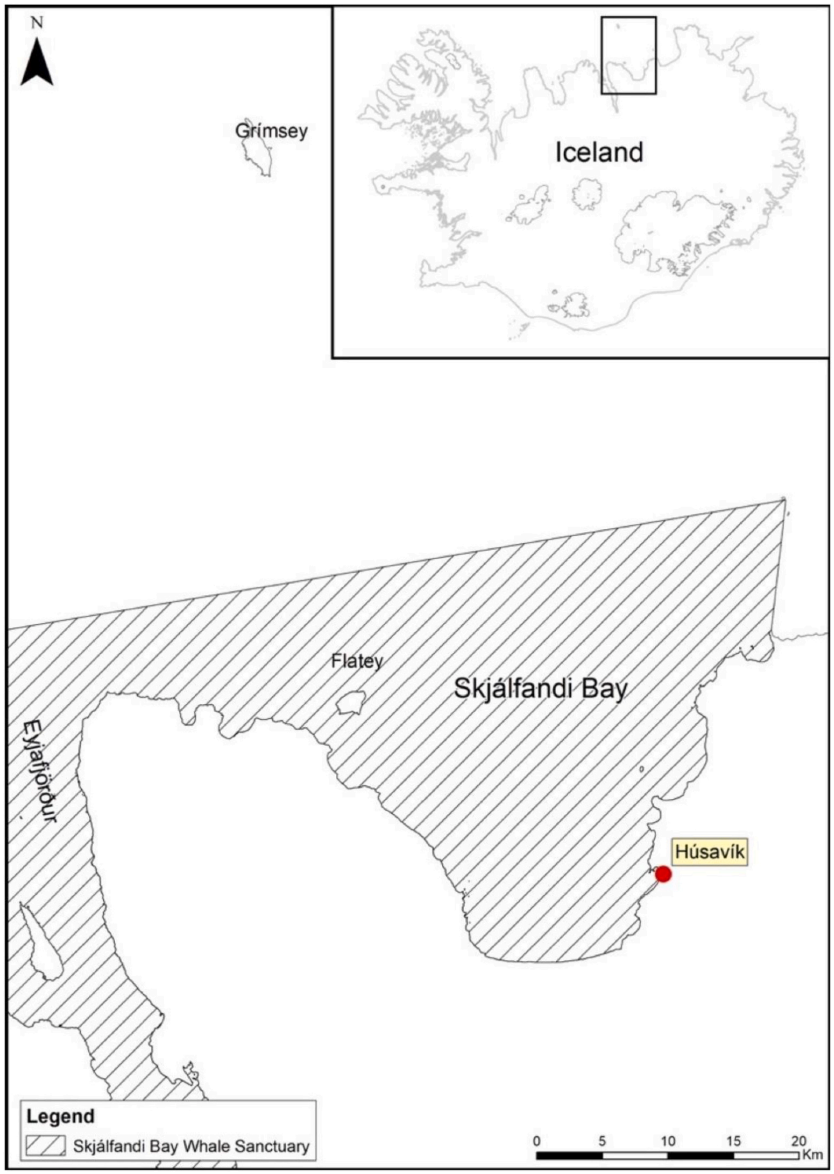


Fig. 1. The boundaries of Skjálfandi Bay Whale Sanctuary.

Húsavík in Northeast Iceland, which is a medium-sized town in northern Iceland and the administrative centre of Norðurþing municipality with around 2500 inhabitants (Statistics Iceland, 2020). It is located around 70 km south of the Arctic Circle in Skjálfandi Bay (Nicosia and Perini, 2016) (Fig. 1). The fodder-rich bay ecosystem provides feeding grounds for several species of fish, birds, and cetaceans. The main economic activities in Húsavík are fishing and fish processing, agriculture, public services, tourism and other service industries (Nordurthing Municipality, 2020).

The most typical cetacean species observed in Skjálfandi Bay have been minke whales (*Balaenoptera acutorostrata*), white-beaked dolphins (*Lagenorhynchus albirostris*), humpback whales (*Megaptera novenagliae*), harbour porpoises (*Phocoena phocoena*), blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*) and killer whales (*Orcinus orca*) (Rasmussen, 2009). Year-round abundance of cetaceans in the bay and the relatively close proximity of their feeding grounds to Húsavík's harbour makes a good spot for whale watching, which became the main tourist attraction in the area soon after its inception in the 1990s (Nicosia and Perini, 2016).

The number of whale watchers in Húsavík has increased almost fourfold in the last two decades: from around 29,000 in 2003 (when visitor data started to be collected) to 104,000 in 2019, constituting 28.5% of all whale watching trips in Iceland, and around 5.2% of all foreign visitors (Icelandic Tourist Board, 2020). Recognising the growing importance of whale watching for the Icelandic economy, the Icelandic Government designated two whale sanctuaries in the nation's most popular whale watching areas: one in Faxaflói Bay and one in

Table 1
Research aims and methods.

	Research aims	
Research methods	(i) to identify the key ES provided by whales in Skjálfandi Bay and values associated with them	(ii) to assess the relative importance of ten key whale ES from a socio-cultural perspective and the factors that influence their valuation
Literature review	x	
Stakeholder mapping	x	
Observations	x	x
Semi-structured interviews	x	x
Preference survey		x

Skjálfandi Bay (Government of Iceland, 2017) (Fig. 1).

This study responds to the need for more primary ES valuation studies in Arctic social-ecological contexts (Malinauskaite et al., 2019). It presents the first attempt to apply socio-cultural valuation in the context of the marine environment in Iceland, exploring the multiple values assigned by a coastal community and its visitors to whale ES, and complementing the biophysical and economic data on the role of cetaceans in Iceland's marine environment and economy (IoES, 2019; Rasmussen, 2014). It does so by combining some of the methods typically used in socio-cultural ES valuation.

The study aims to capture and analyse how inhabitants and visitors of Húsavík perceive and value whale ES in socio-cultural terms. The main objectives of the study are (i) to identify the key ES provided by whales in Skjálfandi Bay and the different place-based values that stakeholders assign to them; and (ii) assess the relative importance of key whale ES from a socio-cultural perspective and the factors that influence it. The paper consists of five sections: Section 2 describes the methods used; Section 3 presents the study results, which are then discussed in Section 4, putting them into a wider context; and the final section 5 concludes the paper, drawing attention to the main findings and future research possibilities.

2. Methods

Unlike in the case of monetary ES valuation, a standard set of methods has not been developed for socio-cultural valuation. Different approaches have been used to assess various aspects of socio-cultural ES values, such as the social and environmental context and relationships between ES beneficiaries and ecosystems (Scholte et al., 2015). Therefore, multiple valuation techniques can be used to uncover the different dimensions of ES values (Santos-Martín et al., 2017). Five different research methods were applied in this study: a literature review, stakeholder mapping, observations, interviews, and a preference survey. They are listed in Table 1 together with the corresponding research aims. Some of the research activities were carried out simultaneously during fieldwork and were used to inform each other.

2.1. Literature review

The purpose of the literature review was to familiarise with the literature on whale ES and their valuation, and sources that could potentially help in fulfilling the study aims. Both academic and grey literature was consulted,[1] including academic journal articles, books, historical sources, online news outlets, and websites. The snowball technique was applied in the literature review, meaning that the initial data sources were used to find more sources (Greenhalgh and Peacock, 2005; Malinauskaite et al., 2019). The technique extended to the semi-structured interviews in the cases where interviewees pointed out additional sources of data.

2.2. Stakeholder mapping

The literature review and four initial interviews with experts in the field of whale resources in Iceland were used to identify the key stakeholders in Iceland and Skjálfandi Bay specifically. The process was ongoing, and the stakeholder map (see Appendix 1) developed in tandem with the data collection as interviewees pointed to other people that could potentially be interviewed. The best practice guides for stakeholder identification and mapping were used (Durham et al., 2014; Reed et al., 2009). The stakeholders were grouped into two subgroups, with economic interest (benefitting economically from whale resources) and non-economic interest (having a stake in whale resources other than economic gains, e.g. management, research or activism) in whale ES. Then the former group were split into stakeholders with a direct or indirect economic interest, and the latter bracketed into those with a direct or indirect regulatory interest. The resultant stakeholder map was used to identify the potential interviewees with interest or/and expertise in whale resources in Skjálfandi Bay.

2.3. Observations

Observations involved spending time in the case study community and observing everyday activities related to whale ES. Both participant and non-participant observations were conducted (Bessette, 2004), meaning that the authors at times participated in activities such as whale watching, and other times passively observed the activities in the harbour and town. Two one-week-long observations took place in June 2018 and August 2019 when the authors stayed in the community, observed daily activities in the town and participated in some of them, talked to people during the semi-structured interviews and in informal settings. These observations resemble the ethnographic methods previously used in ES research (Calvet-Mir et al., 2012; Kaltenborn et al., 2017; Maestre-Andrés et al., 2016).

2.4. Semi-structured interviews

We aimed to interview as diverse a sample as possible and contacted people in all stakeholder groups. As a result, 15 interviews with 16 local stakeholders[2] in Húsavík were conducted during the first fieldwork in June 2018. The stakeholder groups represented in the interviews included: whale watching company senior employees ($n = 2$) and whale watching guides ($n = 4$), two of them early career researchers; representatives from the local government ($n = 3$); senior academic researchers focusing on either whale biology or community resilience (n = 2); local museum employees (n = 3); a senior employee of a local fishing company ($n = 1$); and an owner of a local hospitality business (n = 1).

The interviews were designed with the first research aim in mind: to elicit the key ES provided by whales and values associated with them. Firstly, the interviewees were asked if they were familiar with the concept of ES, and if not, a simple definition was provided. Then, they were asked to describe the most important benefits that people get from

[1] The literature was sourced through academic (Google Scholar, Scopus, and Science Direct) and generic (Google) search engines combining the terms 'whale ecosystem services', 'whale watching', 'whaling', 'role of whales' with 'Húsavík', 'Iceland', 'coastal community', 'value', 'social', and 'cultural'.

[2] Upon a request by two of the interviewees due to time constraints, they were interviewed at the same time. Interviewees were randomly numbered from I1 to I16 to mark the quotations in the results section.

whales in Skjálfandi Bay according to their opinion, if they have changed and how. Finally, respondents were asked about their own experience of whale ES and the role they or their organisation play in the use and management of whale ES. Each interview lasted around one hour, the shortest being around 40 min, and the longest around 90 min. The interviews were mostly conducted in the workplaces of the interviewees, except for a couple which were conducted at a local café.

The interviews were later transcribed in full and coded using the grounded theory inductive approach to qualitative data analysis (Charmaz and Belgrave, 2007; Glaser and Strauss, 1967; Strauss and Corbin, 1990). They were coded using free coding in MAXQDA qualitative analysis software until reoccurring codes, themes and sub-themes emerged, and the codes were systemised accordingly. This allowed for identification and analysis of whale ES and the values assigned to them without pre-conceived terminology, using the interviewees' own words instead (Bullock et al., 2018). The ES and their values elicited during this process were later used to inform the list of the ten key whale ES in the sociocultural survey.

The Common International Classification of Ecosystem Services (CICES) typology (Haines-Young and Potschin, 2018) was used to classify the key whale ES into provisioning, regulation and maintenance, and cultural. To put the results of the interview analysis in the wider context of the ES literature, the values assigned by the interviewees to whale ES were grouped according to the twelve ES value types as defined by Van Riper and Kyle (2014): *aesthetic, biological diversity, cultural, economic, future value, intrinsic, learning, life sustaining, spiritual, recreation, therapeutic,* and *scientific* (Table 4). Furthermore, the identified ES values were also classified into the three value domains typically used by ecological economists – *ecological, socio-cultural,* and *monetary* (Gómez-Baggethun and Martín-López, 2015; Martín-López et al., 2014).

2.5. Socio-cultural preference surveys

The socio-cultural preference surveys were conducted by a team of four researchers during the second visit to Húsavík in August 2019. The survey contained a list of ten key whale ES, the importance of which respondents were asked to rank on a Likert-type scale from 0 to 5–0 being not important at all and 5 being very important. Participants were also asked to answer a set of socio-demographic questions. The ten key whale ES were identified through the observations, analysis of the interviews, and the literature review by Cook et al. (2020). The list and characteristics of the whale ES are outlined in Table 2 together with the methodological sources through which they were identified.

Socio-demographic questions following the best practices in ES valuation, including a standard set of questions about participants' age, gender, level of income, education, number of children, marital status, and residency (Calvet-Mir et al., 2012; Maestre-Andrés et al., 2016; Malinauskaite et al., 2020b). The interviewees and their colleagues were targeted first: employees of municipalities, museums, whale watching companies, the local research centre, tourism businesses etc. Then the general population of Húsavík was targeted in public places, such as the harbour area, local library, swimming pool, cafés, museums, and shops. However, since Húsavík is very popular with foreign visitors and the month of August is within the peak tourist season, it was inevitable that more visitors than locals were targeted as there were more of them present in the public areas.

The results of the survey were analysed using STATA statistical analysis software, eliciting the mean socio-cultural importance scores of the ten whale ES and their relationship to the socio-demographic variables using OLS regression. Since there are very few socio-cultural ES valuation studies to date, the study is exploratory, and results were allowed to emerge from the data rather than from a preconceived hypothesis. Eight socio-demographic dummy variables were used in the OLS regression model to determine statistically significant determinants of the socio-cultural preference scores for each whale ES. The explanations of the variable codes are provided in Table 3. Finally, a two-sample *t*-test was applied to compare the scores assigned by locals and visitors and verify whether there are any significant differences between the means.

3. Results

The results of the study are presented below: the whale ES that emerged from the analysis of the interviews, the values corresponding to whale ES in the context of established ES value classifications in the literature, the results of the socio-cultural valuation survey, significant socio-demographic variables, and some additional issues emerging from the interviews.

3.1. ES identified through analysis of the interviews

The analysis of the interviews revealed that the whale ES mentioned by most[3] interviewees were tourism and recreation (n = 10) and education (n = 10), followed by the role the whales play in local community cohesiveness and identity (n = 8), aesthetic enjoyment (n = 5), and whale food products (n = 5) (Table 4). Ecosystem support (n = 2) and existence value-related whale ES (n = 3) were mentioned by two and three respondents respectively, and one respondent elaborated on the role of whales in spiritual experiences of local ecosystems (n = 1) and inspiration for arts (n = 1). This information was used in conjunction with the literature review and classification of whale ES by Cook et al. (2020) to select ten[4] key whale ES that were later used in the socio-cultural valuation survey (see the list in Table 5).

The interviewees used their own words to describe ES values, attaching them to particular ES. Therefore, the phrases used to describe values and related services partly but not entirely coincide (Table 4). However, there is a distinction between ES and their values: for instance, provisioning ES in the form of whale meat were mentioned by three interviewees but only one of them assigned a nutritional value to it. The identified values were put into a context by classifying them into different types (Van Riper and Kyle, 2014) and domains (Martín-López et al., 2014). This allowed for a comparison of the study results to other ES valuation studies that include multiple values.

Tourism and recreation and educational ES were discussed most extensively by the interviewees as the main visitor attractions in Húsavík are whale watching and the Whale Museum. The interviews indicate that these two whale ES form a synergy as expanding tourism results in more visitors who often ask locals about whales and the surrounding ecosystems, increasing interest of the locals in their marine environment and facilitating local learning: “you would walk into the bookstore in Húsavík and there was a tourist telling you ‘oh, did you know there are these and those whales in your bay?’, and I thought it should be like vice versa”(I6).

Educational ES are generated in whale watching trips where participants not only get to see whales but also learn about other species and the whole ecosystem, in this way enhancing their environmental awareness. Moreover, the Whale School is organised jointly by the Whale Museum and the local primary school for its pupils to get acquainted with the biodiversity of Skjálfandi Bay: ‘the purpose was that people like children in Húsavík would know the whales and know why they are here’ (I6).

An additional point of synergy between recreational and educational whale ES is the cooperation between the whale watching sector and the University of Iceland's Research Centre in Húsavík, which attracts young and motivated researchers who have the opportunity to simultaneously do research and make a living as whale watching guides. This puts Húsavík on the map for marine mammal research, increasing its socio-demographic diversity: ‘Húsavík is like a magnet for young educated people, and it's all due to the whale watching and the activities around the whale watching.’ (I12); ‘the opportunity for the

[3] Even though the interview data analysis using MAXQDA software revealed both how many respondents mentioned each ES as well as the frequency and extent of discussion by each respondent, one mention per interviewee was counted regardless of how many times the same ES was mentioned or to what extent it was discussed by the same person. The reasoning behind this was to give each respondent equal weight in the analysis.

[4] Seven ES that were mentioned in the interviews are listed in Table 4.

Table 2
The key whale ES in the socio-cultural valuation survey.

Ecosystem service	Characteristics	Methodological Source		
		Interviews	Observations	Lit. review
Provisioning ES				
Food products and raw materials	Whale food products: meat, blubber, skin, etc.	x		x
Regulating and maintenance ES				
Nutrient cycling	Redistributing nutrients vertically and horizontally while feeding and defecating.			x
Biodiversity enhancement	Maintaining nursery populations and habitats (including gene pool protection).	x		x
Cultural ES				
Recreation and tourism	Whale watching and other whale-related tourist activities.	x	x	x
Community and cultural identity	Whales as a source of cultural heritage, social cohesion and identity.	x	x	
Spiritual enrichment	Interactions to which people give spiritual and symbolic meaning; experience of connection to nature.			x
Inspiration for arts	Features of whales that inspire arts.		x	x
Education	Direct or indirect interactions enabling cognitive development, education and training.	x	x	x
Aesthetics	Aesthetic experiences.	x	x	x
Existence	'Knowing that whales are there'.	x		x

Table 3
OLS regression model – predictor variables and coding.

Predictor variable	Explanation of coding
Sociodemographic variables	
Children	A dummy variable, with 0 = no children under 18 and 1 = at least one child.
Education	A dummy variable, with 0 = no degree education and 1 = at least an undergraduate degree.
Participation in labour market	A dummy variable, with 0 = not actively participating in the job market at the time of the survey and 1 = active participant. Non-participation includes students, the retired, sick or disabled, carers, people on maternity/paternity leave and the unemployed, while active participation included all employed and self-employed individuals, irrespective of part-time or full time.
Gender	A dummy variable, with 0 = female and 1 = male.
Disposable income	A dummy variable, with 0 = disposable income under 500,000 ISK and 1 = disposable income over 500,000 ISK.
Age	A dummy variable, with 0 = not older than 50 and 1 = older than 50.
Marital status/ cohabitation	A dummy variable, with 0 = not married or cohabiting with a partner and 1 = married or cohabiting.
Residence	A dummy variable, with 0 = resident of Húsavík and 1 = residence outside of the town.

Table 4
Ecosystem services and types of assigned values identified in the interviews.

ES Identified	CICES Group	Number	Percent	ES Value Identified	Value Type	Value Domain	Number	Percent
Tourism & recreation	Cultural	10	62.50%	Economic	Economic	Monetary	16	100.00%
Knowledge & education	Cultural	10	62.50%	Educational	Learning & Scientific	Socio-cultural	10	62.50%
Community identity & cohesion	Cultural	8	50.00%	Socially formed	Cultural	Socio-cultural	10	62.50%
Aesthetic enjoyment	Cultural	5	31.25%	Aesthetic	Aesthetic	Socio-cultural	5	31.25%
Existence	Cultural	3	18.75%	Existence	Intrinsic	Socio-cultural	3	18.75%
Whale meat	Provisioning	5	31.25%	Nutritional	Life-sustaining	Biophysical	1	6.25%
Ecosystem regulation	Regulation & maintenance	2	12.50%	Ecological	Biological diversity	Biophysical	2	12.50%

Table 5
Mean scores of the ten key whale ES identified by survey respondents.

	Total			Locals			Visitors		
Ecosystem service (CICES classification)	Mean total	No. obs.	Standard deviation	Mean locals	No. obs.	Standard deviation	Mean visitors	No. obs.	Standard deviation
Provisioning ES	0.747		1.380	0.724		1.229	0.737		1.391
Food products and raw materials	0.747	589	1.380	0.724	105	1.229	0.737	472	1.391
Regulating and maintenance ES	4.003		1.254	3.810		1.227	4.046		1.254
Nutrient cycling	3.690	588	1.508	3.533	105	1.409	3.715	471	1.531
Biodiversity enhancement	4.316	585	0.999	4.087	104	1.044	4.377	469	0.976
Cultural ES	3.525		1.263	3.449		1.310	3.531		1.334
Recreation and tourism	3.418	588	1.338	3.705	105	1.255	3.365	471	1.344
Community and cultural identity	3.661	587	1.155	3.552	105	1.101	3.677	470	1.160
Spiritual enrichment	2.631	582	1.601	2.592	103	1.746	2.617	467	1.570
Inspiration for arts	2.983	586	1.377	2.923	104	1.446	2.974	470	1.355
Education	4.044	588	1.077	3.905	105	1.156	4.062	471	1.063
Aesthetics	3.523	587	1.396	3.248	105	1.486	3.581	470	1.359
Existence	4.404	587	0.900	4.219	105	0.990	4.438	470	0.881

whale-watching and the research here is huge' (I3).

Community cohesiveness and identity was discussed by half of the interviewees in the context of the transformation of Húsavík from a fishing to whale watching town. Whale watching created new opportunities for the local people not only to make a living locally but also redefine itself as a community with a whale as a new symbol of the town. As one interviewee expressed it: 'it's like a part of the image we have of ourselves – it's the whales and they're important, and we kind of like them because of that' (I14).

Whales are known to inspire admiration, respect and awe due to their aesthetic characteristics, such as majestic appearance and large size (Cook et al., 2020). A whale watching guide noted: 'I've had people getting emotional on the boat, they're just so overwhelmed by what they're seeing' (I4). Cetaceans have been known to also inspire art and music in different parts of the world for centuries (ibid., Sakakibara, 2009). Whales have inspired local art in Húsavík (noticed during observations), which was the motivation behind including the 'inspiration for arts' to the list of ten key whale ES.

ES associated with existence values were mentioned by only three people, which may be because existence is perceived as less tangible than other ES with tangible products, such as recreation and tourism. However, this ES was the only one that did not receive a single 0 mark on the Likert-scale in the preference survey and was the highest-rated cultural ES. It was expressed by one interviewee that 'it is the first animal that became a symbol of maltreatment of the natural living world, globally' (I5), also indicating a symbolic value of this ES. Regulating and maintenance ES were only mentioned by a couple of respondents but were the most highly valued group of ES in the socio-cultural survey, which perhaps indicates rather a lack of awareness than perception of limited importance.

Provisioning ES in the form of whale meat were mostly referred to as a thing of the past that is fading away quickly, having lost their cultural and economic significance. Unlike in Faxaflói Bay in Southwest Iceland, whaling has never been an important economic or cultural activity in Skjálfandi Bay. Some of the interviewees mentioned harvested minke whales being brought to Húsavík harbour a few times a year for local consumption: 'I remember one or two times going to the harbour where there was a whale that has either been killed or stranded, and people were getting meat from it' (I6).

3.2. ES values identified in qualitative analysis of the interviews

When referring to tourism and recreation ES values, the interviewees mostly did so in terms of economic benefits for the Húsavík community and not recreational values that reflect the interests of visitors. This demonstrates the difficulty in translating locally formed values to standardised ES classification frameworks, an issue that was also noted by de Souza Queiroz et al. (2017). All respondents mentioned the economic values ($n = 16$) that the Húsavík community receives from whales through income and employment opportunities in the tourism sector, as the following quotations illustrate: 'if it weren't for the whale watching industry, I think this town would be basically dead' (I4); 'fishermen who lost their jobs in the fishing industry and have gotten employment in whale watching' (I5); 'let's say 90 percent of all my guests are here because of whale watching' (I7).

Socially formed values ($n = 10$), such as community identity, social cohesion, and connection to nature, were mentioned by ten respondents, as were educational values. The number of mentions of aesthetic ($n = 5$) and existence ($n = 3$) values coincided with the number of times whale ES associated with them were mentioned. This is due to the characteristics of these ES that relate to specific kinds of values. Biophysical values (n = 3) were related to the ecological functions of whales and nutritional benefits.

3.3. Preference survey results

The survey was completed by a total of 589 people, 105 of them local residents of Húsavík and 484 visitors. Not all of the respondents completed all of the survey questions, and this resulted in differing numbers of observations for most ES.[5] Table 5 lists the results of the socio-cultural survey: the mean scores of the key whale ES, together with number of observations and standard deviations for three groups – the whole sample, Húsavík residents, and visitors. Fig. 2 lists the mean ES scores and standard deviations of the whole sample.

The survey results suggest that whale ES associated with existence values were the most valued. The second highest-rated ES was biodiversity enhancement associated with the presence of whales in the bay, followed by education, nutrient cycling, community cohesion, and recreation and tourism. Overall, regulating and maintenance ES were the most highly valued of the three groups of whale ES with an overall mean score of 4.00, and provisioning ES were the least highly valued with a mean score of 0.75. The mean score of the cultural ES group was 3.53. The highest standard deviation of 1.38 was observed for provisioning ES, while regulating and maintenance and cultural ES had standard deviations of 1.25 and 1.26, respectively. The highest standard deviation occurred for ES related to spiritual enrichment, nutrient cycling, food and raw materials, and aesthetics.

Húsavík residents valued recreation and tourism ES significantly more than visitors, which is also reflected in the interviews and is hardly surprising, given that whale watching is the main source of income in the local tourism industry. Visitors gave higher scores to biodiversity enhancement, education, aesthetics and existence ES.[6] Regulation and maintenance ES were highest rated despite being the least frequently mentioned in the interviews. These ES were also the ones that needed the most explanation during the socio-cultural survey implementation, and when explained were usually rated relatively highly.

3.4. OLS regression model outcomes

Table 6 presents the results of the OLS regression analysis of the whole sample[7] using the socio-demographic variables listed in the methods section (Table 3). For each of the statistically significant variables, the coefficients and standard errors are listed for each of the ten whale ES from the socio-cultural preference survey. In accordance with the approach of Maestre-Andrés et al. (2016), only the statistically significant socio-demographic variables are displayed.

The most significant socio-demographic variables for provisioning ES were income and gender, both significant at the 1% level. Education was significant at the 5% level, implying that respondents with university-level education valued provisioning ES more. Male respondents and those with university-level education were more likely to give higher value scores to the provisioning ES, while those with higher income – lower scores.

Respondents who were married or in cohabitation with a partner and those who had children under 18 valued regulating and maintenance ES relatively less, while those with a higher level of education did so significantly more. Education, income, age, having children under 18, and residing in Húsavík were all significant variables for valuing cultural whale ES. Respondents with relatively higher income and Húsavík residents gave higher scores to recreation and tourism. Older and university educated residents valued spiritual enrichment more highly; university educated respondents also gave higher scores to inspiration for arts. Those with no children under 18 valued education ES higher, and those with high income – lower. Being

[5] E.g. twelve respondents did not declare their place of residence, resulting in them being included in the total sample but not in the two sub-samples of Húsavík locals and visitors.

[6] Two-sample *t*-test revealed significant differences between Húsavík locals and visitors in valuing five whale ES: biodiversity enhancement and tourism and recreation ES were significant at 1% level; ES associated with aesthetics and existence values at 5% level; and education at 10% level.

[7] It is important to note that the survey sample is not necessarily representative of one population but is rather a mixture of visitors and locals that agreed to be surveyed during the week of fieldwork. While the study provides a snapshot of how whale ES are valued in Húsavík from a socio-cultural point of view, wider generalisations are avoided.

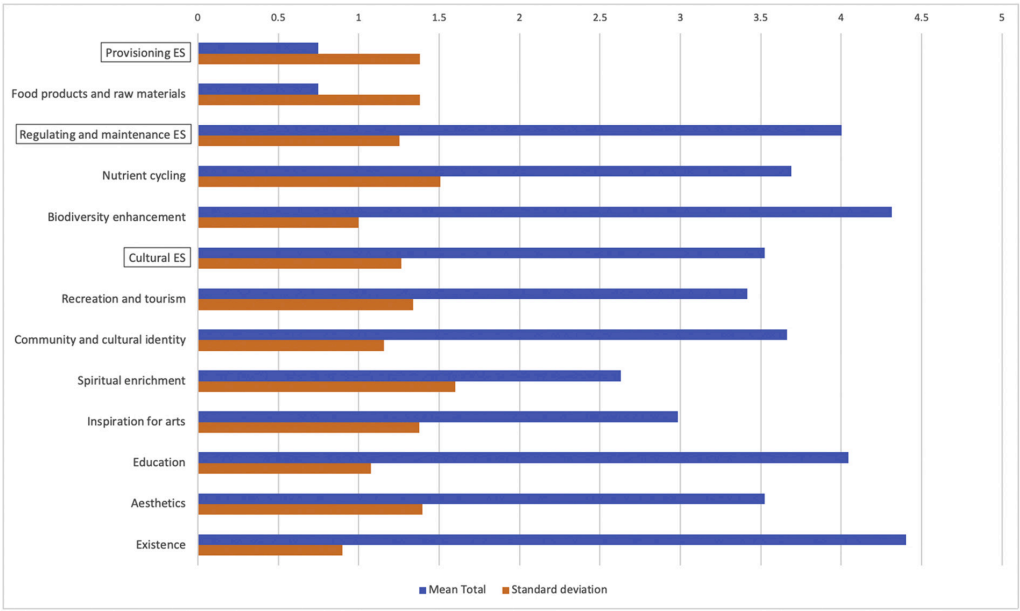


Fig. 2. Mean scores and standard deviations of the ten key whale ES and ES categories.

Table 6
OLS regression results of the socio-cultural preference survey.

Ecosystem service	Significant variables	Coefficient (Std. Error)
Provisioning ES		
Food products and raw materials	Education** p 0.041	0.274 (0.136)
	Gender*** p 0.008	0.320 (0.120)
	Income*** p 0.002	−0.427 (0.139)
Regulating and maintenance ES		
Nutrient cycling	Marital status* p 0.084	−0.281 (0.163)
Biodiversity enhancement	Children** p 0.027	−0.243 (0.100)
	Education*** p 0.000	0.383 (0.101)
Cultural ES		
Recreation and tourism	Income*** p 0.000	0.508 (0.139)
	Residency*** p 0.005	0.436 (0.154)
Community and cultural identity	–	–
Spiritual enrichment	Education*** p 0.000	0.614 (0.174)
	Age*** 0.002	0.558 (0.177)
Inspiration for arts	Education** p 0.041	0.286 (1.400)
Education	Children** p 0.014	−0.293 (0.119)
	Income* p 0.096	0.192 (0.115)
Aesthetics	Age** p 0.032	0.326 (0.152)
Existence	Age** p 0.023	0.233 (0.102)

***indicates significance at 1% level; ** significance at 5% level, and * at 10% level.

over 50 was positively correlated with higher values for aesthetics and existence. The only cultural whale ES that did not have any significant socio-demographic variables was community and cultural identity.

3.5. Shifting perceptions and threats associated with whale ES in Skjálfandi Bay

The interviews and stakeholder mapping revealed a number of issues related to socio-cultural values of whales in the area. Interview data shows that these values have been changing rapidly in tandem with socio-economic changes in Húsavík and Iceland, the biggest change being the shift from the fishing industry to tourism, which was brought up and discussed in some detail by eleven interviewees, all of them native to the area. Changes in individual perceptions and attitudes towards whales and their ES were discussed by twelve of the fifteen interviewees. As one of the interviewees expressed it: 'more and more people understand the true benefits of having a booming tourism industry in town, because a lot of the things that come along with it: increased the standard of living, the things we can do, simply the quality of life' (I10).

Generational differences in these attitudes, and differences among stakeholders, especially between locals and visitors, were discussed most frequently. These changes were not always described as straightforward but as a shift from provisioning to cultural whale ES. This trend is pertained by the following quotes: 'I think that maybe 20 years ago it was not something special to see a whale, but now people are thinking more about whales.' (I15); 'There is a new generation of people in Iceland who see that whaling is not the only way of relating to or using whales. So that is […] thanks to the whale watching, obviously; it has opened up the eyes of Icelanders that there are alternatives.' (I12).

Seven interviewees mentioned noticing changes in whale species composition and abundance in Skjálfandi Bay since the start of whale watching, and five interviewees linked them to climate change. An interviewee noted that: 'In the first years the whale watching was built up from mostly showing minke whales, though there were occasional humpbacks. Since then, there are many more humpbacks, and blue whales are coming to visit with increasing frequency. […] It seems to be related to the availability of feed, and climate change plays a part in the changes in feed availability.' (I5).

Concerns were expressed by five interviewees from the whale watching industry about the unpredictability of whale sightings that underlie tourism and recreation ES. There was a palpable anxiety that highly migratory whales might leave the area due to climate change-induced alterations in the distribution of their prey, notably herring and capelin. This had already happened in some areas in the Arctic, including Kaldfjord near Tromsø, Norway where one of the Húsavík's whale watching companies had been operating, causing a collapse of whale watching in the area: 'then last year [2017] there were no whales because the herring had moved […] even further north' (I1).

Unregulated whale watching[8] was frequently mentioned as another potential threat to cetaceans: 'it is hard to imagine that it is not affecting the whales: it is a lot of noise, and it is a lot of traffic' (I3); 'I mean too many boats chasing too few whales […] they are obviously breaking the rules all the time, these guidelines that they had so earnestly undersigned.' (I12); 'you can have a boat for 20 hours – if you talk about noise, at least, then it is constant' (I11). Previous studies in Iceland confirm that disturbances occur (Christiansen et al., 2013; Lusseau and Bejder, 2007), and research on the topic in Skjálfandi Bay is ongoing.

Globalisation also presents negative effects on Arctic marine ecosystems in terms of increased shipping and tourism, especially cruise ships, the climate change effects of increased traveling as well as increased industrial development (Bock, 2013; Chapin et al., 2015; Johannsdottir et al., 2020). In Skjálfandi Bay, there are concerns over how the industrial development might be affecting the local marine ecosystem: 'at sea, it's also about what will happen with the cargo ships and the noise related the new factory, so that's another increase' (I11). In an assessment prior to a construction of a silicon refinery plant, attention was drawn by scientists to the potential effects of noise from increased shipping and chemical discharges from the plant (Rasmussen, 2009).

4. Discussion

4.1. General findings

In the light of the existing literature, the results shed some light on how people perceive and value ES associated with whales – an important part of the local social-ecological system – in a northern coastal community. Despite being location-specific and methodologically novel, the results are comparable to studies elsewhere and serve as a step towards including socio-cultural values in ES assessments. The results revealed some synergies and trade-offs that can be more easily spotted and quantified on species and functional levels (Beaumont et al., 2007; Hammerschlag et al., 2019; Riisager-Simonsen et al., 2020). The synergies revealed between the ES of tourism and recreation and education and community cohesion suggest that the importance of whale watching in Húsavík extends far beyond economic gains.

There are also possible trade-offs between provisioning and recreational ES in Iceland, as observed by Cook et al. (2020) and Bertulli et al. (2016). Another trade-off within ES is related to unregulated whale watching and the ES of recreation and tourism. This trade-off points to limits to growth of the whale watching industry that has been discussed in the literature, e.g. in Australia (Bejder et al., 2006), New Zealand (Lusseau, 2004), Canada (Williams et al., 2006), and Iceland (Christiansen et al., 2013) that find disruptions in cetacean feeding and breeding activities caused by whale watching. With four whale watching companies operating in Skjálfandi Bay, there is little room to expand even further, even though there are currently no regulations in place to limit the number of boats or tour operators in the bay.

4.2. Contextualising the study results within the ES literature

The results of the qualitative analysis of the interviews indicate that whales have become a characteristic and symbolic part of Húsavík, providing new cultural and economic opportunities for a town that had struggled with its identity since the decline of the local fisheries' industry (Chambers et al., 2017; Guðmundsdóttir and Ívarsson, 2008; Reiter, 2017). It could also be argued that the existence of whales has a more global symbolic meaning for success of environmental protection – if humans are not able to save these flagship species, there may be little hope for others (Mattes, 2017).

In terms of provisioning ES, whaling has never been a big part of the local culture in Húsavík, which partly accounts for its limited importance revealed in this study. Results of a similar study in a location that is heavily dependent on whale meat as a local food source, e.g. Greenland, are likely to be very different (Caulfield, 1997; Malinauskaite et al., 2020a). In terms of regulating and maintanace ES, Maestre-Andrés et al. (2016) also found that ES related to underlying ecological functions of ecosystems tend to be less frequently identified by respondents who possessed no specialist knowledge but assigned relatively high scores in a preference survey when their attention was drawn to them.

Similarly, a lack of awareness of some ES values, such as biophysical and existence, do not necessarily imply their limited importance – but rather limited awareness. Chan et al. (2016) argues that non-instrumental values, such as intrinsic and relational, play a big part in motivating environmental protection, shaping views on personal and collective well-being. Jax et al. (2013) note that existence values tend to be overlooked in ES research, which can result in instrumental values obscuring the intangible wellbeing benefits that originate from non-instrumental values. The fact that survey respondents were often unaware of regulation and maintenance ES but rated them highly after explanation indicates lack of knowledge and perception that the terms associated with this ES group are important. High values were also assigned to regulation and maintenance ES in some other socio-cultural valuation studies (de Souza Queiroz et al., 2017; Maestre-Andrés et al., 2016).

The fact that provisioning ES received a relatively low mean score compared to other whale ES indicates a general view that whale meat consumption plays a limited role in terms of the wellbeing of Húsavík inhabitants. Even those interviewees who had grown up eating it admitted that this ES presently has limited importance. Other studies in Iceland also reveal the fading role of provisioning ES sourced from whales. Gallup Iceland's (2017) survey on Icelanders' attitudes to whaling in 2017 indicated that 81.4% of respondents have not bought whale meat during the twelve months prior to the survey, while only 1% bought it six times or more, indicating very limited demand. Its consumption nowadays is largely symbolic and takes place in food festivals in winter (Brydon, 2006). A contingent valuation survey in Faxaflói Bay, near the capital of Reykjavík, revealed that only 23% of the participants thought that whaling was important to the Icelandic economy, as opposed to 48% that answered the same question about whale watching (Malinauskaite et al., 2020b).

The finding that the ES of tourism and recreation ES were valued more highly by locals than visitors points to its economic importance in the community. A non-monetary valuation study in a coastal area of Bangladesh by Chakraborty et al. (2020) also found that locals valued coastal recreation and tourism ES more than visitors as these services constitute an important part of their livelihoods. Interestingly, community and cultural identity ES were valued more highly by visitors than locals. This might be due to a preconception by visitors about the role of whales in the lives of Húsavík residents that does not necessarily match with local perceptions. Interview data indicates that while local stakeholders are aware of the economic benefits brought by whales, fewer associate these with community cohesion. This ES was discussed by half of the interviewees, which combined with the mean score of 3.55 confirms its socio-cultural significance, albeit it was not rated as highly as in some other similar studies (Calvet-Mir et al., 2012; de Souza Queiroz et al., 2017; Maestre-Andrés et al., 2016).

In terms of significant socio-demographic variables, men were found to be more likely to perceive provisioning ES than women, which has also been found in previous research (Martín-López et al., 2012; Oteros-Rozas et al., 2014). A monetary ES valuation study on the trade-offs between cultural and provisioning whale ES in Iceland found that women were willing to pay more for the expansion of a sanctuary that would limit whaling in the area, as were respondents with higher education (Malinauskaite et al., 2020b). Visitors valued whale meat more than locals, which might be associated with its marketing as a traditional Icelandic food (Bertulli et al., 2016; Huijbens and Einarsson, 2018) and the absence of whaling in the area.

In accordance to the results of the study, some previous research

[8] Whale watching is Iceland is not regulated by law but a voluntary code of conduct was designed and adopted by the Icelandic Whale Watching Association (IceWhale, 2015).

found higher levels of education to be positively correlated with a deeper understanding of ecosystem functioning and higher socio-cultural valuation scores assigned to regulating and maintenance ES (Martín-López et al., 2012; Oteros-Rozas et al., 2014). In the present study, having a spouse and children seemed to reduce respondents' emphasis on regulating and maintenance ES. Oteros-Rozas et al. (2014) observed that people prioritise different ES depending on life stages, and preferences related to regulating and maintenance ES are likely to change with life experiences, including work and family.

The fact that older people and those with higher education gave higher scores to spiritual enrichment may indicate that these sub-groups of respondents may place more emphasis on the less tangible values of ecosystems because they have had more opportunities to contemplate them, a tendency also noted in other studies (Maestre-Andrés et al., 2016; Oteros-Rozas et al., 2014). Inspiration for arts was the second lowest-rated cultural ES with one significant socio-demographic variable – education. This could also be interpreted as a result of respondents' non-familiarity with the less tangible ES and difficulties assigning values to them, also observed in wider literature (Chan et al., 2012a; Chan et al., 2012b).

The mean socio-cultural value scores associated with aesthetics and existence values were both affected by the age of the respondents, which may again indicate that older people are more appreciative of ES which require reflection and contemplation (Oteros-Rozas et al., 2014). The relative importance of 'simply knowing that whales are there' in the survey compared to aesthetic enjoyment perhaps indicates a higher appreciation for intrinsic rather than instrumental values of nature, which aligns with the analysis of (Chan et al., 2016).

Cultural ES represented the largest group of whale ES included in the survey. Even though the respondents were asked to assess different cultural ES individually, they are often closely interlinked and form ES bundles (Martín-López et al., 2012). For instance, aesthetics, spiritual enrichment, and inspiration for arts seemed to be closely interlinked in the interviews; recreation and tourism enables the renewed community identity and opportunities for education, which, in turn, strengthen the tourism sector.

The change in perceptions of whales identified in the interviews indicates an economic and socio-cultural shift from consumptive to non-consumptive uses of whales (Higham et al., 2016). This shift is at least partly facilitated by globalisation, characterised by improved access and sharing of information that affects environmental values, easier access to long distance travel, and advances in science that enabled endangered species to get global attention. These factors, combined with the economic benefits of whale watching in Húsavík, resulted in the shift in local perceptions and socio-cultural values related to whales (Einarsson, 2009; Huijbens and Einarsson, 2018).

The concerns expressed in the interviews regarding she shift and possible disappearance of some whale species from the area are not without grounds as whale migration patterns have changed or are likely to change in the future due to climate change-related factors (Evans and Bjørge, 2013; Salvadeo et al., 2013; Vacquié-Garcia et al., 2018). Ongoing research at the University of Iceland (2020) indicates changing behaviour of humpback whales during the last decade in Icelandic waters, where they have been staying in the winter months increasingly often.

4.3. Academic value and implications for management

ES researchers, users, and practitioners have called for different types of values to be included in ES assessments and policymaking (Chan, Guerry, et al., 2012; Díaz et al., 2015; Jacobs et al., 2016; Martínez et al., 2013). Van Riper and Kyle (2014) stress the need to consider diverse viewpoints to inform resource management decision-making and disentangle the conceptual and empirical relationships between multiple value concepts. Iniesta-Arandia et al. (2014) suggest socio-cultural valuation as a useful tool for prioritising ES and linking ES values to stakeholder perceptions, incorporating qualitative analysis as was done in this study. Walz et al. (2019) stress that understanding the management and decision-making context is a vital first step in carrying out management-oriented socio-cultural valuation.

Scholte et al. (2015) present a framework for integrating socio-cultural values into decision-making, together with monetary and ecological assessments, so that all three ES value domains are covered (Martín-López et al., 2014). Santos-Martín et al. (2017) highlight different ways in which socio-cultural ES assessment can aid in decision-making, including awareness raising, local value and knowledge recognition, addressing relational values in a particular context, conflict identification, and priority setting. A socio-cultural valuation study focused on Brazilian mangroves suggests that taking into account local users' perceptions and values in conservation policies holds the potential to make them more effective and equitable (de Souza Queiroz et al., 2017). Others, however, call for caution when including the results of this type of valuation in management decisions, as it could prove to be detrimental if the surveyed population lacks environmental knowledge about that particular ecosystem (Ruiz-Frau et al., 2018).

An example of how this socio-cultural valuation study could aid decision-making would be if its results would be taken into consideration in the conception and planning of a marine protected area in Skjálfandi Bay, which has been a subject of local debate since 2004 (Hoyt, 2012; Vallejo, 2013). The process has been rather slow due the lack of precedent of such an area in Iceland[9] and the stakeholder-led approach, which includes multiple interests and requires lengthy consultations. The results of this survey could inform this discussion in several ways: firstly, by drawing attention to the different locally formed socio-cultural benefits and values that are likely to be affected by such project; secondly, by identifying possible conflicts between different uses of the bay, e.g. industrial development and ecosystem conservation; and finally, by drawing attention to ES synergies and trade-offs and providing guidance for effective solutions for addressing them (Martín-López et al., 2012).

Furthermore, socio-cultural valuation of whale ES has the potential to inform marine spatial planning (MSP), leading to a more holistic approach (McKinley et al., 2019). This could involve accounting for different local uses of marine resources, knowledge co-production, human wellbeing effects of different scenarios (Klain and Chan, 2012; UNESCO, 2019), and accounting for ES trade-offs in socio-cultural terms (White et al., 2012). While it is important to recognise the complexity in MSP, some consistency in methods and types of data collected in ES research would allow for broader comparisons across cases and make socio-cultural data more applicable for management (Ehler and Douvere, 2009; McKinley et al., 2019; Ruiz-Frau et al., 2018).

4.4. Study limitations

The study suffers the typical limitations of qualitative research related to subjectivity and potential bias on the part of researchers. Designing the stakeholder map, making the interview guide, choosing which interviewees to contact, the coding of interviews, systemising the study results, and interpreting them inevitably involve a certain degree of bias (Norris, 1997). Similarly, the processes of identifying the key whale ES, interpretation and coding of the assigned values, and translating the wording of interviewees into the ES value domain typology involved some subjectivity. We tried to minimise the degree of bias by rigorously following the best practice guidelines of the chosen research methods.

A limitation that arose as the study progressed is that the final list of whale ES used in the survey was informed by the interviews, who were mostly residents of Húsavík, but the majority of survey respondents ended up being visitors. The visitors represent an important group of stakeholders and the final list of the key whale ES might have been somewhat different if they had been interviewed together with the locals. This shortcoming is alleviated to some degree by the fact that the list was also informed by the literature review by Cook et al. (2020)

[9] Almost all of the protected areas in Iceland are terrestrial (Petursson et al., 2016); only about 0.4% of Iceland's waters constitute marine managed areas, and none of them formal MPAs (OECD, 2019).

with a global focus on whale ES as well as observations of the researchers drawn from two weeks of community immersion.

Another shortcoming of the socio-cultural survey relates to the relatively high scores assigned to the whale ES as the respondents were able to give them any score between 0 and 5 without prioritising. This shortcoming is characteristic to other Likert-type surveys (Calvet-Mir et al., 2012; de Souza Queiroz et al., 2017; Maestre-Andrés et al., 2016) and could be at least partly corrected by a requirement to rank items from the most to the least important or to distribute scores, e.g. through the pebble distribution method.

A bias might have been created during the surveys when explanations were required for certain ES, such as regulating and maintenance. Following the explanations, these ES were valued relatively highly. On the other hand, the ES of spiritual enrichment often required explanations, yet it was ranked relatively low, so the presence of bias is not certain.

There is also a difficulty in separating whale ES from marine ES in a broader sense, especially when accounting for them in decision making. Even though it is useful to focus on a few species and analyse their socio-cultural values that are central in a particular community, it is equally important to consider outcomes in a holistic socio-ecological context when making management decisions (Brown et al., 2001; Long et al., 2015).

5. Conclusions and possibilities for further research

The main value of this paper lays in its subject and methodology. ES practitioners have called for ecosystem-service-based assessments, especially for marine ES on species and functional type levels. The multi-method approach applied in the study allowed for a more nuanced analysis of human wellbeing contribution of certain marine ES than a single-method approach would have allowed. The combination of qualitative insights and quantitative survey results uncover the multifaceted nature of human wellbeing benefits from whale ES and reflect stakeholder perceptions and values related to local marine ES.

Cultural ES and their values were most often discussed in the analysis of qualitative data, regulation and maintenance ES were the most highly valued in the socio-cultural valuation survey, and provisioning ES were given little importance in either the survey or the interviews. The study indicates that whales play an important role in the economic, social and cultural life of Húsavík, and that they are perceived as an important part of the Skjálfandi Bay ecosystem by both local residents and visitors. The fact that the existence of whales was the most highly rated whale ES indicates that a large part of the human wellbeing benefits that stem from non-use values related to these animals. Among the biggest threats to whale ES mentioned by interviewees were uncertainty caused by climate change and disturbances to whales caused by the expansion of tourism and industry.

Socio-cultural perspective adds to the depth and complexity to ES valuation. Combined with monetary and biophysical valuation, it can help to capture plural values of ecosystems and their services. The methods used in this study are transferable to other species and ecosystems, and the results provide some interesting information about perceptions and values assigned to marine ES. This exploratory paper provides a snapshot of a point in time in the context of whale ES in Iceland, which serves as a step towards the wider application of socio-cultural valuation to marine ES in the region and globally.

Finally, the socio-cultural approach to ES valuation offers valuable stakeholder-focused insights that can inform decision-making, e.g. Environmental Impact Assessments. Despite the case for including socio-cultural values in ES assessments having been made in the literature, there remains a lack of such valuation studies, especially in the context of marine ES. Further research should aim to fill this gap while refining the methods and working towards making the results more rigorous and comparable across cases and different types of ecosystems. This would help to establish this type of valuation more firmly on the ES research agenda and aid policy makers in familiarising with and including the socio-cultural dimensions of marine resource management.

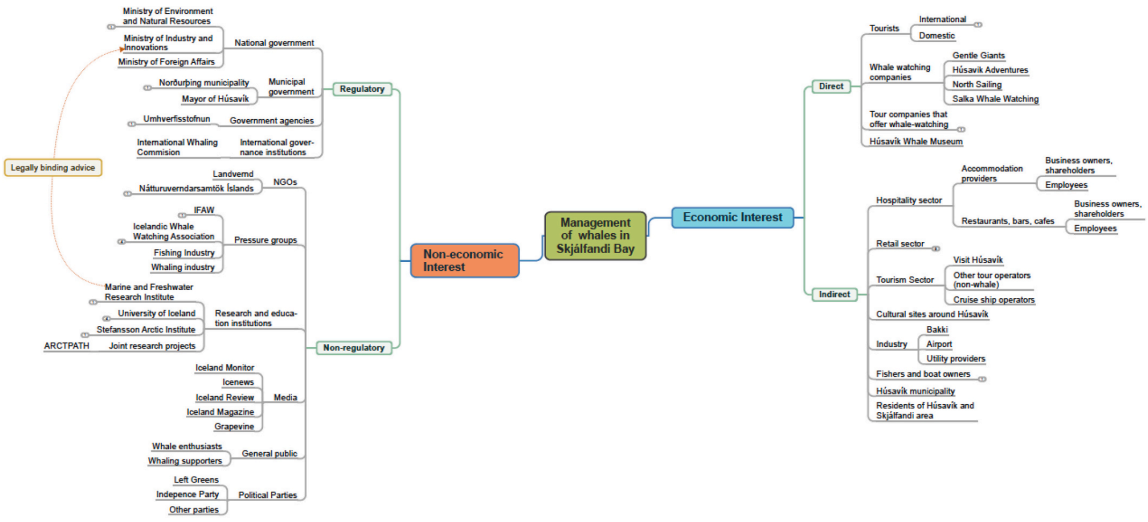
Declaration of Competing Interest

None.

Acknowledgements

This paper has been subject to funding from NordForsk (grant number 76654) via their financial support to the Nordic Centre of Excellence ARCPATH (Arctic Climate Predictions – Pathways to Resilient, Sustainable Communities) and the Doctoral Grant of the University of Iceland Research Fund.

Appendix A. Stakeholder map



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6 Publication IV: Willingness to pay for expansion of the whale sanctuary in Faxaflói Bay, Iceland: a contingent valuation study

Ocean and Coastal Management 183 (2020) 105026

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: http://www.elsevier.com/locate/ocecoaman

Willingness to pay for expansion of the whale sanctuary in Faxaflói Bay, Iceland: A contingent valuation study

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ARTICLE INFO

Keywords:
Whale sanctuary
Ecosystem services
Economic valuation
Contingent valuation method
Willingness to pay
Cetaceans

ABSTRACT

Commercial whaling is a divisive issue in Iceland, and often considered to be irreconcilable with whale watching. The coexistence of both activities in Faxaflói Bay, adjacent to the capital city of Reykjavík, has led to the designation of part of the bay as a whale sanctuary, where whaling is banned. The study utilises the contingent valuation method to elicit the preferences of Icelanders and estimate their willingness to pay (WTP) to expand the sanctuary to the full extent of Faxaflói Bay, with an aim to inform marine spatial planning in Iceland. Using the double-bounded dichotomous approach, the mean WTP for expansion of the Faxaflói Bay Whale Sanctuary was estimated to be 5082 ISK/42 USD per person (1.32 billion ISK/10.9 million USD when multiplied by the number of taxpayers), and 29.7% of the respondents with clearly defined preferences expressed positive WTP. According to the logit regression model, statistically significant socioeconomic and attitudinal variables included age, gender, level of education, number of persons in a household, and attitudes towards environmental conservation and whaling. Policy implications of non-market valuation of marine ES are discussed, pointing to a need to further assess the multiple marine ES values applying a transdisciplinary approach to inform decision-making.

1. Introduction

Diverging views on the value and uses of cetaceans, the largest mammals on Earth, have been the cause of considerable controversy (Bertulli et al., 2016; Einarsson, 2009; Kalland, 1994). Commercial whaling, which has been subject to a moratorium by the International Whaling Commission (IWC) since 1986, is at the centre of this controversy, with only two members of the IWC – Iceland and Norway – still engaging in it. The departure of Japan from the IWC in 2018 demonstrates the ongoing conflict between whaling and non-whaling nations (Ackerman, 2002; Collis, 2019). The disagreement is a source of considerable tension within and outside the IWC, with strong advocacy undertaken by nation states and environmental organisations who consider whaling to be an unsustainable and inhumane practice on one side, and the support for sustainable harvesting of marine mammals as a part of the 'blue growth' agenda and national identities of whaling nations on the other (Lillebø et al., 2017; NAMMCO, 2017).

The two sides of the whaling debate are particularly visible in Iceland, which left the IWC in 1992 and rejoined in 2002, after getting an exemption to the moratorium against whaling. The country resumed scientific whaling in 2003, and commercial whaling in 2006, causing an international protest (Brydon, 2006; Williams, 2006). In February 2019, the Icelandic government announced new whaling quotas for fin and minke whales for an additional five-year period, 2019–2023 (Vísir, 2019). The rise of tourism as the largest economicincome-generating sector in Iceland and the subsequent expansion of the whale watching industry adds a new economic dimension to the issue, which previously had mostly been viewed from ethical (Gillespie, 1996; Scarff, 1980) and

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https://doi.org/10.1016/j.ocecoaman.2019.105026
Received 29 April 2019; Received in revised form 30 September 2019; Accepted 14 October 2019
Available online 24 October 2019
0964-5691/

ecological (Estes et al., 2006; Roman et al., 2014) perspectives. The growing global interest in whales and income from whale watching strengthen the argument that whales may be worth more alive than dead (Einarsson, 2009). With profits from whaling declining, the opponents of commercial whaling have been using the economic argument with increased frequency (Cunningham et al., 2012; Higham et al., 2016; Lusseau, 2008; Parsons et al., 2003).

Different stakeholders' perceptions, values, and uses of whales have resulted in trade-offs between the many whale ecosystem services (ES), can be defined as the benefits that humans draw from nature (Daily, 1997). ES provided by whales they are multiple and intertwined: raw materials, recreational and aesthetic enjoyment, education, spiritual enrichment and cultural identity, and ecosystem support and regulation, among others (Cook et al., 2019a; Roman et al., 2014). Moreover, whales are considered as charismatic megafauna because of their size, appearance and perceived intelligence; they have played an important symbolic role in global conservation movement as well as the cultural identities and spirituality in numerous societies (Brydon, 2006; Kalland, 1994; Kato, 2007; Mattes, 2017).

As whale watching emerged as an important part of many local economies worldwide (Dempster, 2009; Hoagland and Meeks, 2000; Hoyt and Iñíguez, 2008; O'Connor et al., 2009), the conflict between consumptive and non-consumptive uses of whales became a point of focus in conservation, tourism, international politics and ecology over the last few decades. These activities represent two potentially conflicting ways, in which humans benefit from whales, a division that is acutely apparent in Iceland (Bertulli et al., 2016; Rasmussen, 2014). The centrepiece of this controversy is Faxaflói Bay where the capital city of Reykjavík is situated and where both activities take place simultaneously in summer months, causing heightened tension between whale watching companies and animal welfare organisations on the one side and commercial whaling operators on the other (Iceland Magazine, 2017; IFAW, 2017). A whale sanctuary was created in the bay in 2007, banning whaling in the part of the bay with the most whale watching activities, with subsequent expansions in 2013 and 2017. It now encompasses around one third of the bay (Government of Iceland, 2017).

This study responds to the call for more empirical research on whaling and whale watching (Higham and Lusseau, 2007). It attempts to inform this debate using non-market valuation, which is used to estimate willingness to pay (WTP) for changes in ES provisioning. Non-market valuation techniques have often been applied in the contexts of coastal and marine ecosystem management (Aanesen et al., 2015; Brouwer et al., 2016; Navrud et al., 2017; Shen et al., 2015; Tonin, 2018; White et al., 2012) and marine spatial planning (MSP), which is defined as 'a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process' (Ehler and Douvere, 2009, p. 18; UNESCO, 2019). The paper presents an attempt to inform MSP in the context of whale sanctuaries by applying the contingent valuation method (CVM). It has two closely related but distinct aims: (i) to contribute to the currently limited body of academic literature on preferences and WTP related to management arrangements for marine environments and MSP; and (ii) to inform the public debate on different uses of whale ES in Iceland and their trade-offs.

2. Case study and background

Article V of the International Convention for the Regulation of Whaling (ICRW) provides the IWC with the right to adopt regulations related to management of whale stocks, including decisions about management of 'open and closed waters, including the designation of sanctuary areas' (IWC, 1946, p. 2), with a function to provide safe haven for whale populations from commercial whaling pressures. There are currently two such areas in Iceland: one in Skjálfandi Bay in the north of Iceland and another in Faxaflói Bay. Due to perceived trade-offs between commercial whaling and whale watching, a whale sanctuary was established in Faxaflói Bay in 2007, following the resumption of commercial whaling in 2006 (Althingi, 2006). In response to the rapid growth of the Icelandic tourism industry and subsequent expansion of whale watching activities in the bay (Fig. 1), the sanctuary was expanded in 2013 and again in 2017, from the limit between Garðskagaviti in Reykjanes peninsula to Akranes to its current limit from Garðskagaviti to Skógarnes, encompassing around one third of the total area of the bay (Fig. 2, yellow line). This was done by a change in regulation 1035/2017, which forbids whale harvesting in large parts of Faxaflói and Skjálfandi Bays and affects the Icelandic Whaling Law 26/1949 (Government of Iceland, 2017).

The most recent expansion includes the vast majority of the area used for whaling, which made whaling operations less profitable as boats have to go farther out to sea. According to the figures from the Icelandic Ministry of Fisheries at the time (Fiskifréttir, 2018), 335 minke whales were caught in Faxaflói Bay from 2007 to 2016, and out of these 321 (95.82%) were caught in the area that would be included within the expanded whale sanctuary (marked by the red line in Fig. 2). A total of 654 minke whales and 850 fin whales were hunted in Iceland from 2003 to 2018, of which 6 and 144 respectively were caught in the summer of 2018 (IoES, 2019). The harvesting levels in 2018 were well below the quota of 262 permitted for minke whales and 238 for fin whales that year. No whaling occurred in Icelandic waters in 2019. The data from the recent report on the profitability of whaling by the Institute of Economic Studies show that both minke and fin whaling in Iceland are currently not profitable (IoES, 2019). Their report also indicates that nearly all Icelandic fin whale products have been exported to Japan. Japan's withdrawal from the IWC and resumption of commercial whaling in its own waters is likely to reduce the demand for whale meat imports. A further expansion of the whale sanctuary is likely to reduce the economic viability of whaling in Iceland by increasing fuel and labour costs, as boats would have to venture farther out from the Hvalfjörður whaling station.

Whale watching in Iceland has expanded along tourism, now the largest economic sector in the country. The number of foreign visitors in Iceland grew from around 485,000 persons in 2007 to around 2.3 million in 2018 an almost five-fold increase (Icelandic Tourist Board, 2019b). The number of people going whale watching in Iceland has also grown rapidly – from around 72,000 in 2003 to 345,000 in 2018 (Icelandic Tourist Board, 2019a). Multiplied by the average cost of a whale-watching tour, currently around 90 USD, the Icelandic whale-watching industry makes around 33 million USD per annum in direct income. This is a five-fold increase compared to the data from 2008 by O'Connor (2009), where direct income from whale watching in Iceland was around 6.6 million USD. The number of visitors going whale watching in Faxaflói Bay from Reykjavík also increased in tandem with the number of foreign visitors to the country– more than tenfold since the turn of the century – from around 14,000 in 2001 to 148,442 in 2018 (IceWhale, 2019) (Fig. 1).

Non-market ES valuation techniques, such as contingent valuation, have been used in the Icelandic context to elicit preferences and estimate WTP for the preservation of natural areas that are potentially subject to industrial or energy development (Cook et al., 2016, 2017; Cook et al., 2018a; Einarsdóttir et al., 2019). There have not been any attempts to use ES valuation in the context of MSP in Iceland, yet it has been shown to improve the efficiency of marine and coastal management and provide an economic justification for conservation strategies (Börger et al., 2014; Stithou and Scarpa, 2012; Torres and Hanley, 2017). Non-market ES valuation has been applied in MSP in various contexts, e.g. for estimating non-use values of charismatic species such as sea turtles (Jin et al., 2010; Jones et al., 2011) and marine mammals (Langford et al., 2001; Solomon et al., 2004), and informing the creation and management of MPAs (Stithou and Scarpa, 2012; Wallmo and Lew, 2016; Wattage et al., 2011). The relevance of non-market valuation extends to whale sanctuaries, which presents unexplored yet important topic

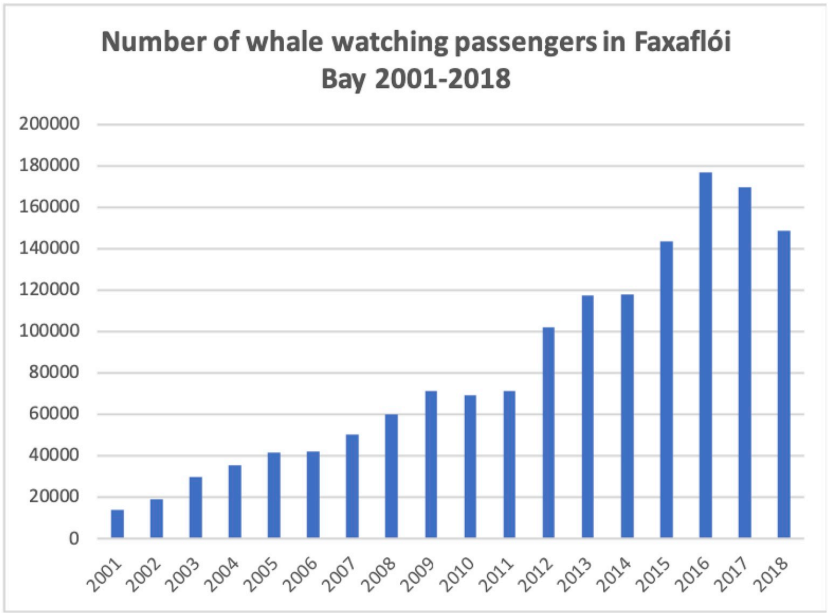

Fig. 1. Number of whale watching passengers in Faxaflói Bay 2001–2018 (IceWhale, 2019).

(Dempster, 2009; Parsons et al., 2003; Rivera et al., 2007), given the heated global and domestic disputes in Iceland concerning the merits of commercial whaling.

3. Methodology

3.1. Economic valuation of environmental change

The concept of ecosystem services is used by economists to estimate the contributions of ecosystems to social welfare (Braat and de Groot, 2012; Butler and Oluoch-Kosura, 2006; Cook et al., 2016). One of the most widely applied ES classification systems, the Common International Classification of Ecosystem Services (CICES), divides ES into provisioning, regulating and maintenance, and cultural services (Haines-Young and Potschin, 2018). Because no markets exist for most ES, it is difficult to account for the human welfare benefits they provide in economic decision-making. Economic rationale is central to much of modern environmental policy, but because many ecosystem services have public goods characteristics and a lack of market prices, their value is at risk of being overlooked by decision-makers (Balmford et al., 2002; Barbier et al., 2009; Freeman III et al., 2014). Contingent valuation is meant to overcome this problem by creating hypothetical markets and eliciting economic values through asking people how much they would be willing to pay to obtain or avoid certain changes to the quantity and quality of supplied ES attained through changes in human activities affecting ecosystems (Freeman III et al., 2014; Pascual et al., 2010; Pearce and Moran, 2013).

The CVM is a flexible, survey-based non-market ES valuation technique that has been in a variety of resource contexts since the 1970s (Arrow et al., 1993; Mitchell and Carson, 2013). Perhaps to date, still the most prominent CV study in the academic literature concerns WTP to prevent another oil spill on the scale of the Exxon Valdez, which ran aground in Prince William Sound, Canada, in 1989 and remains the largest such incident in terms of the volume of oil spilt in Arctic waters (Carson et al., 1992). The study had considerable policy repercussions and affirmed the CVM as a useful valuation approach for eliciting preferences and estimating avoided damages in a marine context when market prices are not available and non-use value is prominent (Carson, 2012; Carson et al., 2003). This study applies the CVM to elicit preferences and estimate WTP in relation to a change in governance arrangements – the expansion of an existing whale sanctuary – which are assumed to imply positive environmental changes for Faxaflói Bay due to the banning of whaling.

3.2. Survey design and administration

The subject of this survey is the population of Iceland with the main aim to estimate Icelanders' willingness to pay for an expansion of the whale sanctuary and their attitudes towards whaling and whale watching in the country. The rationale for excluding foreign visitors from this study is that the debate between the supporters of these two activities have been very heated domestically and because Faxaflói Bay has other economic uses that are not directly related to tourism, e.g. shipping and fishing.

CV can be carried out in various ways: via postal and telephone surveys, face-to-face interviews, or a combination of these approaches (Carson and Hanemann, 2005). With the widespread use of the internet today, web-based surveys have become very popular due to their cost-effectiveness and advantages related to design and implementation (Bonnichsen and Olsen, 2016; Fleming and Bowden, 2009; Lindhjem and Navrud, 2011). These advantages and the fact that 96% of the Icelandic population have access to the internet (Statistics Iceland, 2017) determined the choice of the web-based survey format in this study. Furthermore, internet surveys facilitate versatile, clear and consistent presentation of information, allowing participants to revisit questions and answer them in their preferred order, omitting irrelevant questions based on previous responses. Web-based approaches are particularly useful in CV surveys when randomising bid offers in a discreet manner, leaving respondents unaware of the underlying process.

The survey was designed following the best practice recommendations made by Arrow et al. (1993), Carson (2000), Carson and

Fig. 2. Current limit and proposed expansion of the Faxaflói Bay Whale Sanctuary (Google Maps, 2018, edited by authors).

Hanemann (2005), Dillman (2011) and Johnston et al. (2017). It consisted of three sections: (i) attitudinal questions on environmental issues and economic activities related to whales in Iceland; (ii) brief description of the whale sanctuary, questions on participants' familiarity with the case study site and a bidding process to elicit WTP; and (iii) a set of socio-demographic questions.

In the first section, the survey respondents were asked to pick the most and least pressing current issues in Iceland from a list of 14 environmental and socioeconomic topics dominant in the contemporary public forums in Iceland, such as press and social media. The list was finalised after consulting a mixture of recent Iceland-based CV studies and expert opinions of the authors. The rationale behind this set of questions was to examine how many people prioritise environmental issues over others and how these attitudes relate to their WTP. Next, the respondents were asked to grade on a Likert scale[1] how important they consider whaling and whale watching is for the Icelandic economy, and how strongly they support or oppose minke whaling, fin whaling and whaling in general. The section ended with a question on environmental behaviour, where eight options listing examples of environmental behaviour were provided, including an open-ended option of 'other' and an option not to answer.

In the second section of the survey, a brief description and history of the Faxaflói Bay Whale Sanctuary was provided together with a map (Fig. 2), followed by questions on whether respondents had visited the area in general and in the last twelve months, how often and what activities they undertook during their visit. Those who had not visited the area were asked whether they had plans to do so. This was done to determine whether and how many of the respondents engaged in recreational activities in Faxaflói Bay and to ascertain whether frequent visits and certain activities, e.g. whale watching, sailing and fishing, influenced WTP.

After that, survey participants were asked whether they would be willing to pay a one-off lump-sum tax to expand the whale sanctuary to the proposed limit identified by the red line shown in the map (Fig. 2). Then they were asked to state their reasoning, and those with WTP were asked to complete the bidding process. Following the WTP elicitation process, respondents were presented with two validity check questions to determine whether they fully understood the proposed conservation scenario (Arrow et al., 1993). The final part of the survey consisted of a standard set of sociodemographic questions to determine statistically significant characteristics affecting WTP. They were issued at the end of the survey to avoid a potential dropout of respondents as a protest, a tendency that has been recorded by Carson et al. (2001); Carson and Hanemann (2005); and Rankin and Robinson (2018).

The surveys were administered in collaboration with the University of Iceland's Social Science Research Institute, which possesses a database of over 11,000 persons representative of the Icelandic population.

[1] The Likert scales were presented as follows: 'completely agree/for'; 'somewhat agree/for'; 'neither nor'; 'somewhat agree/against'; and 'completely agree/against' for the two types of questions asked: 'are you for or against (different kinds of whaling)?' and 'do you agree or disagree (that whaling/whale watching is important)?'.

Prior to full dissemination, two pilot studies were sent to a small sample of 25 people each to verify the robustness of the survey design, checking for any errors or inconsistencies. Following the pilot survey and the resulting changes in the survey design, the link to the questionnaire was sent by email to 1500 randomly selected people from the database, a sample that is highly representative of the Icelandic population of 348,350 (Statistics Iceland, 2018). The online survey was open for one month from June 5 to July 5, 2018, during the weeks prior to the resumption of minke and fin whaling in Faxaflói Bay. Respondents were sent one reminder per week over the course of the month. The number of completed surveys was 684, amounting to a response rate of 45.6%. Similar response rates were reported in other CV studies in Iceland (Cook et al., 2018b; Einarsdóttir et al., 2019), yet they are slightly lower than rates typically obtained using other survey formats, such as telephone or in-person surveys (Marta-Pedroso et al., 2007; Whitehead et al., 1993).

3.3. Scenario description and payment vehicle

CV surveys typically include detailed descriptions of alternative scenarios to inform respondents about environmental characteristics and economic costs of each choice, creating a hypothetical market (Carson and Hanemann, 2005; Johnston et al., 2017). In the case of the Faxaflói Bay Whale Sanctuary, its proposed expansion was described, with regulatory and geographic information provided about the site, including the map in Fig. 2. The proposed expansion would enlarge the whale sanctuary from its current limit (Fig. 2, yellow line) to the full extent of the Faxaflói Bay (Fig. 2, red line). A brief description of whaling and whale watching activities were provided along with the map to make sure that respondents were aware of the potential trade-offs and effects of the expansion on both industries. It was highlighted that around 96% of minke whales harvested from 2007 to 2016 were caught in the area inside of the red line (Iceland Magazine, 2018), and therefore the expansion would be likely to have negative effects on whaling in the bay.

Choice of payment vehicle has been found to have a significant effect on overall estimates of WTP in CV studies, therefore, it should be realistic, consequential and incentive-compatible (Mitchell and Carson, 2013; Morrison et al., 2000). Following these recommendations, a one-time additional lump-sum tax payable by all taxpayers in Iceland over the age of 18, irrespective of income, was chosen as the payment vehicle in this study. There were three main reasons for this choice: firstly, it is comparable to other lump-sum taxes in Iceland that respondents are likely to be familiar with, such as the annual fixed levy collected to fund the public television and radio; secondly, its technical feasibility in terms of collection that is similar to other voluntary payments; and, finally, because this type of payment vehicle was successfully deployed in other CV studies in Iceland (Cook et al., 2018a, 2018b; Einarsdóttir et al., 2019).

3.4. Elicitation of willingness to pay and statistical model

WTP elicitation methods in contingent valuation include payment cards, open-ended questions, bidding games and dichotomous choice: single, one and a half and double-bounded (Carson and Hanemann, 2005; Cook et al., 2018b). The latter approach is commonly preferred by CVM practitioners due to its simplicity of use in data collection and statistical efficiency in terms of reduced coefficient variance in comparison to the other types of dichotomous choice (Arrow et al., 1993; Bateman et al., 2002; Hanemann et al., 1991), and these reasons determined the choice of the method in this case. It involves survey respondents with WTP being asked two close-ended questions with bid offers, the second bid offer being dependent on whether the first bid was accepted or not (Hanemann et al., 1991). The conditional WTP for each participant is based on the expectation that the payment amount required for expanding the sanctuary is somewhere between the lower and the upper bid of an individual. The CV literature suggests that when using double-bounded dichotomous choice, the first bid 'anchors' the second by creating a psychological perception that the 'objective' value to be estimated is close to the value of the first bid, leading to starting-point bias (Green et al., 1998; Veronesi et al., 2011). To reduce the possible influence of this bias on the overall WTP, the initial and follow-up bid amounts were randomly varied in the online survey.

Survey respondents were presented with a description of the current and alternative conservation scenarios and asked whether they would be willing to pay a one-time lump sum tax to expand the existing whale sanctuary to the full extent of Faxaflói Bay. Those who expressed WTP were presented with a randomised first bid offer of either 2,000; 4,000; 6,000; 8,000; or 10,000 ISK (Table 3). Following the approach of double-bounded dichotomous choice, if the first bid was accepted, a second, higher bid was randomly selected from the following values in ISK: 4,000; 6,000; 8,000; 10,000; 12,000; 14,000, 16,000; 18,000 or 20,000. If, on the other hand, the first bid was rejected, a randomly selected bid with one of these lower values in ISK was presented: 1,000; 3,000; 5,000; 7,000; or 9,000. The bid amounts in this study were based on recent CV studies concerned with protection of natural areas in Iceland that used the same payment vehicle (Cook et al., 2018a, 2018b; Einarsdóttir et al., 2019) and their appropriateness was verified by two pilot studies (each with sample of 25), in which no negative feedback was received concerning the bid amounts. On the contrary, these bid amounts were found to be realistic and plausible given the valuation scenario under their consideration.

In the statistical model, a survey respondent's WTP is presented as a linear function dependent on several variables, such as individual preferences, sociodemographic, visitor and attitudinal characteristics, and bid amounts:

$$WTP_i = \alpha - b + x_i'\beta + \mu_i \quad (1)$$

where WTP_i stands for the WTP of respondent i; x_i' is a predictor variable vector that represents an individual's socio-economic characteristics; α, b and β are the parameters to be estimated; and μ_i is an error term relating to unobserved factors.

In the double-bounded approach, respondents are asked two rounds of questions, the second of which depends on their response to the first one. As a result, participants with WTP are divided into four groups according to their answers to the bid offers: yes/yes (yy); yes/no (yn); no/yes (ny); no/no (nn).

Following the approach of Kanninen and Khawaja (1995), the probability of a respondent saying 'yes' to the initial bid value *BID* is:

$$P_i^y = prob(yes) = prob(WTP_i \geq BID) \quad (2)$$

while the probability of a respondent rejecting the initial bid is $(1 - P_i^y)$.

Following Hanemann et al. (1991), we use the logistic model where P_i^y can be rewritten as:

$$P_i^y = G(\alpha + \beta BID_i) = \frac{1}{1 + e^{-(\alpha+\beta BID_i)}} \quad (3)$$

where G is the cumulative density function of the individual's i maximum WTP; and α and β are its vector parameters (Hanemann et al., 1991). The expression can be derived using the Hanemann (ibid.) approach where utility is a linear function of income and its error term is distributed following the extreme value of distribution. Assuming that the cumulative density function $G(\alpha + \beta BID_i)$ follows logistic distribution, double-bounded dichotomous logistic models were estimated.

The latter equation (3) leads to the standard binary choice log-likelihood L^{SB} function:

$$L^{SB} = \sum_i y_i log P_i^y + \sum_i (1 - y_i) \log(1 - P_i^y) \quad (4)$$

where y_i equals 1 if the response is 'yes', and 0 if otherwise.

In accordance with the approach by Hanemann et al. (1991), the probabilities of the four response possibilities following the double-bounded bid format are as follows:

$$P_i^{yy} = \frac{1}{1 + e^{-(\alpha+\beta HIGHBID)}} \quad (5)$$

$$P_i^{yn} = 1 - \frac{1}{1 + e^{-(\alpha+\beta LOWBID)}} \quad (6)$$

$$P_i^{ny} = \frac{1}{1 + e^{-(\alpha+\beta LOWBID)}} - \frac{1}{1 + e^{-(\alpha+\beta 1stBID)}} \quad (7)$$

$$P_i^{nn} = \frac{1}{1 + e^{-(\alpha+\beta 1stBID)}} - \frac{1}{1 + e^{-(\alpha+\beta LOWBID)}} \quad (8)$$

where 1*stBID* is the value of the starting bid, *LOWBID* is the lower follow-up bid value, and *HIGHBID* stands for the higher follow-up bid value.

Given these response probabilities, the double-bounded log-likelihood L^{DB} now has four parts corresponding to the four response combinations:

$$L^{DB} = \sum_i I_i^{yy} log P_i^{yy} + \sum_i I_i^{yn} log P_i^{yn} + \sum_i I_i^{ny} log P_i^{ny} + \sum_i I_i^{nn} log P_i^{nn} \quad (9)$$

where I_i stands for the response category for each respondent *i*.

For instances of genuine zero WTP, which excludes protest voters characterised by their objection to paying more taxes in Iceland or having other reasons for not wanting to pay the tax that did not reflect their true preferences towards expansion of the sanctuary, we applied a zero-truncated spike model (Kriström, 1997; Lim et al., 2017; Nahuelhual-Muñoz et al., 2004), which resulted in a fifth group, I_i^{ZERO}. This approach, advised by Hanemann (1984, 1989), Haab and McConnell (1998), and Yoo and Kwak (2002), takes into account a spike at zero that constitutes the truncation of the negative part of WTP distribution and therefore allows for the inclusion of responses of genuine indifference between the two conservation scenarios by allocating them a WTP of zero (Kriström, 1997). The possibility of negative WTP was not considered in this study as per the recommendation of Hanemann (1989) and Haab and McConnell (1997) who referred to the difficulties of ad hoc distribution assumptions for negative WTP:

In the double bounded approach, the mean is calculated integrating the area under the probability function of accepting the bid. The area represents the proportion of the survey respondents who would be willing to pay each amount of the proposed tax and the utility they would get from doing so (Mamat et al., 2013). As negative WTP is not considered in this model, WTP_i^{mean}must be greater than or equal to zero.

From the log-likelihood function (equation (3)), the spike can be defined as $I_i^{ZERO} = \frac{1}{1+e^{\alpha}}$ and a new cumulative distribution function can be defined as $G(\cdot;\theta)$, where θ represents the vector of parameters α, b and β presented in equation (1):

$$G(WTP;\theta) = \begin{cases} [1 + \exp(\alpha - \beta WTP)]^1 & if\ WTP > 0 \\ [1 + \exp(\alpha)]^1 & if\ WTP = 0 \\ 0 & if\ WTP < 0 \end{cases} \quad (10)$$

The mean WTP in the spike model is calculated as follows (Kwak et al., 2013; Yoo and Kwak, 2002):

$$WTP_i^{mean} = \left(\frac{1}{\beta}\right) log(1 + e^{\alpha}) \quad (11)$$

where WTP_i^{mean} is mean WTP and α and β are vector parameters of the cumulative density function of the individual's *i* maximum WTP (Hanemann et al., 1991; Kwak et al., 2013).

3.5. Socio-demographic, attitudinal and visitor variable description

Eleven socio-demographic, attitudinal and visitor variables were used in the final logistic regression model to determine statistically significant determinants of WTP.[2] The explanations of the variable codes are provided in Table 1.

Table 1
Predictor variables and coding.

Predictor variable	Explanation of coding
Sociodemographic variables	
Age	Age based on participants' date of birth.
Gender	A dummy variable, with 0 = female and 1 = male
Education	A dummy variable, with 0 = no degree education and 1 = at least an undergraduate degree.
Residence	A dummy variable, with 0 = residence within 50 km from the Greater Reykjavík area and 1 = residence outside of this boundary.
Participation in labour market	A dummy variable, with 0 = not actively participating in the job market at the time of the survey and 1 = active participant. Nonparticipation includes students, the retired, sick or disabled, carers, people on maternity/paternity leave and the unemployed, while active participation included all employed and self-employed individuals, irrespective of whether it is part-time or full time.
Disposable income	A dummy variable, with 0 = disposable income under 500,000 ISK and 1 = disposable income over 500,000 ISK
Marital status/ cohabitation	A dummy variable, with 0 = not married or cohabiting with a partner and 1 = married or cohabiting.
Number of persons in household	Coded on a scale 0–6 (with an option to state more) and represents a number of persons living in the household, including the participant.
Attitudinal and visitor variables	
Visited Faxaflói Bay	A dummy variable, with 0 = never having visited Faxaflói Bay and 1 = having visited.
Supports whaling	A dummy variable, with 0 expressed objection to whaling in Icelandic waters and 1 = expressed support for it.
Prioritises protection of natural areas	A dummy variable, with 0 = did not identify 'protection of natural areas' as the most important issue for the Icelandic society to solve and 1 = identified it as such.

4. Results

4.1. Responses to attitudinal questions and visiting the study area

Regarding attitudes and perceptions of the most and least important issues in the Icelandic society, improved healthcare sector and affordable housing were perceived by respondents as the most pressing, with 17.54% and 29.68% of respondents identifying them as such (Table 2). Strengthening the tourism sector was perceived as the least pressing issue (29.09%), and protection of natural areas, which is the most relevant issue for this study, was considered the most important by 5.12% of respondents and the least by 4.39%, ranking as the fifth most important and the fifth least important issue on the list.

In terms of environmental behaviour, the most popular ways to reduce environmental impact were recycling, saving energy and water and reducing car use. Donating to environmental causes – perhaps the most relevant environmental behaviour for this study – was an identified environmental behaviour by just over one third (34.35%) of the respondents. About half of the respondents (47.22%) agreed that whale watching is important for the Icelandic economy, and just over one fifth (22.22%) agreed that the same was true for whaling. Only 5.41% strongly disagreed with the statement that whale watching was important for the Icelandic economy, while 28.46% expressed this opinion about the role of whaling. These results suggest a general consensus

[2] Some variables were excluded from the final logistic regression to avoid using variables that were found to be correlated between themselves, e.g. number of children and number of persons in a household.

Table 2
Most and least pressing issues for Icelandic society to address.

Response	Most Pressing		Least Pressing	
	Frequency	Percentage	Frequency	Percentage
Affordable accommodation to buy or rent	120	17.54	10	1.46
Air pollution	24	3.51	24	3.51
Water pollution	7	1.02	44	6.43
Quality of education	28	4.09	9	1.32
Social equity	26	3.80	18	2.63
Discrimination	49	7.16	38	5.56
Economic growth/ employment	62	9.06	17	2.49
Diversification of Icelandic economy	19	2.78	75	10.96
Strengthening tourism sector	7	1.02	199	29.09
Protection of natural areas	35	5.12	30	4.39
Improving waste management	14	2.05	17	2.49
Improving healthcare system	203	29.68	2	0.29
Don't know	35	5.12	43	6.29
Refuse to answer	55	8.04	158	23.10
Total	**684**	**100.00**	**684**	**100.00**

among respondents that, overall, whale watching plays a more significant role in the Icelandic economy than whaling.

In terms of attitudes towards different types of whaling, 31.58% of respondents were strongly or somewhat against minke whaling, 40.79% against fin whaling, and 36.84% against whaling in general. In contrast, 39.33% were in favour of hunting minke whales, 30.41% fin whales, and 34.5% were in favour of whaling in general. In all three cases, approximately one quarter of participants (an average of 26%) did not express an opinion, answering that they were neither for nor against it. Out of 684 persons who completed the survey, 549 (80.26%) had visited marine and coastal areas in Faxaflói Bay, and 335 (48.98%) did so within the twelve months prior to the time of the survey. The activities most often undertaken during visits were walking/hiking (40.64%), sailing (22.37%), fishing (13.45%) and bird watching (13.89%), and only a small fraction (6.14%) had gone whale watching in the bay.

4.2. Preferences and willingness to pay for the expansion of the sanctuary

Out of the 684 respondents, 462 (67.54%) were not willing to pay the tax, 99 (14.47%) were willing to pay, 92 (13.45%) were not sure, and 31 (4.53%) refused to answer the question. All participants were asked to state their reasons for WTP or non-WTP. For the latter group, responses were analysed to determine whether they were protest voters or had genuine zero WTP. 188 (40.69%) of the 462 respondents with no willingness to pay were deemed to be protest voters and excluded from the final results on the premise that their responses did not reflect their true preferences related to the whale sanctuary expansion, the majority of them generally not willing to pay more taxes. A further 49 participants (10.61% of those non-WTP) were excluded from the results as their reason for non-WTP was impossible to determine from their responses.

After these exclusions, 225 (48.70% of the non-WTP sample and 32.89% of the whole sample) participants remained with genuine zero WTP. Zero WTP was determined either on the basis of insufficient disposable income to pay the tax or a clearly stated indifference or aversion towards the expansion of the sanctuary and was accounted for using the spike model. Reasons for non-WTP included support for whaling (56.89%), not having sufficient income (19.11%), and concerns over the possible expansion of whale watching activities and how that might affect the whales (14.22%).

Out of the 99 respondents who were willing to pay, 41 (41.41%) had a preference against whaling in the bay, 37 (37.37%) believed that there are environmental benefits of expanding the sanctuary, 15 (15.15%) expected that the expansion would increase economic benefits from whale watching, and 6 (6.06%) believed that the expansion is needed to increase whale stocks in Icelandic waters. The reasons expressed for WTP and non-WTP complement the attitudinal data on whaling in Iceland, providing a deeper insight on respondents' reasoning in this regard. Among the 99 respondents with WTP, 92 (92.93%) were against whaling in Iceland or indifferent, and among the 225 people with zero WTP, 148 (65.78%) were in favour of whaling, and a further 75 (33.33%) were either against whaling in Iceland or indifferent.

4.3. Bid elicitation responses

Table 3 summarises the responses of participants to the bids offers. Among the 95 respondents who completed the bidding process, 87 (87.88%) accepted the first bid offer and 12 (12.63%) rejected it. Subsequently, of the 87 participants who accepted the first bid offer, 45 (51.72%) answered 'yes/yes', 38 (43.68%) answered 'yes/no', and 4 (4.60%) refused to answer, resulting in their responses being dropped from the final results. From the 12 respondents who rejected the first bid offer, 8 (66.67%) had 'no/yes' and 4 (33.33%) had 'no/no' responses. The acceptance probability of the first bid gradually decreased as the sums increased, except for 6.000 ISK bid, but it is more random in the second bid where the highest bid acceptance rates are for 14.000 ISK and 8.000 ISK (not including 4.000 ISK, which was only offered once). Similar bid acceptance patterns were found in other ES valuation studies

Table 3
Summary of bid responses.

First bid amount ISK	Yes	No	Second higher bid amount ISK	Yes	No	Refuse to answer	Second lower bid amount ISK	Yes	No
2000	17 (94.44%)	1 (5.56%)	**4000**	1 (50.00%)	1 (50.00%)	0	**1000**	2 (66.66%)	1 (33.33%)
4000	17 (89.47%)	2 (10.53%)	**6000**	1 (100%)	0 (0.00%)	0	**3000**	5 (71.43%)	2 (28.57%)
6000	18 (94.74)	1 (5.26%)	**8000**	4 (50.00%)	4 (50.00%)	0	**5000**	1 (100.00%)	0
8000	14 (82.35%)	3 (17.65%)	**10000**	5 (62.50%)	3 (37.50%)	0	**7000**	0	0
10000	21 (80.77%)	5 (19.23%)	**12000**	7 (46.67%)	6 (40.00%)	2 (13.33%)	**9000**	0	1 (100.00%)
			14000	9 (75.00%)	3 (25.00%)	0			
			16000	6 (42.86%)	7 (50.00%)	1 (7.14%)			
			18000	4 (44.44%)	5 (55.56)	0			
			20000	8 (44.44%)	9 (50.00%)	1 (5.56%)			
Total (% of 99)	**87 (87.88%)**	**12 (12.12%)**	**Total (% of 87)**	**45 (51.72%)**	**38 (43.68%)**	**4 (4.60%)**	**Total (% of 12)**	**8 (66.67%)**	**4 (33.33%)**

Table 4
Summary of predictor variables.

Predictor variables	WTP for expansion (n = 99)	Genuine zero WTP (n = 225)
	Mean (Standard Deviation)	Mean (Standard Deviation)
Sociodemographic variables		
Age	46.66 (19.21)	52.47 (15.85)
Gender	0.39 (0.49)	0.66 (0.47)
Education	0.52 (0.50)	0.32 (0.47)
Residence	0.74 (0.44)	0.67 (0.47)
Participation in labour market	0.66 (0.48)	0.72 (0.45)
Disposable income	0.15 (0.36)	0.23 (0.42)
Marital status/cohabitation	0.67 (0.47)	0.78 (0.41)
Number of persons in household	2.63 (1.34)	2.95 (1.41)
Attitudinal and visitor variables		
Visited Faxaflói Bay	0.67 (0.47)	0.63 (0.48)
Supports whaling	0.07 (0.26)	0.66 (0.47)
Prioritises protection of natural areas	0.20 (0.40)	0.02 (0.14)

focused on marine and coastal protection (Rodella et al., 2019; Wang and Jia, 2012).

4.4. Socio-demographic characteristics

Table 4 provides the descriptive statistics for the regression model's predictor variables grouped according to respondents' WTP (positive or zero) for the expansion of the sanctuary. The mean outcomes with standard deviations in parentheses are provided for each predictor variable. The predictor variable information suggests that those willing to pay for the expansion tend to be slightly younger with an average age of around 47 as opposed to 52 for those with zero WTP; better educated, with 52% and 32% respectively being degree-educated; and tend to prioritise protection of natural areas more than the respondents with zero WTP. Gender and support for whaling were other two variables that differed considerably between the groups, with 60.61% of those with WTP being female compared to 39.39% of those with no WTP. Far fewer whaling supporters were willing to pay for the sanctuary expansion (7.07%), compared to 65.78% whaling supporters that had genuine zero WTP.

Table 5
Logistic regression results - Faxaflói Bay.

Variable	Coefficient (Standard Error)
Socio-demographic	
Age	−0.312 (0.118)***
Gender	−0.595 (0.346)*
Residence	0.115 (0.388)
Education	0.715 (0.360)**
Labour market participation	−0.203 (0.412)
Income over 500,000 ISK	−0.286 (0.464)
Marital/cohabitation status	0.492 (0.422)
Number of persons in the household	−0.430 (0.146)***
Attitudinal and visitor	
Visited Faxaflói Bay	0.549 (0.497)
Supports whaling	−2.917 (0.444)***
Prioritises protection of natural areas	1.957 (0.660)***
Constant	2.155 (0.895)***
N	287
Log-likelihood	−115.245
LR Chi^2	139.320
Prob. > Chi^2	0.000
Pseudo R2	0.377

***indicates significance at 1% level; ** significance at 5% level, and * at 10% level.

4.5. Logistic regression model and WTP estimates

The results of the logistic regression model with standard errors in parentheses are presented in Table 5. As a result of the failure by some respondents to complete either the attitudinal or the socio-demographic survey questions, the eventual sample dropped from 324 to 287 observations. In the logistic regression, the most important determinant of WTP is the constant and the statistically significant predictor variables include age, number of persons in the household, support for whaling and prioritising protection of protected areas, which were all significant at the 1% level. Education was significant at the 5% level; and gender – at the 10% level.

The mean WTP calculated using logistic regression and the zero-spike model is set out in Table 6. When the 225 observations with zero WTP were included, the mean WTP was 5,082 ISK (42 USD in 2018 prices); if we restricted the observations to non-zero WTP, the mean was 17,117 ISK (141 USD in 2018 prices). When the mean WTP (including genuine zeros), is multiplied by the number of tax payers in Iceland in 2016, which was around 260,426 (Directorate of Internal Revenue, 2016), it amounts to around 1.32 billion ISK (10.9 million USD in 2018) (Table 6).

5. Discussion

5.1. Attitudinal data

The problems in the healthcare sector and lack of affordable housing that have dominated the Icelandic public debate over the last few years were most often marked in the survey as the most pressing issues. That just over 5% of respondents chose the protection of natural areas as the most pressing issue in Iceland indicates limited concern about nature conservation, which may be partly due to the perceived pristineness of Icelandic nature, a commonly reported preconception (Karlsdóttir, 2013; Sæþórsdóttir et al., 2011, 2018). Recycling and improving efficiency of resource use were most often selected types of individual environmental behaviour, which is similar in other OECD countries (Eurobarometer, 2014).

The respondents' scepticism about the importance of whaling to the Icelandic economy resonates with the ongoing debate on the economic viability of whaling, where the majority of opinions in the popular media argue that whaling is a loss-making industry that damages the image of Iceland internationally (Kjarninn, 2015), while their opposition contends that controlled harvesting of whales is a sustainable use of natural resources (IoES, 2019) and a part of Icelandic national identity (Brydon, 2006).

The survey results reveal an approximately three-way division of opinion about Icelandic whaling – one third for, one third against and one third indifferent. This division largely coincides with the recent survey data from Gallup (2017) and Media and Market Research Iceland (MMR, 2018). In 2017, 24.7% of surveyed Icelanders were against minke whaling, 45.8% were in favour of it, and 29.5% did not express an opinion. The respective percentages for fin whaling were 29.3% against, 35.4% for, and 35.4% neutral. MMR survey data from 2018 shows that 34% were supportive of a resumption of whaling in Iceland in 2018, 34% were against, and 31% did not express an opinion.

The relatively lower support for fin whaling can perhaps be explained by the fact that fin whales are an endangered species globally according to the International Union for Conservation of Nature (IUCN) and that its harvesting in Iceland has been unsteady and resumed in 2018 after a two-year break (IoES, 2019). Even though fin whale stocks in Iceland are reportedly healthy and the harvesting quota adheres to strict standards (Víkingsson, 2019), the endangered status makes their utilisation less appealing to the public. Moreover, resumption of fin whaling has received a considerable amount of attention in the international media (The Guardian, 2018; The Seattle Times, 2018), which may have influenced respondents' opinions, together with the fact that

Table 6
Mean willingness to pay for expansion.

Variable	Number of observations	Mean ISK	Standard error	95% confidence interval		Multiplied by Icelandic taxpayers
WTP (including genuine zero WTP)	320	5082	553.1174	3993.431	3993.431	≈1.32 billion ISK
WTP (excluding genuine zero WTP)	95	17117	1142.628	14848.42	14848.42	≈4.46 billion ISK

fin whales are much larger animals than minke whales that have been more commonly hunted in Icelandic waters.

5.2. Willingness to pay outcome

WTP elicited in this study of 5082 ISK/42 USD per person is considerably lower than the individual WTP estimates from the previous CV studies in Iceland, which range between 7,122 ISK/60 USD and 24,790 ISK/207 USD (2018 prices) (Cook et al., 2018a, 2018b; Einarsdóttir et al., 2019). This may be partly due to the differing contexts – the previous CV studies in Iceland were concerned with preservation of currently unprotected natural sites while this case is related to expansion of an existing protected area. Moreover, this is the first CV study in Iceland concerning non-market valuation of marine environments while the earlier studies focused on terrestrial ecosystems. The former have been widely debated and have been on the public policy agenda or a few decades while the latter dates back just over a decade since the resumption of commercial whaling.

One of the reasons provided by respondents for non-WTP was the fact that expanding the sanctuary in does not imply any major transaction costs as it involves simply redrawing, 'an imaginary line in the water' (survey data). Moreover, 14.22% of those with genuine zero WTP expressed their concern over potential negative effects of expanding whale watching activities in the bay. This concern is legitimate as whale sanctuaries by default do not imply any control over activities other than whaling, while whale watching presents its own disturbances to whales (Cook et al., 2019b; Lusseau and Bejder, 2007; Ritter, 2003).

Even if lower compared to the previous ES valuation studies in Iceland, the WTP sum of 1.32 billion ISK elicited in this study is not insignificant when put into the context of the economic gains from whale ES through commercial whaling and whale watching. The most recent data from the Institute of Economic Studies at the University of Iceland (IoES, 2019) estimates that minke whaling made around a 3.8 million ISK (32,000 USD) loss in 2016, and fin whaling was not economically viable during the first few years after its resumption in 2013 due to high initial costs of restarting operations. The total income from whale watching in Iceland, according to the same study, was 3.2 billion ISK (27 million USD) in 2017, with total profits of around 100 million ISK (855,000 USD) (IoES, 2019, p. 21). The WTP to expand the sanctuary elicited in this study amounts to around 41% of the total income from whale watching in 2017. When the number of whale watching passengers in the Faxaflói Bay in the same year (169,630 according to IceWhale (2019), is multiplied by the average cost of a whale watching tour from the Reykjavík harbour (around 11,000 ISK), the direct expenditure amounts to around 1.9 billion ISK (16 million USD), of which the aggregate WTP in this study is around 68%.

The fact that respondents with positive WTP were willing to pay significantly more than the whole sample including zero WTP highlights that the issue of whaling in Iceland provokes strong diverging opinions, either for or against, and reiterates the main points of the discussion on participants' attitudes in relation to opinion polls on public support for whaling in Iceland (Gallup Iceland, 2017; MMR, 2018). The proportion of the sample (after exclusion of protest voters) who were willing to pay for the expansion was almost 30%, which is similar to the proportion of the Icelandic population that expressed their aversion to whaling in the previous polls.

This study contributes to the growing body of literature concerned with non-market valuation of marine ES and MPAs, yet varying contexts and approaches to study design limit the comparability of WTP outcomes. A few recent studies broadly related to the underlying general themes of this paper and applying similar valuation methods include Casiwan-Launio et al. (2011) on residents' WTP and willingness to work (WTW) for the preservation of a fishery reserve in Philippines Bicol region; Boxall et al. (2012) on the economic values associated with the recovery of marine mammal populations in Canada; Kenter et al. (2013) CV study on divers' and anglers' WTP for potential MPAs in the UK; and Batel et al. (2014) on economic values of marine conservation of an MPA for bottlenose dolphins. The study also resonates with some of the broader themes in literature on the role of ES valuation in MPA management and marine spatial planning (Hanley et al., 2015; Hussain et al., 2010; Jobstvogt et al., 2014; Russi et al., 2016; Torres and Hanley, 2017).

5.3. Significance of the sociodemographic characteristics for WTP

The statistical significance of age and gender for WTP in the regression model coincides with frequent association of support for whaling in Iceland with statistically older male population. There was no significant correlation between WTP and income but the number of persons in the household was significant at 1% level. This suggests that disposable income does not have a significant association with WTP but having to support more family members does. Jacobsen and Hanley (2009) in an analysis of 46 contingent valuation studies concerned with biodiversity preservation from around the world found that income was only significant in 39% of the database studies. Non-significance of income for WTP is also prevalent in a number of non-market valuation studies concerned with marine conservation (Batel et al., 2014; Börger et al., 2014; Robles-Zavala and Chang Reynoso, 2018), but has been found to be significant in others (Brouwer et al., 2016; Jobstvogt et al., 2014; Ressurreição et al., 2011; Ressurreição et al., 2012).

Gender, age and education have been found to have significant correlation with WTP in numerous ES valuation studies in industrialised countries (Jin et al., 2010; Liu et al., 2019; Ressurreição et al., 2011). Comparing the logistic regression model results to other CV studies in Iceland, gender, education, residence and high income were also found to be statistically significant in the CV studies of Hverahlíð and Eldvörp geothermal areas (Cook et al., 2018a). Income also had a statistically significant impact on WTP for preservation of the Heiðmörk natural park near Reykjavík (Cook et al., 2018b).

5.4. Implications of the study outcomes for decision-making

Marine and coastal ES specification, valuation and analysis of trade-offs have the potential to inform decision-making and maximise ecological, economic and social outcomes pertaining to their management (Brown et al., 2001; Lester et al., 2013; White et al., 2012). The aggregate WTP of 1.32 billion ISK elicited in this study could be used to communicate Icelanders' preferences related to expansion of the Faxaflói whale sanctuary, e.g. included in a cost-benefit analysis (CBA), should one be undertaken. Since the expansion would simply entail moving the sanctuary limit, the costs are likely to be negligible and the CBA would be likely to pass the Samuelson (1954) test, meaning that the aggregate social benefits would exceed the costs and characterise the change as socially desirable (Rodella et al., 2019). Moreover, the WTP estimate, together with the attitudinal data, could be used to support arguments concerning the significance of cultural ES provided by whales and to depict Icelandic stakeholder views on economic activities taking place in Faxaflói Bay when making decisions related to marine spatial

planning.

Whale sanctuaries, however, are a rather weak form of environmental governance with the only activity prohibited in them being commercial whaling while other activities with potential impacts on whales, such as sailing, whale watching, fishing and shipping, remain unaffected (Gjerden, 2008; Hinch and De Santo, 2011; Hoyt, 2005, 2012). Reviews of the two large IWC-designated whale sanctuaries conclude that they lack scientific basis for the efficient protection of species and have been politically rather than scientifically motivated (Gerber et al., 2005; Zacharias et al., 2006). Cook et al. (2019b) find that the contribution of the Faxaflói Bay Whale Sanctuary to ecosystem-based management is very limited and that a clear set of preferences and measurable objectives is necessary to improve its efficacy. With an increasing number of economic activities taking place in the bay, there is a need for marine spatial planning that considers risks, interactions and trade-offs between them, and economic ES valuation can play an important role in decision-making.

5.5. Ecosystem services implications of study

Our study indicates that there may be a change in the ES provided by whales in Faxaflói Bay if the whale sanctuary was expanded: more cultural ES sourced through whale watching and reduced provisioning ES from whaling. The most recent expansion of the sanctuary in 2017 already caused a considerable decline in minke whaling (Fiskifréttir, 2018). The proposed expansion is likely to make whaling even less profitable as vessels would have to venture farther away from the whaling station, thus reducing the supply of provisioning ES sourced from whales. On the other hand, the proposed expansion is likely to have a positive impact on whale watching and the supply of cultural whale ES. The previous increase in the size of the sanctuary was at least partly motivated by potential benefits to tourism (Vísir, 2017). That 47.22% of respondents identified whale watching as important for the Icelandic economy compared to 28.46% who thought that whaling is important suggests that the economic gains from cultural ES are perceived to be more significant than those from provisioning ES. Whale watching activities, however, can have their own effects on whales, raising environmental concerns (Lusseau and Bejder, 2007; Rasmussen, 2014; Ritter, 2003). A study by Christiansen & Lusseau (2015) focused on Faxaflói Bay revealed that encounters with whale watching boats cause behavioural disturbances in minke whales, leading to changes in feeding and breeding habits, and that a large increase in these interactions could negatively affect long-term whale conservation in the bay.

5.6. Study limitations and further research

In the absence of other attempts to assess values of whale ES in Iceland, this study serves as a guide for further research on the topic, yet it is not without its limitations. Firstly, to address the management needs, other ES value dimensions than monetary should be studied (Martinez-Alier et al., 2010; Stålhammar and Pedersen, 2017). For example, non-WTP for the sanctuary expansion does not necessarily imply that people do not value certain whale ES – they may value them in non-monetary terms, e.g. intrinsic values concerning existence, inspiration or aesthetic enjoyment (Chan et al., 2012; Jacobs et al., 2016; Kato, 2007). These values can be accounted for using non-monetary ES valuation techniques, e.g. sociocultural valuation, and integrated valuation methods (Dempster, 2009; Gómez-Baggethun and Martín-López, 2015; Gómez-Baggethun et al., 2014).

Secondly, due to the lack of reliable scientific information, descriptions of the conservation scenarios did not include predicted changes in whale ES and respondents had to make decisions based on incomplete information, which can potentially reduce the reliability of the study (Blomquist and Whitehead, 1998; Schläpfer, 2008). The current scientific knowledge about biophysical processes in the Faxaflói Bay marine ecosystem in relation to different economic activities and ES provisioning is very limited, therefore natural science research in these areas would be instrumental in enabling better-informed future valuation studies (Guerry et al., 2012; Tallis and Polasky, 2009).

Thirdly, a relatively high proportion of protest voters presents a potential problem to the reliability of WTP results. The 41% proportion of protest voters determined in this study reaches the upper limit of the acceptable range of between 20% and 40%, as defined by Carson (1991). However, the proportions of protest voters vary greatly between other CV studies in Iceland – from 24% to 81% – which can be explained by the perception of already high taxes and the tendency of the public to distrust government spending (Cook et al., 2018a, 2018b; Einarsdóttir et al., 2019). In CV studies concerned with marine conservation from other parts of the world, the percentage of reported protest voters ranges from 10% (Ressurreição et al., 2011) to 20%–42% (Giraud et al., 2002; Jobstvogt et al., 2014; Rodella et al., 2019; Wang and Jia, 2012).

Protest voters were excluded from the final results of the study following recommendations by Edwards and Anderson (1987), Jorgensen et al. (1999) and Carson and Hanemann (2005) in order to avoid distortion of WTP results through responses that do not reflect true preferences about given scenarios (García-Llorente et al., 2011). However, CV literature also points out that the exclusion of protest voters may result in sample selection bias (Calia and Strazzera, 2001; Halstead et al., 1992) and impact estimates of WTP (Dziegielewska and Mendelsohn, 2007; Haab, 1999). This is an issue to keep in mind when interpreting the results and designing future studies, where additional questions could be asked to better verify the reasons for (non)WTP that would allow for a more accurate designation of protest voter status (Blamey et al., 1999; Dziegielewska and Mendelsohn, 2007).

In theory, some of the respondents may have had negative WTP, which is not considered in this study as per the recommendations by Hanemann (1989) and Haab and McConnell (1998). This means that the results have to be interpreted with caution, especially when making policy recommendations (Clinch and Murphy, 2001). Around one third of the survey respondents had a preference against the expansion of the sanctuary resulting from either support for whaling or concerns over effectiveness of the proposed conservation scenario, but the study was not designed to account for the preferences of this group who may have negative WTP. This issue could be addressed in future studies by providing a wider range of bid options and additional questions or by applying different valuation methods, such as discrete choice experiments, where respondents are asked to choose between different conservation scenarios, allowing to account for a wider range of preferences (Clinch and Murphy, 2001; Hanley et al., 2001). Also, the most recent expansion of the sanctuary to its current limit in 2017 might have affected the results of the study as respondents may not see the urgency in further expansion. The results might also have been very different if the study had occurred in the aftermath of the recent decision by the government of Iceland to continue whaling for the next five years, permitting the harvesting of 209 fin whales and 217 minke whales annually until 2023 (Vísir, 2019).

Finally, the preferences of visitors who generate the majority of income from whale watching are not taken into consideration in this study as it was concerned with the preferences of the Icelandic people. Icelanders rarely go whale watching and thus the trade-off between whale watching and whaling, although important, may not be as directly relevant to their welfare as that of the many foreign visitors who are the main ‘consumers’ of whale watching and, to some extent, whale meat (Bertulli et al., 2016). Even though the economic gains from both industries largely go to Icelanders, the aesthetic enjoyment and other less tangible recreational and cultural benefits enjoyed by visitors constitute an important part of whale ES values that should be considered. For this purpose, a CV study estimating the consumer surplus of the whale watching visitors in Faxaflói Bay is currently underway, aimed at accounting for preferences of foreign visitors in this regard.

Further research should also address the limitations listed above through non-monetary valuation and better estimates of non-use values

of whales in Iceland; natural science research on ecological effects of different economic activities related to whale resources; and further development of non-market valuation techniques to address the problems of a high percentage of protest voters and potentially negative WTP. For improved understanding of trade-offs between different uses of whale resources that could inform MSP, a transdisciplinary approach is required as well as close cooperation between ES valuation practitioners, natural scientists and policy practitioners (Granek et al., 2010; Guerry et al., 2012; Jobstvogt et al., 2014; Lester et al., 2013; Torres and Hanley, 2017).

6. Conclusion

Effective marine spatial planning requires reconciliation of different and sometimes conflicting activities and resulting trade-offs. For this purpose, a transdisciplinary approach is needed combining environmental, social and economic information and transcending subject boundaries to provide policy-relevant research. Using the contingent valuation method, this study set out to elicit Icelanders' preferences and estimate willingness to pay for the expansion of the Faxaflói Bay Whale Sanctuary, which would ban commercial whaling in the entirety of the bay. In so doing, it adds new data to the international non-market valuation literature on marine spatial planning and, in particular, the whale watching versus whaling debate in Iceland. It holds a potential to inform decision-makers about the trade-offs between cultural and provisioning whale ES and public preferences regarding the management of Faxaflói Bay.

The mean willingness to pay of the 320 respondents who expressed clear preferences regarding the possible expansion, including genuine zero WTP, was 5,082 ISK (42 USD in 2018), which, when upscaled to the number of taxpayers in Iceland, amounted to 1.32 billion ISK (10,9 million USD in 2019). The study shows that younger people, women, university-educated respondents and those who prioritise the protection of natural areas had higher WTP, whereas supporting whaling and living with more people in a household negatively affected WTP. It also reinforces the outcomes in public opinion polls that Icelanders are divided on the issue of whaling. This information is very timely, with fin and minke whaling in Iceland having been extended until 2023 and the public debate on whaling continuing locally and internationally.

However, some important questions remain regarding the effects of economic activities on the marine ecosystem of the Faxaflói Bay and its capacity to provide ES; valuing the full range of ES provided by whales, trade-offs between different ES; and management mechanisms that would address them. Further research in these areas could inform marine conservation and spatial planning in Iceland and beyond from an ES perspective, contributing to the United Nations' Sustainable Development Goal 14 on the conservation and sustainable use of oceans, seas and marine resources, and adoption of ecosystem-based management.

Declaration of competing interest

This work is supported by the Nordic Centre of Excellence ARCPATH "Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies" (Grant No. 76654), funded by the Nordic Arctic Research initiative. We wish to confirm that none of the authors have any conflicts of interest that impinge on the publication of this paper.

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7 Publication V: Interactive governance of whale ecosystem services: governability assessment of three case studies in the Arctic

Interactive governance of whale ecosystem services: governability assessment of three case studies in the Arctic

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Abstract

Arctic social-ecological change is accelerated by the multifaceted effects of climate change and globalisation. Among other things, this means changing dynamics of human-ecosystem interplay in Arctic social-ecological systems (SES) through altered availability, co-production and use of marine ecosystem services (ES), which as implications for governance. A group of species illustrative of this change are whales, on which Arctic coastal communities have depended for millennia. The study (i) presents a new conceptual model combining ES co-production and interactive governance frameworks; and (ii) applies a multi-method approach in the assessment of governability of whale ES in three Arctic coastal locations – Húsavík in Iceland, Andenes in Norway and Disko Bay in Greenland. Based on a literature review, stakeholder mapping, observations, and analysis of 54 semi-structured stakeholder interviews, the study finds that governability of whale ES is the highest in the Icelandic case study due to the relative simplicity of its SES, limited number of governance interactions between stakeholders and their ability for self-governance. It also finds that sustainable interactive governance of whale ES and other marine resources requires the recognition that much of it happens outside of formal institutions, necessitating inclusive approaches in the efforts to improve it. Systematic assessment of governability reveals governance shortfalls and potentials, addressing which can potentially help to direct marine resource management towards sustainability, notably by making it more inclusive, adaptive and reflective of stakeholder needs and values.

Keywords: interactive governance; governability; social-ecological systems; whale ecosystem services; Arctic coastal communities

1. Introduction

Given the complexity of environmental problems, it is becoming increasingly clear that governance of natural resources requires an integrated transdisciplinary approach (Primmer et al., 2015). In this inquiry, the divisions between social and ecosystem domains are abandoned and viewed instead as social-ecological systems (SES) – a concept that refers to an understanding of societies and ecosystems as dependent on each other and mutually responsive through constant, multi-layered interactions and co-evolution (Berkes et al., 2000; Folke et al., 2016; Gual & Norgaard, 2010; Kallis, 2007; Ostrom, 2009). In SES, ecosystem services (ES) occur at the intersection between the social and ecological domains through co-production processes, which imply human agency (Palomo et al., 2016; Solé & Ariza, 2019; Spangenberg et al., 2014).

Arctic SES are particularly affected by climate change and globalisation, and studying intertwined social-ecological processes is especially important when designing governance instruments in the region (Arctic Council, 2015, 2016; Falardeau & Bennett, 2019). The latest Arctic Marine Strategic Plan 2015-2025 advocates implementation of Ecosystem Based Management (EBM) and a focus on human well-being through provision of ES (Arctic Council, 2015). Whale ES present a group of marine ES that is important to Arctic coastal communities in terms of sustenance, culture, and tourism (Cook et al., 2020; Malinauskaite et al., 2021; Meek et al., 2011).

Whale ES derive from dynamic social-ecological interactions and analysis of their governance calls for a holistic analytical approach (Cook et al., 2019; Hinch & De Santo, 2011; Malinauskaite et al., 2021; Meek et al., 2011; Zacharias et al., 2006). One such approach is the interactive governance (IG) and governability framework, according to which natural resource governance implies a web of multi-layered interactions between co-evolving SES components, formal and informal actors, institutions, and ecosystems. The holistic view of governance as a co-evolving, multi-actor and multi-scale process implied by the framework makes it equipped to account for social-ecological complexities (Partelow et al., 2020). Moreover, systematic assessment of governability can reveal governance potentials that, if capitalised upon, can help to direct marine resource management towards sustainability (Chuenpagdee, 2011).

The IG theoretical framework can be applied to resource systems in order to examine their components and the extent of their governability, drawing desirable governance trajectories. It has gained prominence in the governance literature since its inception in 2000s but has scarcely been applied outside the area of fisheries governance (Bavinck et al., 2005; Jentoft & Chuenpagdee, 2015; Kooiman et al., 2005). The present study utilises the framework in the context of whale resources in the North Atlantic part of the Arctic, focussing on three coastal communities in Húsavík in Iceland, Andenes in Norway and Disko Bay in Greenland and the ways in which whale ES are co-produced and governed in these SES.

This paper combines the concepts of SES, whale ES and their co-production (Cook et al., 2020; Malinauskaite et al., 2021) with the interactive governance and governability framework, with the main aim of assessing their governability. It does so by (i) designing a new conceptual model that combines whale ES co-production and interactive governance frameworks; (ii) identifying the main components of IG of whale ES in the three case studies; (iii) assessing the governability of whale ES in the three SES using a framework developed

by IG scholars for marine resources; (iv) discussing the findings in the context of the needs and values expressed by stakeholders, and determining the extent to which they are reflected in the current governance of whale ES in the case study locations.

Section 2 of the paper outlines the interactive governance and governability framework, embedding it in the concept of ES co-production and presenting a new conceptual model. Section 3 of the paper lays out the methodology used to achieve the research objectives. Section 4 provides some background information on the three case studies. Section 5 lists the results of the analysis, which are discussed in Section 6 in relation to the values, needs and problems expressed by stakeholders. Section 7 concludes the paper, reiterating its main findings.

2. Theoretical framework

2.1. Interactive governance and governability

Governance is concerned with a wide array of interactions between state, market and civil society with a purpose to solve existing problems and/or create new opportunities (Bavinck et al., 2005). The term is more inclusive than "policy" and "management" which typically denote design and application of concrete tools (Kooiman et al., 2005). Interactive governance then refers to a sum of governing activities carried out by public and private actors in accordance with their needs and values (Kooiman & Bavinck, 2013). The two key characteristics of interactive governance emerge from these definitions: firstly, it is an interactive, multi-layered process involving a wide array of actors; secondly, this process is responsive to the needs and values held by these actors, which makes the concept stakeholder-focused (Jentoft, 2007). ES values in this paper refer to the values assigned to different whale ES by stakeholders. They are defined here as "perceived qualities of an environment that provide material and nonmaterial benefits to people" (van Riper & Kyle, 2014, p. 375) and are categorised into three value domains – biophysical, sociocultural and monetary (Martín-López et al., 2014).

In interactive governance theory, governability refers to "the quality of governance" (Kooiman & Bavinck, 2013, p. 9). It is determined by the interactions between different IG components outlined in Table 1. Governability provides a conceptual basis for assessment of interactive governance and its ability to solve problems and create opportunities. It has three main components: system to be governed (SG), which denotes an SES that is governed; governing system (GS), which consists of formal and informal actors and institutions involved in governance of that system; and governance interactions (GI), which represents the interface between these two systems (Kooiman et al., 2008). The interactive governance model consists of four main pillars: properties, elements, orders, and modes (Kooiman & Bavinck, 2013), which are explained together with their components in Table 1. The synonyms in the last column refer to the terms used interchangeably in this paper for these components.

Table 1. Definitions of the key components of interactive governance theoretical model as per Kooiman et al. (2008) and Kooiman and Bavinck (2013).

COMPONENT	DEFINITION	SYNONYMS
Actor	Any social unit possessing agency or power of action.	Stakeholder
Sustainability	Ability of an SES to sustain human wellbeing and ecosystems indefinitely or for a very long time.	
System-to-be-governed (SG)	A system connecting natural and social phenomena, where social processes depend on natural conditions and vice versa. Should be viewed as a part of a bigger system.	Social-ecological system
Governing system (GS)	Total set of mechanisms and processes stemming from state, market or civil society that are available for guidance, steerage and control of a system-to-be-governed.	
Governance interactions (GI)	Mutually influencing relations between two or more entities or actors in a governance setting.	
PROPERTIES		
Diversity	Nature and degree to which entities within system differ.	Heterogeneity
Complexity	Quality or state of being complex or composed of interconnected parts. Expression of social-ecological interdependencies.	
Dynamics	Degree of change stemming from tensions which create flows of energy, materials, and information.	Change
Scale	Dimension of space and time of systems-to-be-governed and governing systems.	
ELEMENTS		
Image	Guiding lights of "how" and "why" of governance, including visions, knowledge, ideas, judgements, goals, convictions, theories, etc.	Vision
Instrument	A sum of available tools for governance, e.g. laws, regulations, guidelines, taxes, subsidies, etc.	Tool
Action	Implementation of instruments according to set guidelines or the taking of action by one actor or entity that is followed by others.	Problem solving
ORDERS		
Meta order of governance	Setting values and principles to guide policy.	Governance vision
Second order of governance	Institutional settings which enable, sustain and give focus to governance.	Institutional setting
First order of governance	Day-to-day activities by governing actors tackling problems and creating opportunities.	On-ground action
MODES		
Hierarchical governance	Implies a one directional flow from governing system to system-to-be-governed. Typical style of governance in which governments interact with their (groups of) citizens.	Top-down; policy; management
Co-governance	"Horizontal" collaborative and cooperative governance interactions where no one actor plays a dominating role.	Collaborative; co-management
Self-governance	Capacity of social entities to govern themselves. Implies participation by actors.	Participatory governance

Fig. 1, sourced from Chuenpagdee et al. (2008, p. 3), shows how the different components of the IG framework outlined in Table 1 are interlinked through governance interactions and how they contribute to governability. Fig. 1 implies a close link between governability and interactive governance, which is explained by Kooiman and Bavinck (2013, p. 10): "*There is a close relationship between the two terms. An attempt to improve governance inevitably results in the need to explore and assess governability. Vice versa, the governability of societal systems can only be understood in/with reference to their basic qualities*".

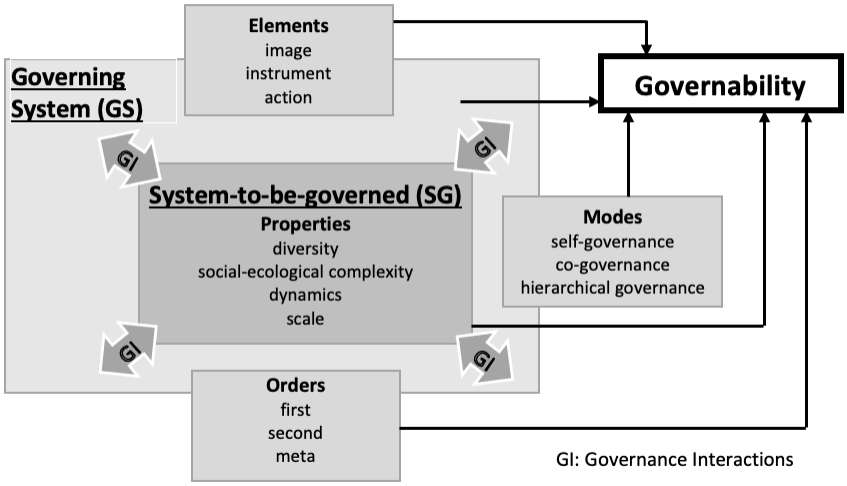

Figure 1. Linkages between interactive governance and governability. Adapted from Chuenpagdee et al. (2008, p. 3). GS is comprised of three main elements: images, instruments and actions. Images guides governance, instruments enable it, and action puts instruments into practice. Images are concerned with meta order of governance, i.e., values and principles that guide it; instruments relate to the second order and institutional setting; and actions – to the first governance order, which refers to concrete actions and tools applied in practice. In this model, governance can be top-down, collective, or self-directed, referring to the three governance modes. Both GS and SG have characteristics of diversity, complexity, dynamics and scale that affect the governability of a system and influence GI.

2.2. Whale ES co-production and interactive governance

According to the Common International Classification of Ecosystem Services (CICES), whale ES can be classified into provisioning, regulation and maintenance, and cultural ES (Cook et al., 2020; Haines-Young & Potschin, 2018). This ES classification system was chosen for this study due to its embeddedness in the ES cascade model (Haines-Young & Potschin, 2010) that provides the basis for the whale ES co-production and governance model in Fig 2. Provisioning whale ES include food products and raw materials; regulation and maintenance – enhanced primary productivity, biodiversity and evolutionary potential as well as climate regulation (carbon sequestration via whale carcasses); and cultural whale ES include but are not limited to tourism (whale watching), inspiration for arts, sacred, religious and spiritual beliefs, community cohesiveness and cultural identity, education, aesthetics, and existence and bequest values (Cook et al., 2020; Riisager-Simonsen et al., 2020; Roman et al., 2014).

The ES co-production model presented in Fig. 2 stems from the observation that ES formation requires active human inputs to co-produce them (Bruley et al., 2021; Fischer & Eastwood, 2016; Malinauskaite et al., 2021). The schematic, developed from the ES cascade model by Haines-Young and Potschin (2010), was designed to incorporate the involvement of different actors – in this case whale ES co-producers and users – into ES formation, following the approach of Spangenberg et al. (2014). It presents the main stages in whale ES formation and the underlying social-ecological processes that enable their existence, as

described by Malinauskaite et al. (2021). In addition, governing system, governance interactions and system-to-be-governed with its main properties were added.

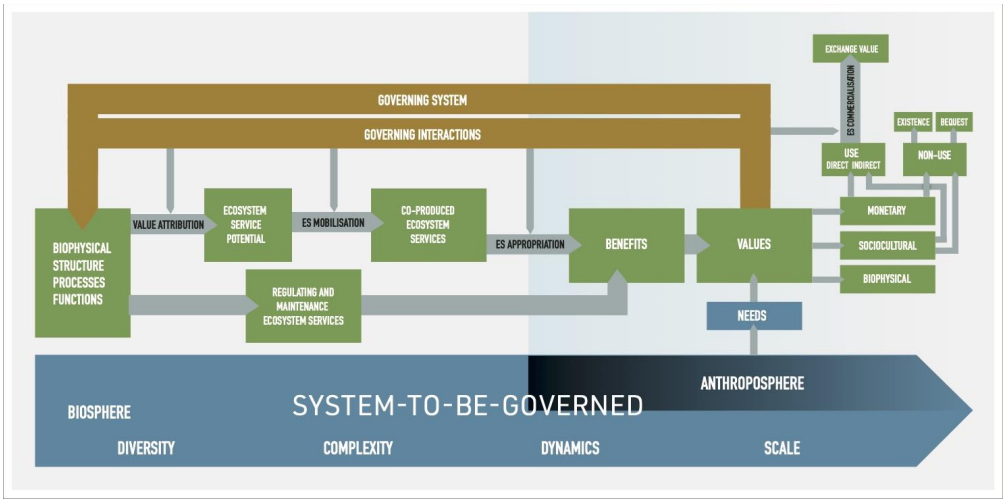

Figure 2. Whale ES co-production and interactive governance model.

Fig. 2 illustrates how human actors benefit from whales through ES co-production and how their needs and values feed into the governing system and governance interactions. System-to-be-governed includes the sub-systems of the biosphere, on the supply side, and the anthroposphere, on the demand side of ES, highlighting the dependence of humans on ecosystems. The co-produced whale ES in the middle constitute a part of the SG, while co-production processes are affected by governing system, interactions, ES values and stakeholder needs.

3. Methods

The paper uses case study research to assess the governability of whale ES according to interactive governance and governability theory. The case studies, described in the next section, were chosen due to their proximity to the Arctic Circle, some geographical and economic similarities and presence of whales ES. All three SES examined in this study are located on Arctic and sub-Arctic coasts that share biophysical features that support the presence of cetaceans. They are all coastal communities faced with rapid biophysical and socioeconomic changes induced by climate change and globalisation (Cole et al., 2016). Furthermore, they have all experienced a partial shift in economic activities from extractive uses of marine resources to service-based economic activities, especially tourism, in the years leading up to the COVID-19 pandemic. All three communities depend on whale ES for their livelihoods and wellbeing to some extent.

To assess the governability of whale ES in the case studies according to the interactive governance model, a mixture of methods was used: (i) literature review; (ii) stakeholder mapping; (iii) semi-structured interviews; and (iv) participant and non-participant community-based observations. Firstly, a review of literature available on whale ES, their values and management in the case study countries and the Arctic as a whole was conducted. Academic and grey literature was consulted for this purpose, and snowball technique was applied to find more sources (Greenhalgh & Peacock, 2005; Malinauskaite et al., 2019).

Secondly, the results of the literature review helped to identify the key actors in the area of interactive governance of whale ES in the three case studies. The best practice guidelines for stakeholder identification and mapping were used (Durham et al., 2014; Reed et al., 2009). The process was iterative and ongoing, and the stakeholder maps (Appendixes A, B and C) were being further developed in tandem with the data collection process as interviewees pointed to actors[1] that could be interviewed. The resulting stakeholder maps were used to identify potential interviewees with interest or/and expertise in whale ES.

Thirdly, semi-structured interviews with a wide range of actors were conducted using the best practice guidelines in qualitative research methods (Hennink et al., 2020). The fieldwork for the case study research took place in Húsavík, Iceland in June 2018 and August 2019, in Andenes, Norway in September 2018, and in Disko Bay, Greenland in August-September 2019. Representatives of most stakeholder groups that were identified during stakeholder mapping (Appendixes A, B and C) were contacted to get as diverse a sample as possible. A total of 54 interviews with 57 people were conducted between June 2018 and September 2019: 19 interviews with 20 stakeholders in Iceland, 15 interviews with 16 respondents in Norway, and 19 interviews with 20 participants in Greenland. The interviewees represented an array of private and public sector institutions, NGOs and the general public identified in stakeholder maps (Appendixes A, B and C).

The interview guides (Appendix D) were designed to elicit the key ES provided by whales and their values, as well as management practices and needs. Each interview lasted around one hour, the shortest being around 30 minutes, and the longest around 90 minutes. The interviews were mostly conducted in the workplaces of the interviewees, and a few were conducted at other locations, such as respondents' homes and local cafés. The interviews were conducted following ethical practices in qualitative research, such as ensuring anonymity and giving an option opt out of questions (Esterberg, 2002; Yin, 2017).

Finally, community-based observations took place during the fieldwork parallel to the interviews. Observations consisted of spending time in the case study communities and observing everyday activities related to whale ES. Both participant and non-participant observations were conducted (Bessette, 2004). The observations resemble the ethnographic methods previously used in ES and interactive governance research (Kaltenborn et al., 2017; Maestre-Andrés et al., 2016; Pullin, 2013; Song & Chuenpagdee, 2013).

The interviews were recorded, transcribed and coded deductively according to IG theory, identifying its main components in the case studies. As opposed to inductive coding methodologies, such as grounded theory (Charmaz & Belgrave, 2007), in deductive data analysis codes are predetermined in order to examine the key ideas of a theory on which it is based (Elo & Kyngäs, 2008; Hyde, 2000). This type of explanatory case study analysis is also known as "theory building" as it examines various components of a theoretical argument with the help of a case study (Yin, 2017). Coding was initially based on the governability model by Kooiman et al. (2008), but the data suggested some sub-codes for specific features of each case study. In the process, additional code groups emerged but the code groups determined

[1] The actors were grouped into two subgroups, with economic interest (benefitting economically from whale ES) and non-economic interest (having a stake in whale ES other than economic gains, e.g., management, research or activism) in whale ES. Then the former group were split into stakeholders with a direct or indirect economic interest, and the latter – into those with a direct or indirect regulatory interest.

before the analysis remained. Qualitative data analysis software MAXQDA was utilised, which allowed the revisiting and revising of codes and segments as the analysis progressed.

Finally, governability of the three case study SES was assessed using the framework by Chuenpagdee et al. (2008, p. 4) presented in Table 2. The assessment matrix presents a tool for evaluating the governability of a resource system in accordance with the components of the IG framework. The criteria outlined in the middle column of Table 2 corresponds to the main components of the model elaborated in Table 1 and Fig. 1: prevalence of properties of the system-to-be-governed (*their high prevalence indicate low governability and vice versa*); goodness of fits of elements (*the better the fit, the higher governability*); responsiveness of modes (*high rate of mode responsiveness indicate high governability and vice versa*); performance of orders of the governing system (*high performance indicates high governability and vice versa*); and presence and quality of governance interactions (*presence of many GI impedes governability, but their quality enhances it*). The guiding questions in the right column of Table 2 present the indicators according to which the governability of a system is judged to be "high", "moderate" and "low" according to the criteria for each of the components.

Table 2. Governability assessment criteria. Adapted from Chuenpagdee et al. (2008, p. 4).

Governance component	**Governability criteria**	**Examples of governability questions**
System-to-be-governed (SG)	- Prevalence of properties	*Diversity* - Types of ecosystems and habitats - Demographics of stakeholders *Complexity* - Linkages between species, ecosystems and habitats - Level of cooperation and/or conflicts between stakeholders *Dynamics* - Short and long-term bio-ecological changes - Level of migration and mobility of stakeholders *Scale* - The range and representativeness of the ecosystem - The social, cultural and ethnic boundary of stakeholders
Governing system (GS)	- Goodness of fits of elements - Responsiveness of modes - Performance of orders	- Appropriateness of the governing elements in moving towards desirable outcomes - Effectiveness of the governing mode and its ability to respond to governance challenges - Capacity of the governing orders to function, operate and lead to desirable outcomes
Governance interactions (GI)	- Presence of interactions	- Existing forms and qualities of the interactions, including representativeness, effectiveness of communication and level of information flow

4. Case study description and institutional settings

The town of Húsavík is located in Skjálfandi Bay, Northeast Iceland, with just over 2,300 inhabitants (Statistics Iceland, 2019). The most typical cetacean species in the bay are humpback, minke, and blue whales and harbour porpoises. Their abundance has been attracting visitors since the 1990s, and whale watching has since become the main tourist attraction in town, drawing more than 100,000 visitors per year (Nicosia & Perini, 2016). This partly facilitated a shift from a resource- to service-based economy following the decline of the local fishing industry (Benediktsson & Karlsdóttir, 2011; Karlsdóttir & Ingólfsdóttir,

2011). In 2017, Skjálfandi Bay was declared a whale sanctuary[2] together with Faxaflói Bay in the capital area due to their importance as whale watching areas (Government of Iceland, 2017).

Andenes in northern Norway is a town with around 2,700 inhabitants (Statistics Norway, 2019). The main species of whales are sperm, humpback, minke whales and orcas. Whale watching started in the late 1980s and has become an important part of the town's economy and the tourism industry in the whole Vesterålen region, yet fishing remains the main economic pillar (Bertella, 2017; Cosentino, 2016). There are plans to commence The Whale project in the town, which will consist of an interactive exhibition, conference venue and cultural centre (The Whale, 2019). Norway is one of the three nations globally engaging in commercial whaling, together with Iceland and Japan. According to the interview data, minke whaling occurs in waters close to Andenes.

Disko Bay in Greenland is the largest open bay in western Greenland, measuring 150 km north to south and 100 km east to west. The main town, Ilulissat, is the third largest settlement in Greenland with around 4,500 inhabitants (Statistics Greenland, 2019). The Disko Bay area has become a popular tourist destination in the decade prior to COVID-19 pandemic, offering various tourist activities, including whale watching, but fishing remains the most important economic activity in the area. The main species of whales in Disko Bay are bowhead, humpback, minke, beluga and narwhal. Unlike in the other case studies, Greenlanders engage in indigenous whaling, which is important for the food security and cultural identity of the local population (Caulfield, 1993; Suydam & George, 2021; Tejsner, 2014).

The international institutions affecting whale ES governance in all case study locations include the International Whaling Commission (IWC), North Atlantic Marine Mammal Commission (NAMMCO[3]), European Union (EU); European Economic Area (EEA), The United Nations Convention on the Law of the Sea (UNCLOS), Arctic Council, Greenpeace, Sea Shepherd, and International Fund for Animal Welfare (IFAW). IWC provides recommendations for whale species monitoring and setting whaling quotas and methods (Punt & Donovan, 2007); NAMMCO uses soft governance tools to influence research and sustainable use of marine mammal resources in the North Atlantic (Avango et al., 2013); the Artic Council acts as a platform for international dialogue on the issues related to the region, including biodiversity and marine resource governance (Barry et al., 2020); the EU and EEA are involved in environmental and trade agreements that affect the case study countries (Molenaar et al., 2014); UNCLOS influence the legal framework, according to which marine-based activities are governed (Stoessel et al., 2014); and the environmental non-governmental organisations (ENGOs) and other pressure groups lobby for humane treatment of whales, most notably by banning whaling (Young et al., 1994).

[2] Whale sanctuary implies that whaling in the area is not permitted. However, unlike in Faxaflói, whaling has not occurred in Skjálfandi for decades, and has never been an important economic activity in the area.
[3] NAMMCO's objective is "to contribute through regional consultation and cooperation to the conservation, rational management and study of marine mammals in the North Atlantic" (NAMMCO, 1992, p. 1).

Table 3 below lists the main governing institutions in each case study based on the interviews, literature review and stakeholder mapping.

Table 3. The formal and informal governance institutions related to whale ES in the case study SES.

	Húsavík	**Andenes**	**Disko Bay**
Formal governing institutions up to national level	**Local**: Norðurþing municipality **National**: Ministries of Industries and Innovation, Fisheries and Agriculture, and Foreign Affairs; Icelandic Whale Watching Operators' Association – IceWhale; Icelandic Transport Authority; Marine and Freshwater Research Institute (MFRI)	**Local**: Andøy municipality; Norland region county; local tourism offices for Andøy and Vesterålen; Samskåp innovation agency **National**: Ministries of Trade, Industry and Fisheries and of Transport and Communications; Norwegian Whale Watching Operator's Association – NorWhale; Norwegian Institute of Marine Research; Norwegian Maritime Authority; Norwegian Fisheries Directorate;	**Local**: Avannaata and Qeqertalik municipalities; local tourism offices and councils; harbour operator – Royal Arctic Line; local hunters' unions **National**: Ministries of Fisheries, Hunting and Agriculture, of Nature & Environment and of Industry, Energy & Research; Greenland's Fisheries License Control Authority (GFLK); Greenlandic Institute of Natural Resources; Fishermen' and Hunters' Organization (KNAPK); Danish authorities (>3 nautical miles)
Informal governing institutions	**Local**: whale watching companies; fishermen; citizen and business pressure groups; universities; researchers; whale watching guides **National**: media; political parties; fishing and whaling industries; ENGOs	**Local**: whale watching companies; fishermen and fishing companies, universities; researchers, businesses, investors **National**: media, political parties, fishing and whaling industries; ENGOs	**Local**: hunter/fishermen groups; whale watching operators; hospitality sector; fishing companies; community social media sites **National**: political parties; fishing and tourism industries; media

Figure 3 shows the locations of the three case studies in Greenland, Iceland and Norway.

Figure 3. The geographical locations of the three case studies. Adapted from Google Maps (2021).

5. Results

The results are structured in the following way: firstly, the overview of the key whale ES are listed, together with the main co-production processes and values; secondly, the results of the assessment of SG properties are summarised; then the components of interactive governance are assessed according to the criteria outlined in the methods' section and its guiding questions are listed at the beginning of each sub-section for clarity; finally, at the end in the results, the overall outcomes of the governability assessment are summarised.

5.1. Whale ecosystem services and their values

Table 4 presents the main whale ES identified by the interviewees as well as co-production activities and values associated with them. The percentages of ES values in the bottom row are based on the respective number of mentions by the interviewees. Biophysical values were most prominent in Disko Bay in the form of nutrition and food security; monetary values that refer to gains from economic activities related to whale ES; and socio-cultural values – to non-material and relational values held by people towards nature in this case – the less tangible values mostly related to cultural whale ES, such as community identity and inspiration for arts (Martín-López et al., 2014; Stålhammar & Thorén, 2019; van Riper & Kyle, 2014).

Table 4. Whale ES, their co-production activities, and values.

	Húsavík	**Andenes**	**Disko Bay**
Key **whale ES** in each community	Recreation and tourism Education Aesthetics Ecosystem regulation and biodiversity enhancement	Recreation and tourism Education Aesthetics Ecosystem regulation and biodiversity enhancement Provisioning	Provisioning Recreation and tourism Aesthetics
Key **co-production activities** of whale ES	Whale watching operations Academic research Whale museum and school program Whale-inspired art	Whale watching operations Promoting local tourism The Whale museum project Academic research	Hunting activities Traditional cultural practices, such as food and art Whale watching operations Sharing whale pictures on community social media
Main **values** attached to different whale ES	Monetary (88.9%) Socio-cultural (55.6%)	Monetary (93.3%) Socio-cultural (80.0%)	Nutrition and food security (94.7%) Monetary (78.9%) Socio-cultural (78.9%)

While in Húsavík and Andenes recreation and tourism, education and aesthetics ES were most often mentioned, provisioning ES and hunting were the most discussed in Disko Bay. The main ES values in the first two case studies stem from the local economic benefits of whale watching, followed by education, aesthetics, ecosystem regulation and biodiversity enhancement, and socio-cultural values associated with them: "*in 2013, tourism became the biggest economic sector in Iceland, and whale watching became the best-selling and most important entertainment activity in the tourism sector*" (I9[4]). In Disko Bay, provisioning whale ES are mostly associated with nutritional and economic values, but they often also have a socio-cultural dimension, especially in terms of identity: "*It's a part of our identity, it's how we see ourselves*." (G2).

[4] The letters refer to the case studies countries, in which the interviews were taken: G – Greenland, I – Iceland, N – Norway. All interviewees were numbered randomly for each case study.

5.2. Prevalence of properties of systems-to-be-governed

Table 5 summarises the results of the assessment of SG properties and the corresponding levels of governability, as per the explanation in the methods section. Based on analysis of the SES properties, the governability of whale ES in Húsavík and Andenes was estimated to be moderate, and in Disko Bay – low. In the following sub-sections, the properties of the three SES are discussed based on the interview data. Social-ecological complexities, including actors' needs, problems and trade-offs between activities are discussed in most detail as they largely determine the problems to be solved by interactive governance.

Table 5. The level of the properties of the systems-to-be-governed.

	Húsavík	**Andenes**	**Disko Bay**
Level of SES **diversity**	Diversity – moderate because of socio-demographic factors	Diversity – low because of both social and biological factors	Diversity – moderate, mostly because of diversity of species and activities in the bay
Level of SES **complexity**	Complexity – moderate because of different activities and their multi-layered effects on whales, and few manageable conflicts	Complexity – low because of limited ecological and social interactions, and relatively few conflicts	Complexity – high because of multiple whale species and activities in the bay, together with many arising conflicts
Level of SES **dynamics**	Dynamics – high due to the high rate of socio-economic change, changes in attitudes and in whale species observed	Dynamics – moderate because of the military base closure and changes in observed whale numbers	Dynamics – high due to high rate of changes in whale species observed, hunting practices and rapid societal change
Scale	Governance of whale ES mostly happens locally, but presence of whales depends on global processes	Governance of whale ES mostly happens locally, but their availability depends on global processes	An interplay between global, national and local scales, especially in whaling, but whale ES depend on global processes
Overall governability based on SG properties	*Moderate – due to medium/high prevalence of properties but global nature of whale ES*	*Moderate – mostly due to the global scale of processes underlying whale ES*	*Low – because of high complexity and dynamics and the global nature of whale ES*

5.3. Diversity

- *Types of ecosystems and habitats that are presented*
- *The demographics of stakeholders*

The interview data finds supportive evidence that all three SES present low to medium levels of complexity and diversity when compared with some more biologically and culturally diverse systems with more species and actors nearer the equator (Bavinck & Kooiman, 2013). There are typically a few main whale species observed and utilised in the case study locations. Humpback, fin, minke, killer and pilot whales are typical in all case study locations, depending on the season, while blue whales are more often observed in Skjálfandi Bay. Belugas, narwhals and Greenlandic whales are found in Disko Bay, and sperm whales – near Andenes.

The populations of the three case study communities are relatively homogenic, however, socio-demographic diversity is gradually increasing in Húsavík and Andenes in tandem with the expanding tourism sector. This is less the case in Greenland where foreign workers mostly come in the summer months and leave afterwards without much interaction with the

locals. In all three SES, the local actors have diverse interests, while the recorded diversity of attitudes towards whales, especially intergenerational, is more typical in Húsavík than in the other case studies. Relatively low economic diversity was observed in all three SES. In Disko Bay, a high diversity of hunters' livelihood strategies in response to hunting regulations and seasonal availability of resources was observed.

5.3.1. Social-ecological complexity

- *Linkages between species, ecosystems and habitats*
- *Level of cooperation and/or conflicts between stakeholders*

The complex ecological ties between whaling, fishing and fish stocks are under-researched and not agreed upon between actors and even experts: "you can't blame one species in a web of millions of interactions" (I1). Several different activities take place in the marine environments of all three case study locations, including whale watching, fishing and shipping. The latter activity was especially pronounced in Húsavík in relation to the then new silicon plant Bakki where interviewees discussed multi-directional and multi-layered effects of tourism and heavy industry on whales and local ecosystem.

The SES complexities mentioned in Andenes included the many co-existing activities in the local waters, including minke whaling, whale watching and seismic exploration as well as differentiated effects of human activities on different whale species. High complexity was observed in Disko Bay due to multiple interactions between tourism, fishing, hunting and shipping. Movement of whales along the coast of Greenland makes their populations difficult to distinguish from one another and to assess impacts of human activities. Complex social issues related to the outmigration of women, gradual loss of traditions and difficulties of getting local workforce were also discussed in Disko Bay.

The main actors identified during the stakeholder mapping in all three SES presented in Table 5 include whale watching operators and guides, local authorities, citizens, visitors, fishing and other industries. The Greenlandic case study stands out because here the most often mentioned actors were hunters who are also fishermen, since there is no distinction between the two in Greenlandic culture (Caulfield, 1993; Suydam & George, 2021).

Table 6. Main actors, their needs and problems.

	Húsavík	**Andenes**	**Disko Bay**
Actors/ stakeholders	Whale watching operators and guides Local authorities Local citizens Visitors Researchers Fishermen Whale museum Heavy industry	Whale watching operators and guides Local authorities Local citizens Visitors Fishing industry Oil industry Museums	Hunters/fishermen Local municipalities Local citizens Visitors Scientists Whale watching operators State and local authorities
Actors' **needs** and **problems**	**Regulatory**: lack of non-consumptive marine resource management and regulations on marine activities **Tourism**: unsustainable tourism practices and mass tourism; bureaucracy of	**Regulatory**: lack of formal regulations and enforcement on marine activities **Tourism**: high tourism seasonality; decreasing sperm whale sightings; need for staff training in whale watching, better tourism	**Regulatory**: bureaucracy and weak enforcement of hunting rules; ineffective communication between scientists and hunters; insufficient whaling quota; a need to revise national fishing policy

	transportation authorities; high tourism seasonality; need for better infrastructure and more cooperation in the local tourism sector **Research**: lack of research funding and data on accumulative anthropogenic effects on whales **Societal**: housing shortage; **l**ack of integration of foreign workers in community **Environmental**: need to protect local marine ecosystem **Economic**: need for more investment in the local economy and more locally residing year-round taxpayers	infrastructure and transport connections **Research**: lack of baseline research on local marine species and research funding **Societal**: loss of jobs due to departure of the military base **Environmental**: uncertainty caused by climate change **Economic**: need for more locally residing, year-round taxpayers	**Tourism**: need for investment in local tourism and infrastructure; mass tourism and cruise ships; high tourism seasonality; lack of local workforce, regional tourism strategy and harbour space in Ilulissat **Societal**: loss of traditional knowledge; housing shortage; outmigration of women; government corruption **Environmental**: uncertainty caused by climate change; overfishing by nets

The threats posed to whale populations by accumulative anthropogenic effects, such as climate change, bycatch and pollution, were present in all case studies. The fast rate of biophysical change in the ocean causes sudden whale species shifts. There is little systematic research on accumulative anthropogenic effects, and the interview data indicates a need for such research as well as baseline research for some whale species: "*You need baseline data, you need to know what's there, how many they are, what's the trend of the populations, what do they eat and what's important to protect to preserve these species.*" (N6)

Lack of formal whale watching rules and enforcement mechanisms presents challenges in all three locations: "*everybody's interested in going to see the whales year after year after year because that's a part of the business plan. But at the same time, you have no regulations or no policies."* (N13). Other problems common to all case studies include high tourism seasonality, lack of local tourism infrastructure and regional tourism planning: "*we need to have cooperation, we need to have strategy plans, we need to have strict policy how we are doing it*" (N12). A shortage of research funding and locally residing taxpayers were identified in Húsavík and Andenes, while uncertainty caused by climate change and lack of cooperation between local actors in tourism was evident in Andenes and Disko Bay.

Due to the indigenous whaling component, some additional problems were identified in Disko Bay, such as a need for more inclusive monitoring of whale populations: "*Listen more to the hunters, not scientists, because they are visiting for a short time, but the hunters live here. Their lifestyle is based on what they know, what they observe from year to year*." (G20). It was also mentioned that climate change and hunting regulations make it increasingly difficult for hunters to provide for themselves. The lack of local participation in the growing tourism sector and the need to take traditional knowledge into consideration in governance were also discussed: "*it must be possible to have more commitment or more understanding and more collaboration between the hunters and the government or any other [actors]. Because traditional knowledge is also very important*." (G4). Another need expressed in Greenland was for more whale meat that has historically been an important part of local

nutrition: "*We can eat much more meat and mattak from the whales you find on Greenland's coast. It's a problem for the Greenlandic people that we must not shoot the whales in our coast. It's a big problem*." (G16)

Most often mentioned trade-offs were related to possible negative effects of whale watching on whales. In the Icelandic interviews, the trade-off between provisioning and other whale ES was named by five interviewees, in Greenland – once, and not at all in Norway. The conflicts and trade-offs between actors' activities and needs are listed in Table 6. The common conflicts include rivalry between actors for harbour space; negative effects of heavy industry, oil exploration and the military on local marine ecosystems; conflicts between the whale watching operators about resources or whale watching methods; and the negative effects of mass tourism on the nature and quality of life, especially in regard to cruise ship tourism: "*The cruises are not so welcome, somehow, because compared to the number of tourists they have, they don't spend so much money in destinations, and the pollution they make is more than average*." (G9)

Table 7. Conflicts and trade-offs between stakeholders' needs and activities.

	Húsavík	**Andenes**	**Disko Bay**
Conflicts and trade-offs	**Tourism**: some whale watching companies reluctant to pay local tax; **l**ocals getting tired of large numbers of tourists; housing crisis caused by expansion of tourism; some whale watching captain conflicts at sea; competition for harbour space; fishermen feel pushed out of the harbour and local economy by whale watching **Whale ES trade-offs**: whaling and whale watching debate in Iceland; negative effects of whale watching and marine traffic on whales **Industry**: disagreement between locals about industrial development	**Tourism**: the conflict between the two local whale watching companies; disagreements between actors about the code of conduct in whale watching **Whale ES trade-offs**: whale watching vs. whaling debate in Norway; inappropriate whale watching/snorkelling can harm whales and fishing industry **Whales vs. fishermen**: whales eating halibut off fishing lines; overfishing can cause outmigration of whales **Industry**: negative effects of marine traffic, military manoeuvres, seismic surveys on whales	**Hunting**: disagreement between hunters and government on quotas; distrust between hunters and scientists**; c**onflicts between hunters over customs and quotas **Tourism**: competition for harbour space in Ilulissat; foreign tourism companies perceived as not giving enough back to community; local opposition to mass tourism, especially cruise ships **Whales vs. fishermen**: trade-off between increased number of whales and fishing; whale-small boat collisions **Local vs. foreign actors**: international opposition to whaling affects local livelihoods; grievances over historical overhunting by foreign parties

In Iceland, small-boat fishermen allegedly feel pushed out of the harbour and the local economy by whale watching: "*I think the fishermen here… there was quite a lot of unhappiness about the fact that the whale watching companies were sort of taking over the harbour*." (I16). A conflict between the two main whale watching operators in Andenes negatively affects local tourism and the working environment: "*Well, in a respectful way you can benefit much more – it's easier to be out on the sea. But now it's a lot of swearing and threatening and stuff. It's not a good atmosphere to work in*." (N14)

The Greenlandic context presents a unique set of conflicts in Disko Bay related to provisioning whale ES. Firstly, there is disagreement between hunters and the national government about whaling quotas and distrust between local resource users and scientists about species' monitoring. There are also conflicts between full-time and part-time hunters over whaling quotas and between old and young hunters over hunting customs. Another conflict is caused by the increasing number of humpback whales that compete with the local fishermen for polar cod, which is used as bait for halibut. Fishermen have been seen by visitors and locals shooting at whales, which is seen by some as damaging to local tourism.

Increasing numbers of whales in Disko Bay result in more frequent whale-boat collisions and more whales being trapped in fishing gear, inevitably damaging it and often dying. Fin and humpback whales have been witnessed destroying fishing equipment, and narwhals – scaring fish away. These factors and whale meat being one of the main local sources of nutrition, historically, at times result in unfavourable attitudes towards whales: "*I think we have too many whales in the Arctic area*." (G16). Another conflict has to do with governance scale and self-determination as the international disagreements about whaling play out locally. Discontent has been expressed by Greenlandic interviewees about outsiders making decisions about their livelihoods, and hostility was expressed towards radical environmental organisations: "*If we think about our culture, if we look at the Sea Shepherd, for us those are morons. Sea Shepherd, Greenpeace – they are most respect-less people in the world. […] They are just young and stupid. Because no one can be quite the vegetarian here*." (G3)

5.3.2. Dynamics

- *Short- and long-term ecological changes*
- *Level of migration and mobility of stakeholders*

The level of SES change is high in all three locations, as is common in Arctic localities due to increased accessibility resulting from climate change and globalisation (Cole et al., 2016; Stocker et al., 2020; Young, 2010). All three case study locations experienced rapid increases in visitor numbers in the last few decades prior to the COVID-19 pandemic, and the local marine ecosystems are affected by changing whale migration patterns due to changing availability of prey and extent of sea ice: "*All living resources are moving up, north, slowly moving. We are now forced to sail further up north to hunt, also because the ice in winter becomes thinner*." (G20)

In both Norway and Iceland, diminishing importance of whale meat as a source of nutrition was mentioned as well as changing public attitudes towards whales, partially due to the rapidly growing whale watching sector. In Húsavík, rapid changes in economy and community identity were mentioned as result of the shift from a resource to service-based economy. This change is also related to the increase in research activities in the local university centre and influx of foreign workers. In Andenes, socio-economic change was discussed mostly in relation to the closure of the local military base and increase in tourism.

In Disko Bay, reduction in whaling quotas, changes in formal hunting rules and resulting reduction in availability of whale meat were discussed. Hunters discussed the erosion of customary rules occurring among the new generation of hunters, development of hunting equipment, local effects of climate change, e.g., reduction in winter sea ice, and the shift from hunting to fishing in the recent decades. Rapid change in the Greenlandic society in terms of lifestyle, culture and economic opportunities indicate a high rate of social dynamics.

5.3.3. Scale

- *The range and the representativeness of the ecosystem*
- *The social, cultural and ethnic boundary of stakeholders*

The focus on highly migratory cetaceans puts the study in a global context, and their longevity means that whale ES governance unfolds over large geographical and temporal scales. For instance, the whaling restrictions introduced by the IWC's 1986 moratorium on whaling started to bring results over the decade, e.g., through visible increases in humpback whale populations in the Arctic. However, actors tend to use short-term timescales to reach their immediate goals, and local institutions dealing with the immediate effects of changes often have little power to influence long-term governance. This creates a scale mismatch: "*Our fishing policy has not been revised in 20 years, so it's too old now. We need a fishing policy that looks forward long time in the future*." (G16)

The governance of whaling is determined largely on a global scale but plays out on national and local scales, which is especially evident in Disko Bay. International bodies, such as the IWC, have a lot of decision-making power, while indigenous whalers do not always feel that global governance reflects their needs, values and interests: "*They have never seen a whale, they know what a whale is, and the whales, in my eyes, is only meat […] IWC is a very powerful organisation and they tell us how many different kinds of whales we should shoot per year*." (G16). A similar sentiment was expressed about the climate change policy: "*Greenlandic people talk about the climatic change: we can see it, we can feel it, we can mark it, but it's a big policy in the world. Greenland is just a little part of it*." (G16)

5.4. Governing systems

Table 8 lists the main elements of the three governing systems – vision, instruments and actions – based on the interviews, together with final results of the governability assessment, explanations for which are provided in the following sub-sections.

Table 8. The main governance elements of the three governing systems.

	Húsavík	**Andenes**	**Disko Bay**
Governance **vision** (meta order)	**"what"** Sustainable tourism sector Protection of local resources Increased public awareness of local ecosystems and whale ES Diverse local economy Young, vibrant and diverse community **"how"** Science-based governance Participatory co-governance Adaptive governance	**"what"** Small scale sustainable tourism Protection of local resources Coordinated regional development Four local economy pillars: fisheries, tourism, technology, and "good life" Increased public awareness of the local marine ecosystem Young and vibrant community **"how"** Flexible, adaptive and research-based governance Local citizen-led innovation	**"what"** Protecting the local resources Respecting hunting traditions Coordinated regional sustainable tourism development Diverse local economy **"how"** Fewer hunting restrictions Environmental stewardship Science-based governance Holistic, inclusive and cooperative local governance Inclusion of traditional ecological knowledge (TEK) in governance
Governance **instruments** (second order)	**Formal** Whale sanctuary Whaling quotas Harbour fees State monitoring of whale	**Formal** Holistic local and regional economic development strategy Whaling quotas	**Formal** Whale watching rules set by the municipality Whaling quotas Hunting licences for free-

	populations **Informal** Code of conduct in whale watching Educational campaigns	 **Informal** Code of conduct in whale watching Educational campaigns	time and full-time hunters State monitoring of whale populations Tax duty for tour operators **Informal** Customary hunting rules Joint participatory research
Governance **actions** (first order)	**Local actor-driven** Actor cooperation Knowledge sharing, e.g., through Whale Congress Advocacy for an MPA Making tourism operations more sustainable and diversifying its products **Partially externally driven** Scientific research Infrastructure and industrial development	**Local actor-driven** Actor cooperation Knowledge sharing internationally Making tourism sector more sustainable, reducing scale and diversifying its products Developing The Whale project Attracting investment **Partially externally driven** Scientific research Infrastructure development	**Local actor-driven** Actor cooperation Adapting to change by diversification of hunting and tourism activities **Partially externally driven** Scientific research Improving and limiting whaling methods Infrastructure development Freeing whales caught up in fishing gear

In addition to the governance visons expressed by the interviewees, overarching NAMMCO principles discussed by the representative interviewed are common to all case studies as they are all members of the organisation. These principles include: basing governance on best available scientific evidence; implementation of ecosystem-based management (EBM) principles; including anthropogenic effects in modelling and governance; researching and addressing the bycatch problem; fair representation of all marine mammal ES user groups and their worldviews and values, including TEK in governance; making relevant governance information accessible to stakeholders; promoting sustainable whaling practices among NAMMCO members, advancing technology to minimise animal suffering and supporting the Blue Growth agenda of sustainable use of marine resources (Burgess et al., 2018).

5.4.1. Goodness of fits of elements

- *Appropriateness of the governing elements in moving towards desirable outcomes*

The desirable governance outcomes common to all three SES included protecting the local resources, at the same time as expanding the tourism sector and making it more sustainable, developing local infrastructure and diversifying local economies (Table 8). Protection of whale resources was a part of the governance vision in all three case studies: "*the main concern here is: don't disturb the narwhals, don't disturb the belugas… don't disturb our food resource*" (G1). The education and involvement of the public has also been emphasised: "*the public should take care of this in an active way and manage the use of marine natural resources in a sustainable way, not unlike national parks*" (I9). Especially in Greenland and Norway, a vision of small-scale and high-end tourism was pronounced: "*We're not out to get the most tourism, but we want to have the right tourists, the ones that appreciate the nature and the experience. And I think it's very important as well to find that balance as well, not to overdo it*." (N9). In Andenes this vision was supported by a regional tourism development strategy, while this was not the case in Disko Bay. Infrastructure development was ongoing in all case study locations but was described as slow.

Willingness to stay flexible in pursuit of the governance vision and adaptable to change is an aspect of the governance vision that is common to all case studies: "*We just take things as*

they come – we are very flexible. So, there comes some good with it and it's also some bad, because you actually don't have a common goal." (N13). The identified lack of baseline research on whale populations makes the vision of science-based governance unrealistic. Actor cooperation was present in all case study locations as a means to achieve governance goals, which indicates ability of actors to self-organise. This was less true in Disko Bay where hunting rules are binding decided outside the SES and the tourism sector is more fragmented.

The governance objective of protecting whale resources and sustainable tourism is partially reflected in the existing instruments, especially related to whaling quotas and state monitoring of whale populations, but there are few binding regulations regarding non-consumptive whale ES. Some of the governance actions, including cooperation between actors, knowledge sharing and voluntary improvements in whale watching methods, aim to bridge the gap between governance vision and reality, but the observed fit of elements does not suggest high governability in either of the case studies. Flexibility in vision was fulfilled to a much larger extent as actors have space for that in the absence of formal rules and regulations.

Based on this this evidence, the goodness of fits of elements in Húsavík and Andenes implies moderate governability due to relative correspondence between the expressed visions, instruments and actions, and in Disko Bay – low governability, mostly owing to the inadequacy of governance instruments and actions for fulfilling the governance vision identified in Table 8.

5.4.2. Responsiveness of modes

- *The effectiveness of governance modes and its ability to respond to governance challenges*

In Húsavík, the main governance challenges expressed by the actors in relation to whale ES were the exponential growth of the tourism sector, lack of research to better understand the effects of this expansion and lack of infrastructure that could accommodate activities of all actors in the harbour. The dominant governance mode by which these challenges were addressed in this community was self-governance, mentioned by most (72.2%) of the interviewees: "*The code of conduct here in the bay has been developed by us ourselves*." (I9). Despite some calls for stricter binding regulations in whale watching and creation of a local MPA, hierarchical governance does not seem to be the preferred governance mode among actors who mobilised to self-govern. The university research centre cooperates with whale watching companies in order to address some of the identified research gaps. The harbour infrastructure is managed by the local government, which is a subject to pressures from local interest groups. This makes hierarchical governance more difficult, but most issues are being addressed.
On the basis of this evidence, the rather high effectiveness of governance modes in Húsavík implies high governability in regard to these criteria.

In Andenes, the main governance challenges discussed by the interviewees were related to uncertainty caused by climate change, lack of binding regulations in whale watching, a need for better cooperation in local tourism development and the need for baseline research on the local marine ecosystem. At the time of this study, the dominant governance mode in which these challenges were addressed was self-governance in the whale watching sector but there was a gap in rule enforcement. Co-governance prevails in the local tourism sector, a strategy

for which is being developed and implemented by the local government in cooperation with concerned actors. The research on local whale populations, however, remains sporadic and is done by individual researchers that have to secure their own funding. In this area, the self-governance has not been effective in filling this gap.
On the basis of this evidence, the effectiveness of governance modes in Andenes is low to medium, as it only partly meets the needs and problems expressed by the actors, which implies low governability.

In Disko Bay, the main whale ES governance challenges mentioned by interviewees relate to the lack of infrastructure, actor cooperation and involvement of locals in the tourism sector, uneven distribution of tourism seasonally and geographically, and uncertainties caused by climate change. Self-governance was the prevailing mode when addressing the challenges in tourism, while all three modes are present in co-production of provisioning whale ES through hunting activities, which are governed by international bodies, state and customary rules. Creation and implementation of a regional tourism strategy and inclusion of locals would require more co-governance in the tourism sector in Disko Bay, while state hierarchical governance may be required to address infrastructure needs. In terms of hunting, the top-down approach to hunting regulations is not acceptable to all actors, some of which advocate for more co-governance initiatives through joint projects, such as PISUNA (2020).
On the basis of this evidence, the effectiveness of governance modes in Disko Bay is judged to be moderate, implying moderate governability according to this criterion.

5.4.3. Performance of orders

- *The capacity of the governing orders to function, operate and lead to desirable outcomes*

This section briefly looks into how the whale ES values and principles of meta governance in each study location expressed by the interviewees are reflected in practice (Table 8). The NAMMCO principles are reflected to a moderate degree in Húsavík and Andenes, but to a low degree in Disko Bay, mostly owing to the limited extent to which the values held by local whale resource users are integrated in decision-making. In Húsavík, clashing worldviews between fishing and whale watching communities were observed, implying a lack of shared image in whale ES governance. Tools, such as EBM, are not yet applied in whale ES management in the case studies and inclusion of locals in the tourism development in Disko Bay remains limited.

In terms of whale ES values expressed by stakeholders in Húsavík, monetary values sourced from whale watching prevail. These values are at least partly reflected in the decision of the Icelandic state to declare Skjálfandi Bay a whale sanctuary. Differing priorities of the institutions responsible for marine governance in Iceland, especially fishing and tourism sectors, add to the governance complexity in Húsavík as their different meta governance values are competing. This is also reflected in the clash between the worldviews of fishermen and whale watching operators. The vision of a healthy local marine ecosystem that supports the presence of whales and whale watching has little embeddedness in the second order of governance, as there are no binding rules to ensure the protection of whales in Skjálfandi Bay. However, the first order self-governance by local actors, including whale watching companies and researchers, respond to the values of environmental sustainability. They include but are not limited to cooperation and knowledge sharing, advocacy for a local MPA and increasing sustainability of whale watching operations, e.g., by the introduction of electric boats.

This implies moderate level of governability based on the functioning of governance orders.

Economic values of sustainable small-scale tourism based on healthy whale populations, research-based governance and actor cooperation were the most pronounced meta governance values in Andenes. These values are regionally rather than nationally based, and whale watching is viewed as the main tourist attraction benefitting the whole of Vesterålen region. The commencement of The Whale project confirms its importance, yet there is little research to date on the local cetacean populations and no binding rules to protect them from human activities, excluding whaling. The local whale watching operators share an interest in ensuring the sustainability of their activities, but not a consensus on how to do it. The second order – institutional setting – is largely missing as there is no formal managing body governing this activity, leaving it up to the actors to manage their day-to-day activities. Unlike in Húsavík, tour operators in Andenes do not agree on best practices, and even though some research exists on the impacts of human activities on whales, firstly, it is not decisive, and secondly, there are no legal enforcement mechanisms to ensure that scientific advice is followed.
Based on this, the governability of whale ES in regard to governance orders is judged to be low.

In Disko Bay, the main values associated with whale ES are related to nutrition and food security, followed by economic and symbolic values related to provisioning ES. Whale watching plays a less important role in tourism here than in the other two case studies. There is an apparent clash between the globally dominant "Western" and local worldviews and values related to whale ES. This is also true in other whaling countries, but it came up more often in Disko Bay due to the importance of whale meat for local culture and nutrition. The meta values of sustainability and respect for nature here include responsible use of marine resources, including when whaling, and they are also reflected in NAMMCO principles. The indigenous whaling quotas and species monitoring reflect both Western and local values, yet some local actors argue that their values and knowledge are overlooked in the second order of governance.
The fact that indigenous whaling takes place in Greenland and that most of local whale populations are recovering, indicates moderate level of governability based on the effectiveness of governance orders.

5.4.4. Governance interactions

- *The existing forms and qualities of the governance interactions, including representativeness, effectiveness of communication and level of information flow*

The most common governance interactions embedded in the elements (Table 8) include those within and between whale watching companies at sea; research activities and communication of their results to actors and the public; adaptation to social-ecological change by altering ES co-production processes, e.g., by diversification of tourism and hunting; regional development planning to address local needs; monitoring of whale populations in Greenland and MPA advocacy in Húsavík. Information flow seems to be rather effective between local actors participating in governance interactions, with the exception of Andenes where the two local whale watching company owners are in conflict. Communication is somewhat less efficient between scales: there is some mismatch between national and local governance priorities, and the link is even more severed between local and global scales, as is shown by the example of indigenous whaling in Greenland and global discontent with it.

The interviews reveal that much of whale ES governance happens through informal interactions between whale watching operators, researchers, local citizens and hunters' groups. due to the absence/inadequacy of institutional framework for addressing governance needs, actors self-govern, and many of these interactions remain unrecorded and often underrepresented in formal institutions. This is true for certain hunting and whale watching activities where hunters and captains cooperate to protect local marine ecosystems. Disko Bay stands out somewhat in this regard due to the presence of indigenous whaling. Hunting licenses are set by the government for full- and free-time hunters, and traditional customary rules are in place in hunters' groups. Technological advances and recommendations by NAMMCO and IWC have resulted in improvements to hunting methods, and joint participatory research projects, such as PISUNA (Cuyler et al., 2020; PISUNA, 2020), contributed to more of a more inclusive approach to species monitoring.

A number of implications of governance interactions for power relations came up in the interviews in Iceland and Greenland. In the former, they included the historical privilege of the fisheries' sector in Icelandic marine policy, regional inequalities resulting from introduction and eventual consolidation of individual fishing quota in the 1990s and the lack of integration of foreign workers into the local community. In the latter, the lack of political power by Greenlanders internationally regarding the use of local natural resources and historical whale overhunting by foreign parties were the most discussed power inequalities: "*I think that Greenlandic people are more interested to shoot and eat whales, because it's the animal we have in our area, in our coast. What would you think if your government one day said [that] you must not eat pork in your country? Or the chicken?*" (G20)

Among other inequalities discussed in Greenland were uneven whaling quota distribution based on political power within the country, the fact that tourism is mostly run by foreigners and whale meat is not affordable for poorer members of society. In terms of gendered issues, male dominance in whale ES co-production and the identity struggle of non-educated men as hunting loses its importance were discussed in Greenland, and the fact that female researchers are not always taken seriously. In Iceland: "*there were mainly middle-aged white men there, and they [female researchers] asked questions like 'Aren't you concerned about the whales?', and they were actually laughed at during the meeting, because it's not important […] because you're emotional and you're a woman and you're not... wearing a tie*." (I10)

Based on the discussion above, the governance interactions in Húsavík were judged to have moderate presence and high qualities in terms of representativeness and effectiveness of communication between actors, implying high governability. In Andenes, governance interactions had moderate presence but comparatively low qualities, mostly due to the lack of effectiveness of communication between actors, implying low governability. In Disko Bay, the governance interactions are many and they somewhat lack representativeness and information flow between actors, implying low level of governability based on governance interactions.

5.4.5. Overall results of the governability assessment

In Table 9, the results of the governability assessment of whale ES in the three case studies is summarised. Based on the discussion about the criteria above, the overall governability of whale ES was assessed to be the highest in Húsavík, where it was judged to be moderate to high, while it was judged to be low to moderate in Andenes and Disko Bay, simply by summing up the results of each criterion assessment outlined in each section.

Table 9. Results of the governability assessment of the three case studies. Table template adapted from Chuenpagdee et al. (2008, p. 17).

	Level of governability		
Governability criteria	**Húsavík**	**Andenes**	**Disko Bay**
For a system-to-be-governed: - prevalence of properties	Moderate	Moderate	Low
For a governing system: - goodness of fits of elements	Moderate	Moderate	Low
- responsiveness of modes	High	Low	Moderate
- performance of orders	Moderate	Low	Moderate
For governance interactions: - presence of gov. interactions	High	Low	Low

Overall, the Húsavík case study had the highest level of governability as the governance modes were judged to be relatively responsive to challenges at hand, especially in terms of self- and co-governance, while the SES itself was characterised by moderate diversity and complexity, increasing its governability. The quality of governance interactions and effectiveness of communication between stakeholders largely determined this result. The overall governability of whale ES in Andenes was judged to be low as neither the governance modes nor performance of orders corresponded sufficiently with the governance vision communicated by stakeholders, even though relatively low diversity and complexity of the system and moderate fits of governance elements increased its governability. The high rates of complexity and dynamics in Disko Bay resulting from pronounced effects of social-ecological change and multiplicity of actors, poor fit of governance elements and limited number of observed governance interactions which were often affected by mismatch in scale, resulted in its governability being judged as low. However, the main value of this exercise lies in the identification and discussion of the governance components and issues rather than its final outcomes.

6. Discussion

6.1. Significance of the governability assessment results

The results of the governability assessment are more indicative than conclusive and could be used to identify areas for improvement (Chuenpagdee et al., 2008). It presents a potentially useful thought exercise for thinking about multifaceted SES governance. Whale ES only constitute a small part of the three SES explored, but their governability assessment uncovers some parts of the social-ecological interplay that can be addressed through carefully designed governance tools. For instance, if responsiveness of governance modes is low, additional tools could be introduced, e.g., facilitating better links between actors at different levels or introducing binding regulations where self-governance is sufficient to ensure sustainability. To the best knowledge of the authors, the study presents the first attempt to apply the IG model to whale ES and is one of the first to apply the framework outside fisheries governance. The detailed exploration of whale ES governance and governability through analysis of a rich dataset provides more focused analysis than previous global studies of entire resource systems, e.g., by Chuenpagdee et al. (2008) and Jentoft and Chuenpagdee (2015).

The different stages of whale ES co-production activities discussed in the study involve numerous governance interactions and present various governance perspectives and challenges. For instance, the value attribution stage (Fig. 2) depends to a large extent on the value context of a particular SES: what in one location is seen as an opportunity for tourism

development can be perceived in another context as a food resource, and in the third – as both. Whale ES present a unique and difficult-to-predict part of Arctic marine resources due to their migratory nature and uncertain effects of climate change. Most of the co-production activities discussed are altered following the biophysical, socio-cultural and economic changes related to whale ES. The body of literature focused on whale ES has been growing steadily, partly owing to the global focus on biodiversity conservation and nature-based solutions to climate change (Chami et al., 2019; Cunningham et al., 2012; Malinauskaite et al., 2021). These constant dynamics imply a need for governance to be adaptive, but at the same time reduces the governability of whale ES. The governability assessment also revealed the importance of considering local contexts in ES co-production and governance scale interplay, such as in the case of whale hunting and monitoring in Disko Bay.

6.2. Extent to which stakeholder values and needs are reflected in governance

The common goal in whale ES governance that emerged in all three case studies was the need to ensure the sustainability of whale populations in the Arctic. It stems from the multiple whale ES values and gives their governance a unified vision – healthy marine ecosystems that are able to sustain local whale populations and human wellbeing. This vision can be potentially advanced by applying the concepts of ecosystem stewardship and EBM that encourage communities to engage in environmental protection outside formal institutions and markets (Chapin et al., 2015; Folke et al., 2016; Roman et al., 2018). In whale watching, the actors manage their activities according to company and customer values, while in whaling the rules are guided by science and imposed from outside of the SES. The values attached to healthy marine ecosystems are reflected in governance to a limited extent as marine ES conservation measures in the case study locations are very few.

The example of how strict whaling quotas resulted in large increases in humpback whale numbers in Disko Bay shows how a governance tool designed to solve one problem can create another. Abundance of whales, perceived as a positive outcome globally, can create problems for some coastal communities, resulting in conflicts (Bridgewater, 2003). This is but one example of how clashing worldviews and values attached by different actors to ecosystems play out locally. It seems that in this case, the "Western" view of a whale as a majestic animal that should be protected is reflected in formal governance to a greater extent than the local perception of whale as a food source or competitor for fish (Einarsson, 2009; Huijbens & Einarsson, 2018; Kalland, 1994). This point touches upon the fact that while some governance mechanisms respond to some actors' needs and values, they may clash with others, presenting ES trade-offs. This fact that has been in observed in the natural resource governance literature (Alexander et al., 2016; Moynihan et al., 2011) and essentially means that many governance instruments will create winners and losers.

It is also important to consider how ES benefits are distributed between actors and how power is shared (Berbés-Blázquez et al., 2016; Solé & Ariza, 2019). The historical injustices related to overharvesting of whales by foreign parties in Greenlandic waters is still acutely felt (Caulfield, 1993; Rud, 2017). Moreover, some actors felt that the nation's ability to ensure food security using local resources is compromised by the decisions made by external actors in international organisations, while their needs and values have not been considered sufficiently. This view of the Arctic and its indigenous communities as a "periphery" that is best managed by greater and presumably more competent outside parties is often noted in Arctic governance literature (Freeman, 1993; Nuttall, 2005; Young et al., 1994). In terms of the distribution of economic benefits from whale watching, the tour operators benefit the most, leaving the local communities to take up some of the cost of rapidly expanding tourism,

especially in Húsavík and Disko Bay. This has also been witnessed in other Arctic locations, especially in relation to cruise ship tourism (Kaiser et al., 2018; Olsen et al., 2020; Stewart et al., 2015).

6.3. Relevance for Arctic marine resource governance

The governability assessment exercise in this study provides an example of what to look for when examining the governability of a resource or a resource system (Jentoft & Chuenpagdee, 2015). This is very timely in the context of the Arctic, the governance of which suffers from sectoral and jurisdictional fragmentation (Young, 2010, 2016). The value of approaching marine resource governance in a holistic manner lays in its potential to address sustainability concerns systematically (Chuenpagdee, 2011). Multifaceted governance of whale ES examined in this study confirms that the Arctic region is subject to dynamic social-ecological interactions and multiple interests (Hamilton et al., 2000; Vammen Larsen et al., 2019). Successful governance of the region's marine ecosystems will require acknowledgement of this complexity and designing arrangements where all legitimate stakeholders' needs are considered, the concepts of EBM and marine spatial planning are promoted, and cooperation is encouraged within, between and outside the formal institutions, such as the Arctic Council (Arctic Council, 2015; Barry et al., 2020; Young, 2010).

Meta-level governance is concerned with values, and ES valuation has the potential to inform governance vision and the choice of instruments, in line with the requirements of the Arctic Marine Strategic Plan (Arctic Council, 2015) and the Economics of the Ecosystems and Biodiversity Scoping study for the Arctic (CAFF, 2015). However, ES valuation has to take into consideration value pluralism as both ES and interactive governance scholars warn against over-simplification of ES and their values (Chuenpagdee & Mahon, 2013; Gómez-Baggethun & Martín-López, 2015). Moreover, the actor-centred approach applied in this study provides valuable insights about local resource users which are relevant for inclusive policy making, especially in the context of mixed economies, such as Greenland's (Cole et al., 2016; Vammen Larsen et al., 2019).

6.4. Study limitations and further research

The reasoning for the judgements of governability according to different components of the model are provided at the beginning of each sub-section of the results', but it inevitably involves a certain degree of subjectivity on the part of the researchers (Chuenpagdee et al., 2008; Jentoft & Chuenpagdee, 2015). Attempts were made to alleviate this rigorously by following the assessment criteria and careful analysis of the case study data. The assessment, which is based primarily on the interviews and observational data, is potentially subject to researcher bias in interviewee selection, coding and assessment of criteria (Gerring, 2004; Norris, 1997; Yin, 2017). Having said that, a well-designed case study research can reveal some general insights into the phenomena that is being studied (Flyvbjerg, 2006), and therefore some of the commonalities identified between case studies possibly reveal general tendencies in Arctic marine ES governance. A study such as this can also be subject to misinterpretation of the comparative importance of issues discussed – the fact that a certain code came up more often does not necessarily mean that a particular issue is more pressing than others. To correct for this possible problem, triangulation of data was applied (Esterberg, 2002; Flick, 2008).

The choice of IG framework and subsequent deductive approach to coding suggests certain assumptions about the subject, which does not allow for the themes to be determined

inductively, e.g., as per the grounded theory approach (Charmaz & Belgrave, 2007). However, the purpose of this study was to analyse governance through the IG lens, for which deductive coding is more appropriate (Yin, 2017). The study is based on a series of interviews with actors that were willing to share their insights at a given point in time, yet much has changed since they were conducted, not least as a result of the COVID-19 pandemic, especially its ramifications for the tourism industry. The results present a snapshot in time in three North Atlantic/Arctic locations, revealing how whale ES governed, which is illustrative but not necessarily generalisable. Future research should further examine the governance and resilience of Arctic marine ecosystems and SES, focusing more extensively on synergies and trade-offs between different Arctic marine ES, including whale ES, and different governance instruments.

7. Conclusions

The study examines whale ES co-production processes in the light of interactive governance model, providing the first governability assessment in this context. The value of the governability assessment also lies in its contribution to theory as it combines ES and interactive governance models, providing a lens through which co-production and governance of whale ES are examined. All three case study countries – Iceland, Norway and Greenland – have substantial state presence and formal governing frameworks within which local interactive governance happens. However, for cultural and regulating and maintenance whale ES, governance tools are somewhat lacking, failing to keep up with the social-ecological changes. This gap in governance is often filled by actors via self-governance. The paper presents insights into social-ecological interactions related to whale ES in the context of the rapidly changing Arctic. The multiple ways in which communities benefit from whales imply ES co-production and diverse formal and informal governance interactions. The governability assessment has revealed multiple issues in whale ES governance that could be picked up by policy makers.

The multitude and complexity of governance interactions related to ES provided by one group of species revealed in this paper implies high complexity of Arctic marine resource governance. This is a sobering realisation but also one that has the potential to guide governance to a more holistic direction, which considers its multiple aspects and engages relevant stakeholders on all levels, accounting for their needs and values. This is not an easy task, but it is neither a task for one nor a few selected entities. It is rather an invitation to view governance as an interconnected web of actors, including civil society, state and markets, that are represented by formal and informal institutions. This view supports transdisciplinary inquiry and inclusiveness in governance research in the Arctic and beyond.

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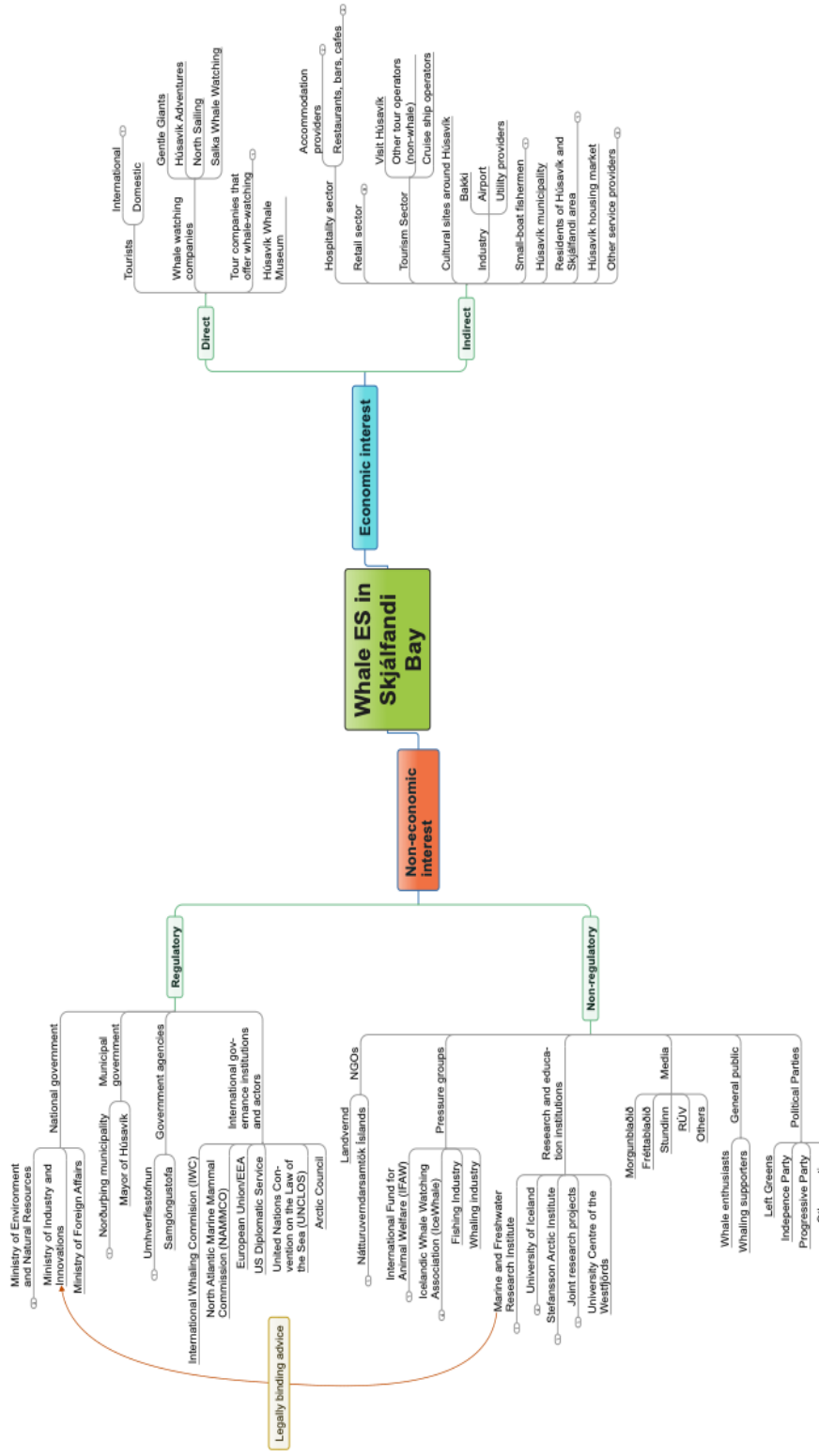
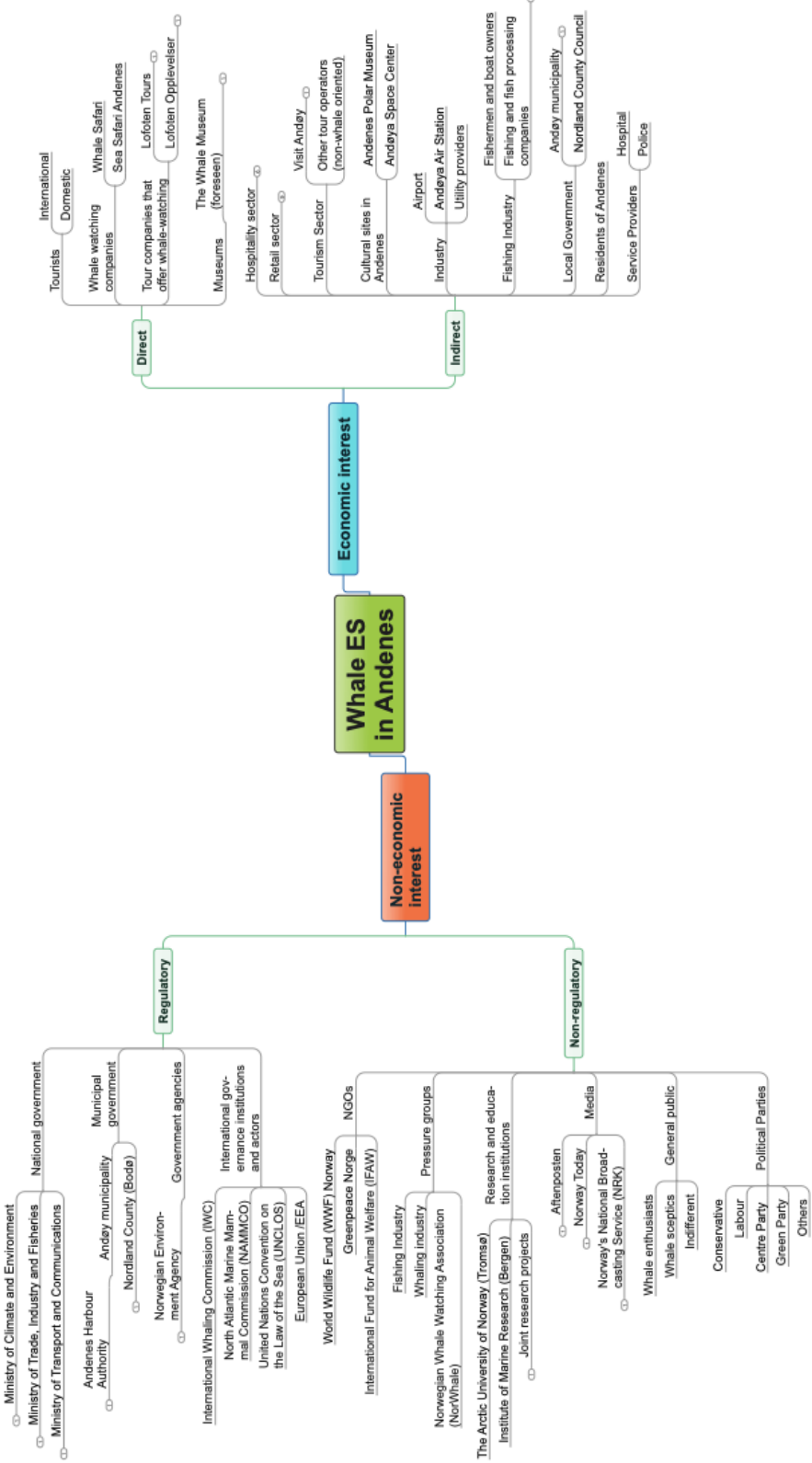
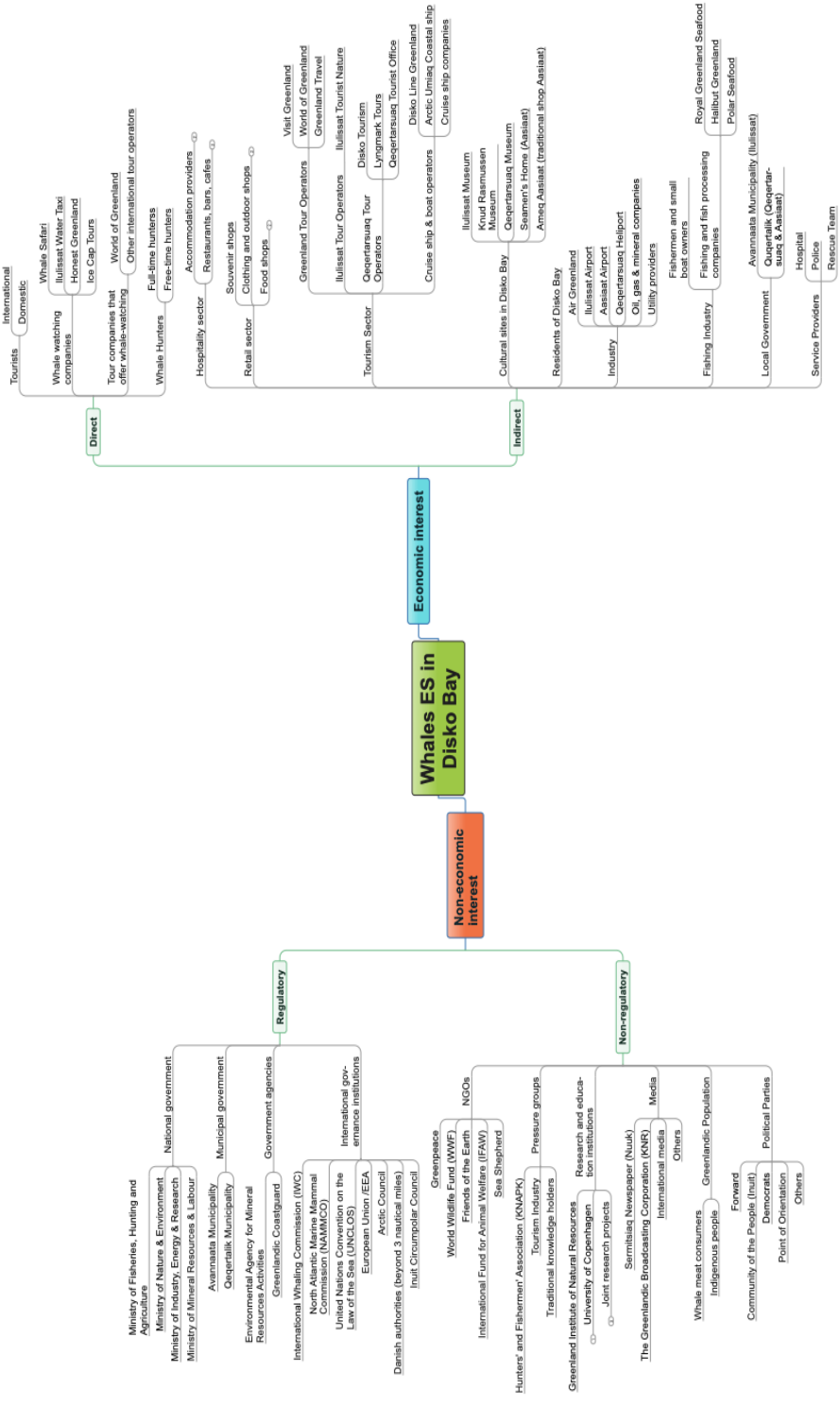
Appendix A


Whale ES in Skjálfandi Bay
Economic interest
Direct
Tourists
International
Domestic
Whale watching companies
Gentle Giants
Húsavík Adventures
North Sailing
Salka Whale Watching
Tour companies that offer whale-watching
Húsavík Whale Museum
Indirect
Hospitality sector
Accommodation providers
Restaurants, bars, cafés
Retail sector
Visit Húsavík
Tourism Sector
Other tour operators (non-whale)
Cruise ship operators
Cultural sites around Húsavík
Industry
Bakki
Airport
Utility providers
Small-boat fishermen
Húsavík municipality
Residents of Húsavík and Skjálfandi area
Húsavík housing market
Other service providers
Non-economic interest
Regulatory
National government
Ministry of Environment and Natural Resources
Ministry of Industry and Innovations
Ministry of Foreign Affairs
Municipal government
Norðurþing municipality
Mayor of Húsavík
Government agencies
Umhverfisstofnun
Samgöngustofa
International gov-ernance institutions and actors
International Whaling Commision (IWC)
North Atlantic Marine Mammal Commission (NAMMCO)
European Union/EEA
US Diplomatic Service
United Nations Con-vention on the Law of the Sea (UNCLOS)
Arctic Council
Legally binding advice
Non-regulatory
NGOs
Landvernd
Náttúruverndarsamtök Íslands
Pressure groups
International Fund for Animal Welfare (IFAW)
Icelandic Whale Watching Association (IceWhale)
Fishing industry
Whaling industry
Research and educa-tion institutions
Marine and Freshwater Research Institute
University of Iceland
Stefansson Arctic Institute
Joint research projects
University Centre of the Westfjords
Media
Morgunblaðið
Fréttablaðið
Stundinn
RÚV
Others
General public
Whale enthusiasts
Whaling supporters
Political Parties
Left Greens
Indepence Party
Progressive Party
Other parties

Appendix B


Whale ES in Andenes
Economic interest
Direct
Tourists
International
Domestic
Whale watching companies
Whale Safari
Sea Safari Andenes
Tour companies that offer whale-watching
Lofoten Tours
Lofoten Opplevelser
Museums
The Whale Museum (foreseen)
Indirect
Hospitality sector
Retail sector
Tourism Sector
Visit Andøy
Other tour operators (non-whale oriented)
Cultural sites in Andenes
Andenes Polar Museum
Andøya Space Center
Industry
Airport
Andøya Air Station
Utility providers
Fishing Industry
Fishermen and boat owners
Fishing and fish processing companies
Local Government
Andøy municipality
Nordland County Council
Residents of Andenes
Service Providers
Hospital
Police
Non-economic interest
Regulatory
National government
Ministry of Climate and Environment
Ministry of Trade, Industry and Fisheries
Ministry of Transport and Communications
Municipal government
Andøy municipality
Andenes Harbour Authority
Nordland County (Bodø)
Government agencies
Norwegian Environment Agency
International Whaling Commission (IWC)
International governance institutions and actors
North Atlantic Marine Mammal Commission (NAMMCO)
United Nations Convention on the Law of the Sea (UNCLOS)
European Union /EEA
Non-regulatory
NGOs
World Wildlife Fund (WWF) Norway
Greenpeace Norge
International Fund for Animal Welfare (IFAW)
Pressure groups
Fishing Industry
Whaling industry
Norwegian Whale Watching Association (NorWhale)
Research and education institutions
The Arctic University of Norway (Tromsø)
Institute of Marine Research (Bergen)
Joint research projects
Media
Aftenposten
Norway Today
Norway's National Broadcasting Service (NRK)
General public
Whale enthusiasts
Whale sceptics
Indifferent
Political Parties
Conservative
Labour
Centre Party
Green Party
Others

Appendix C


Whales ES in Disko Bay
Economic interest
Direct
Tourists
International
Domestic
Whale watching companies
Whale Safari
Ilulissat Water Taxi
Honest Greenland
Ice Cap Tours
Tour companies that offer whale-watching
World of Greenland
Other international tour operators
Whale Hunters
Full-time hunters
Free-time hunters
Hospitality sector
Accommodation providers
Restaurants, bars, cafés
Retail sector
Souvenir shops
Clothing and outdoor shops
Food shops
Tourism Sector
Greenland Tour Operators
Visit Greenland
World of Greenland
Greenland Travel
Ilulissat Tour Operators
Ilulissat Tourist Nature
Qeqertarsuaq Tour Operators
Disko Tourism
Lyngmark Tours
Qeqertarsuaq Tourist Office
Cruise ship & boat operators
Disko Line Greenland
Arctic Umiaq Coastal ship
Cruise ship companies
Indirect
Cultural sites in Disko Bay
Ilulissat Museum
Knud Rasmussen Museum
Qeqertarsuaq Museum
Seamen's Home (Aasiaat)
Ameq Aasiaat (traditional shop Aasiaat)
Residents of Disko Bay
Air Greenland
Ilulissat Airport
Aasiaat Airport
Industry
Qeqertarsuaq Heliport
Oil, gas & mineral companies
Utility providers
Fishing Industry
Fishermen and small boat owners
Fishing and fish processing companies
Royal Greenland Seafood
Hallbut Greenland
Polar Seafood
Local Government
Avannaata Municipality (Ilulissat)
Qeqertalik (Qeqertarsuaq & Aasiaat)
Service Providers
Hospital
Police
Rescue Team
Non-economic interest
Regulatory
Ministry of Fisheries, Hunting and Agriculture
National government
Ministry of Nature & Environment
Ministry of Industry, Energy & Research
Ministry of Mineral Resources & Labour
Avannaata Municipality
Municipal government
Qeqertalik Municipality
Environmental Agency for Mineral Resources Activities
Government agencies
Greenlandic Coastguard
International Whaling Commission (IWC)
North Atlantic Marine Mammal Commission (NAMMCO)
United Nations Convention on the Law of the Sea (UNCLOS)
International gov-erned institutions
European Union /EEA
Arctic Council
Danish authorities (beyond 3 nautical miles)
Inuit Circumpolar Council
Greenpeace
World Wildlife Fund (WWF)
Friends of the Earth
NGOs
International Fund for Animal Welfare (IFAW)
Sea Shepherd
Hunters' and Fishermen' Association (KNAPK)
Tourism Industry
Pressure groups
Traditional knowledge holders
Greenland Institute of Natural Resources
University of Copenhagen
Research and educa-tion institutions
Joint research projects
Non-regulatory
Sermilsiaq Newspaper (NuuK)
The Greenlandic Broadcasting Corporation (KNR)
International media
Media
Others
Whale meat consumers
Indigenous people
Greenlandic Population
Forward
Community of the People (Inuit)
Democrats
Point of Orientation
Others
Political Parties

Appendix D

INTERVIEW GUIDE: WHALE ECOSYSTEM SERVICES AND GOVERNANCE IN ARCTIC COASTAL COMMUNITIES

Purpose: to get stakeholder insights on local whale ecosystem services and their governance

Interviewers: Laura Malinauskaite and David Cook

Location and date: Húsavík, Iceland, Andenes, Norway, and Disko Bay, Greenland. June 2018 – September 2019

Interviewee:

1. **Introduction** (*introduce ourselves, ARCPATH project and purpose of the research*)
   - Ethical issues: we will ensure your anonymity; the interview will be recorded.
   - Introduction: say names and positions. We are a part of an Arctic-wide project called "ARCPATH: Arctic Climate Predictions - Pathways to Resilient, Sustainable Societies" that was developed in response to a Nordic Council of Ministers initiative "Responsible Development in the Arctic: Opportunities and Challenges". The project involves partners from nine countries (Norway, Denmark, Finland, Sweden, Iceland, Russia, China, Canada and the U.S.) and twelve institutions. Some of the activities include sea ice and climate modelling and predictions as well as attempts to estimate what these mean for Arctic societies and sustainable development in the Arctic. Our work group is called "Climate, Socio-Ecological Systems, Cetaceans and Tourism", and the main purpose of our research is to examine the benefits that societies get from marine mammals, how these benefits are changing with intensifying climate change and rapid economic development, especially tourism, how marine ecosystems are managed currently and how they could be managed sustainably in the future. This part of the project focuses on case studies in Iceland, Norway and Greenland.
   - The purpose of this interview is to get your views on management of whales. There are no right or wrong answers in this interview – we would simply like to hear your point of view on the matter. The data will only be used for scientific research.
   - Introduce whale ES: we focus our research on the concept of ecosystem services, which can be defined as the benefits that people draw from ecosystems. They can be direct (e.g. meat from whaling and income from whale-watching) and indirect (e.g. increased business revenues from whale-watching tourism), obvious (e.g. presence of wildlife) and less visible (e.g. nutrient regulation). It is good to have this concept in mind when answering the questions, but please do not get too distracted by it – management of whale resources ultimately translates into management of their ES.
   - Introductory/warm-up questions:
     - Please state your position, organisation you are affiliated with, how long have you worked there and where you are located?
     - Please shortly describe if and how your work is related to whales?
       Probe: work, studies, activism, love for animals, place of residence, etc.

2. **Opening questions**
   - Please explain what you do in your current work. Does it relate to whales directly or indirectly and how?
   - Introduce the stakeholder map – do you think we have placed your organisation correctly on it? If not, why? Is there anyone else/any organisation that should be added to the map? (Who else should we interview?)
   - Referring to the concept of ES explained earlier, what benefits have humans derived from whales in your local community?
     Probe: local biodiversity, existence value, economic gains from tourism, research and education, symbolic values, meat and raw materials from whaling, etc.

3. **Key questions** (*recent past, changes, current situation, future vision*)
    - Do you think that you derive any benefits from whales personally, and if yes, what are they?
      Probe: existence, bequest, non-use, cultural values, economic benefits.
    - In your experience, has the way that people perceive whales in your community changed in the last couple of decades? If so, how? Has your perception changed over time? If yes, how and why?
      Probe: rhetoric for/against protection against whaling, effects of whale-watching, idealising of whales in popular culture, cultural identity, etc.
    - Have you noticed any major changes in the way that people do to benefit from whales in your community and in general in the last couple of decades? If so, what have been the main drivers?
      Probe: provisional vs cultural ES; environmental movements, tourism, changing generational attitudes, lifestyle change, globalisation, changing ideologies and worldviews.
    - Do you think these changes have been for better or for worse (in terms of social welfare of the residents of your community)? Explain in your own words.
      Probe: better/worse for whom? depends on the point of view, interests, etc.
    - How would you evaluate the present situation of whale populations in Norway (environmental sustainability), in general terms and/or compared to other countries?
      Probe: whale stocks, health of ecosystems, wellbeing, better/worse than other whaling countries, improving, declining, etc.
    - Looking at the stakeholder map, who do you think benefits the most economically (directly and indirectly) from the changes that you mentioned and who are losing out?
      Probe: tourists/locals, whale-watching companies, tourism sector, government, businesses, municipalities, men/women, different employment sectors.
    - Looking at the map, who do you think has the most/least influence over what is happening in whale governance in your community and country the moment? Who should have most influence, in your opinion? Sub-questions:
        - Who are the principal decision makers (formal)?
          Probe: national government, municipality, businesses.
        - Who have the most non-regulatory influence (informal**)**? Explain why, how?
          Probe: individuals, businesses, NGOs, media, activists, researchers, etc.
        - Who are the most vulnerable to changing uses and governance of whales but have little influence? Explain why and how?
          Probe: whaling companies, local communities, employees, different economic sectors, people that depend on whales for livelihoods, men/women, seasonal workers, etc.
    - What role does your organisation (or you personally) play in the way whale resources are managed in your community?
      Probe: research, awareness raising, policy making/implementation, lobbying, co-producing ES.
    - Do you have any suggestions for improving the governance of whales and their resources? (How might you like to see it change and why?)
      Probe: increased protection status, de-regulation, clear government guidelines, co-operation between sectors (whale-watching, shipping, whaling, fishing), marine protected areas, etc.
    - If so, how could these changes be implemented? In your own words.
      Probe: more or less stringent laws, public awareness, education, information campaigns, protests, more research, funding, international cooperation, etc.

4. **Closing/wrapping up questions**
    - In your view, what are the biggest challenges and opportunities related whale governance in your community, country and in general today? How could they be tackled/seized?

- Would you like to add anything that we have not yet discussed? Any concluding remarks?
- Do you have any suggestions for us in terms of what we should look at when building a picture of whale governance in the Arctic? What else we should consider regarding management of whales, what is missing in stakeholder map, have we overlooked anything in our questions?