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

Authors:

Laura Malinauskaite (corresponding author), Environment and Natural Resources, Faculty of Social and Human Sciences, University of Iceland, Gimli, Sæmundargata 2, 101 Reykjavík, Iceland, email: lam6@hi.is

David Cook, Environment and Natural Resources, Faculty of Environment and Life Sciences, University of Iceland, Gimli, Sæmundargata 2, 101 Reykjavík, Iceland, email: dac3@hi.is

Brynhildur Davíðsdóttir, Environment and Natural Resources, School of Engineering and Natural Sciences, University of Iceland, Oddi, Sæmundargata 2, 101 Reykjavík, Iceland, email: bdavids@hi.is.

Helga Ögmundardóttir, Faculty of Social and Human Sciences, University of Iceland, Oddi, Sæmundargata 2, 101 Reykjavík, Iceland, email: helgaog@hi.is

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: ecosystem services; co-production; marine mammals; Arctic coastal communities; social-ecological systems

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 & 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 & 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.

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 Figure 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.

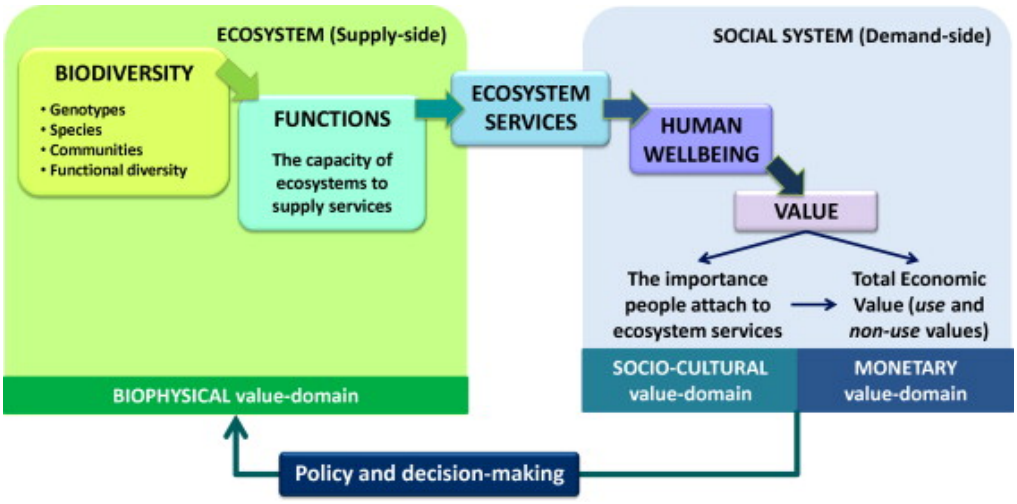

Figure 1. Conceptual framework of ES cascade model and value domains embedded in social-ecological systems. Sourced from Haines-Young and Potschin (2010) and Martín-López et al. (2014).

Fig. 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 Figure 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 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 Figure 1 with the co-production theory by Spangenberg et al. (2014), seeking to overcome some of

[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.

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.

Research methods and case study locations

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 & 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.

Case study locations

Húsavík is a medium-sized town in Northeast Iceland with just over 2,300 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 & 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 2,700 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 4,500 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.

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

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 & 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.

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.

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.

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.

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 & 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).

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.

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).

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).

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.

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.

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.

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 & Roach, 2017).

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.

An expanded Whale ES cascade model including co-production processes

Table 1, below, follows the same CICES classification system of ES (Haines-Young & Potschin, 2018) used above to list whale ES. It employs the Total Economic Value (TEV)[2] framework to

[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

identify different types of use and non-use values that are later presented in Figure 2 below. It adds the value domains outlined in Figure 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.

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

Table 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

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.

Living whale	Community cohesiveness and cultural identity	Community / ecosystem interaction Social/cultural activities	Cultural heritage, source of social cohesion and identity	Sociocultural; direct non-consumptive use
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 whale ES co-production model presented in Figure 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.

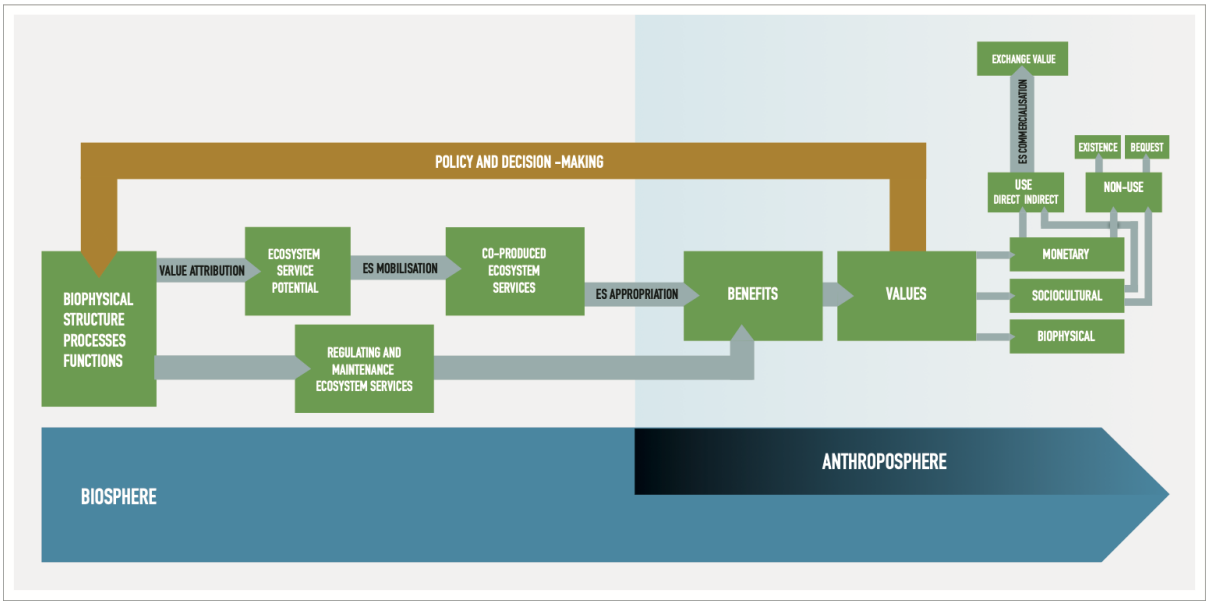

Figure 2. Whale ES cascade model for whale ES. Adapted from Haines-Young and Potschin (2010), Spangenberg et al. (2014), and informed by ARCPATH case study research.

Figure 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.

The stages of whale ES cascade explained

The five stages of the whale ES cascade model in Figure 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.

Biophysical structure/process/ function

The schematic in Figure 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).

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. 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.

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. 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.

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.

[3] [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 & Davíðsdóttir, 2016).

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.

Value

In Figure 2, above, the ES values are divided into the three domains first delineated in Figure 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 & 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.

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. 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.

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.

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.

ES appropriation

To be able to hunt whales and get access to the provisional type of 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.

ES commercialisation

Use values of whale ES become exchange values through ES commercialisation as set forth in Figure 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 Figure 2).

In Húsavík, where 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.

Discussion and conclusion

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

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

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 (Figures 1 and 2), exchange values are the most commonly used in ES valuation, often detracting from 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.

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 Figure 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.

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 Chapter 16 in this volume). The second link, which is the focus of this chapter, is between environmental change and human wellbeing (see also Chapter 18). 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.

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