TEV (TOTAL ECONOMIC VALUE) ANALYSIS OF A MARINE ENVIRONMENT IN NORWAY

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ABSTRACT

The push for ecosystem based management has opened up not only for including more of the natural systems when managing fish resources, but also a broader perspective on the human systems, and the diverse activities in the sea. This is reflected for instance in the EU Maritime Policy where fisheries is just one of many activities that marine management must take into account. Research into valuation of natural resources has shown that non-use values may be substantial in the marine environment; These are e.g. existence values, such as the existence of rare species and benthic components such as corals, and option values with regard to potential future applications, e.g. in marine bioprospecting. In addition, indirect use values, such as habitat values, recreational values and nutrient cycling often far exceed the direct use values, which are typically the value of the fisheries, aquaculture and marine tourism. Applying and critiquing the Total Economic Value (TEV) set up, we have estimated marine direct use values, including fisheries and aquaculture, indirect use values and non-use values in Nordland county in Norway, specifically connected to the Lofoten-Vesterålen marine area. Lofoten-Vesterålen is the most important spawning ground for commercial fish resources such as cod and herring, and it is also a very popular tourist destination. Yet when studying some of the other values that the marine environment supplies, these traditional values are not necessarily the most important.

Keywords: Total Economic Value, marine coastal area, Lofoten-Vesterålen, Norway

INTRODUCTION

The valuation of environmental goods and services, and the TEV (Total Economic Value) approach in particular, has been one of the fastest growing areas in environmental and ecological economics over the last 30 years (Turner et al 2003). One of the most cited articles is Costanza et al.'s (1997) synthesis of more than 100 ecosystem valuation studies deriving average values per hectare for a large number of ecosystem services and culminating in a single aggregated value of the world's ecosystem services. Most studies, however, have more modest aims and do not apply the TEV approach comprehensively but derive single function valuations (see for example Bergstrom et al 1990, Creedy and Wurzbacher 2001, Croitoru 2007). Turner et al. (2003) note that TEV studies have been applied to mainly terrestrial regions, with only a few studies considering marine environments. Beaumont *et al*. (2008) is the only published overarching TEV study in the marine environment that we are aware of. In this paper we carry out a TEV analysis for a coastal marine environment under pressure, i.e. we monetize the goods and services for one of Norway's most pristine marine ecosystem, as well as discuss some of the steps towards tying this knowledge to political decision making.

The allocation of scarce resources among competing users and the focus on multiple objectives has long been an issue in the pluralistic nature of sustainable forest management (Wang 2004), and the main objective of any forest management regime is, according to Weigand (1998), to search for the compatibility of timber and non-timber values. In a recent article Gamborg and Rune (2008 p.800) argue that "capturing the full value of forests is helpful in getting a better basis for policy and management decisions". They show the multifaceted nature and value of forests by use of the TEV model and discuss how results from TEV-studies can be incorporated in decision making. However, they stop short of monetizing the different goods and services the forest provides and do not set up a systematic framework for policy implementation. When it comes to marine resources the discussion about compatibility of different use as well as non-use values has not yet been as present as within forestry[1]. This, in spite of the fact that sea areas are becoming increasingly crowded by multiple users where the activity of one group is likely to affect both use and non-use values of other groups (Degnbol and Wilson 2008). One such example can be found in the North Sea, where since the early 1970s extensive oil and gas exploration has been developed alongside extensive fisheries. According to a study by Olsgård and Gray (1995) the two industries are not incompatible, though there are minor negative effects of the oil industry upon the fisheries.

Due to a decrease in the number of new oil and gas fields in the North Sea, the oil industry now turns its eyes to the Norwegian and Barents seas. These seas contain some of the most important spawning grounds for cod and other commercially valuable stocks, and "The Integrated Management Plan for the Barents Sea and the sea area off Lofoten and Vesterålen" (hereafter referred to as the Management Plan) (Norwegian Ministry of the Environment, 2005) was drawn up in order to obtain a broader picture of the state of these seas with respect to ecosystems, hydrological and meteorological conditions. In spite of the name, the Management Plan did not provide recommendations regarding the compatibility of the marine resource uses in question; in fact, the Management Plan includes no valuation or analysis of potential user conflicts. In order to obtain some input regarding these issues, the Norwegian Ministry of the Environment in 2007 commissioned a report with the objective to identify the total economic value (excluding gas and oil payoffs) of the most vulnerable part of the sea covered in the Management Plan - the coast off the island groups of Lofoten and Vesterålen. The results of the report, given in Armstrong et al (2008) are the basis for this paper, the main contributions being the presentation of an overarching TEV study of a small marine area, namely the coastal area off the Lofoten-Vesterålen islands in Norway. This paper has two aims; firstly to identify goods and services from the ocean outside Lofoten-Vesterålen, and to inform with regards to their values. Furthermore, the paper creates awareness of the relationship between these goods and services with regard to their relative sizes in value.

In the next section we describe the environmental characteristics of the study area; Lofoten-Vesterålen. This is followed by a section on the TEV methods applied to determine values presented in the results section. A discussion concludes the paper.

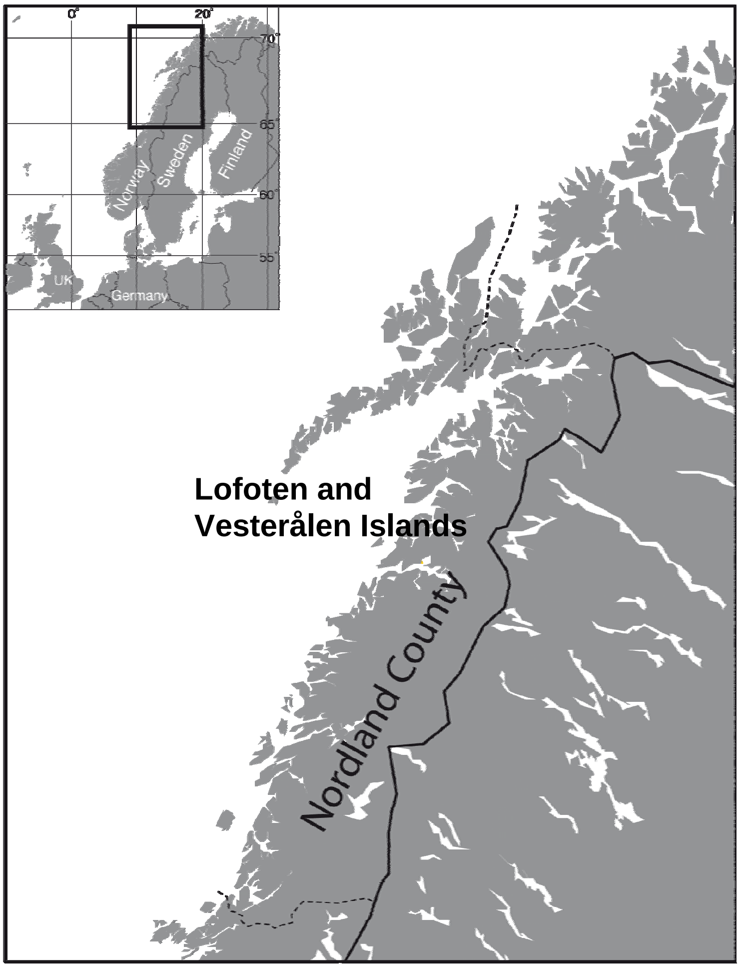
DESCRIPTION OF COASTAL AREA: LOFOTEN-VESTERÅLEN

The coastal area off Lofoten-Vestarålen represents one of Norway's most pristine marine ecosystems. The Management Plan describes the sea area west and north of the Lofoten-Vesterålen Islands as particularly clean, rich and productive (see Figure 1), i.e. it represents key areas of spawning, egg and larval drift for commercially important fish stocks such as cod and herring. Some of these areas are also important for breeding, moulting and wintering for seabirds such as the lesser black-backed gull, Steller's eider and the Atlantic puffin. In addition these areas include valuable benthic fauna in terms of cold-water corals and sponge communities.

The traditional primary users of the Barents Sea and the sea of the Lofoten-Vesterålen islands are the fishing and maritime transport industries, but there is growing pressure for oil and gas extraction, transport of oil, cruise traffic and marine bioprospectors. The Lofoten Islands host some of the oldest incumbent fisheries in Norway, i.e. the Lofoten fisheries on spawning cod date back to the Viking era. The traditions and culture which were developed around this fishery have prevailed and constitute an important part of the relatively large tourism industry. The Lofoten Islands, with their mix of exceptional natural beauty and old, culturally rich fisheries traditions, are one of the most famous tourist destinations in Norway, and six communities in the Lofoten islands have applied for admission to be included in UNESCO's world heritage list. They have applied on a mixed site basis, implying that the uniqueness consists of a mixture of natural and cultural values.

Value estimations in this study are applied to the territorial waters of Nordland County (see Figure 1) as this area captures most of the key biological processes and commercial activities of Lofoten-Vesterålen detailed above. It also represents the lowest geographical level for which data on marketed goods and services are available. The county territorial waters extend 12 nautical miles out to sea, cover an area of 57 440 km^2 and measure an average depth of 230 metres.

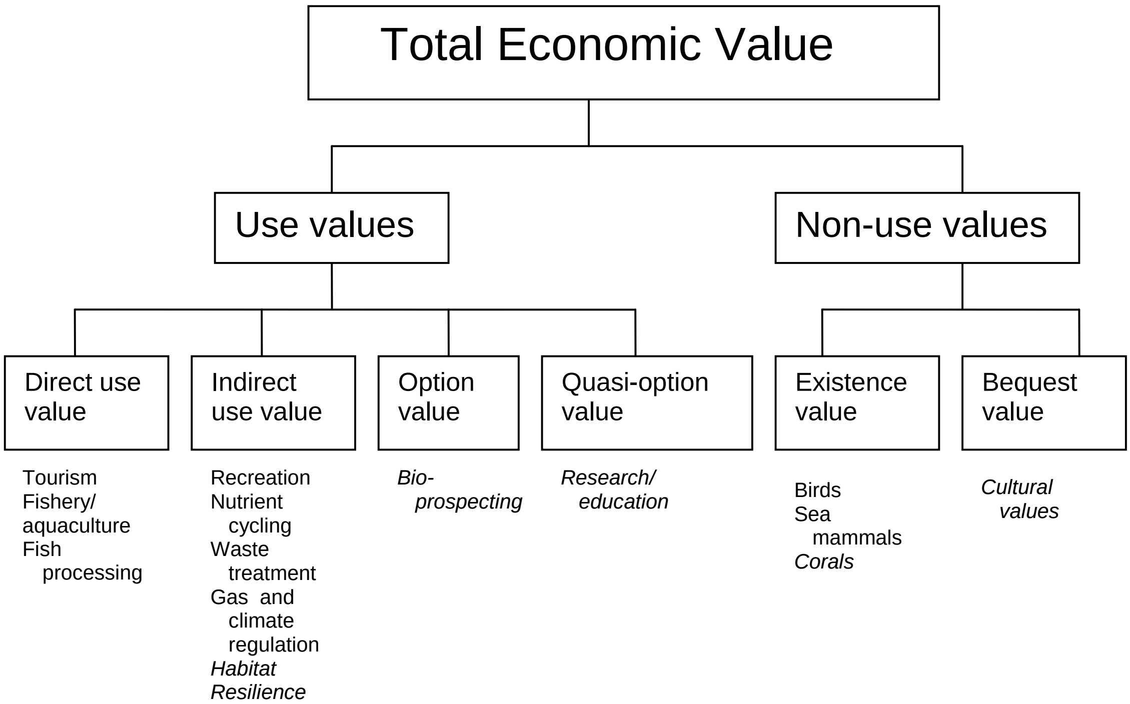
Figure 1 Map of the study area; the waters outside Nordland county



METHOD: TOTAL ECONOMIC VALUATION (TEV)

The TEV concept, as presented in Figure 2, is a useful framework for the identification of values connected to natural environments (Pearce & Turner 1990)[2,3]. It divides values into use and non-use values, with use values encompassing economic production where the natural environment is a factor of production, and non-use values representing values connected to the pure existence of the natural environment. Use values can be divided into subgroups; direct and indirect use values, as well as option values. The direct use values can be measured by studying market interactions directly. Typical examples from the marine environment are fisheries, aquaculture and tourism. The indirect use values support or add to the direct use values, but are not found explicitly in markets. Examples from marine environments are habitats and food for commercial species. Also services such as circulation of nutrients and bioremediation of waste are indirect use values, as they affect the direct use values. Option values describe the potential value creation of a natural environment in the future, while quasi-option values, a subset of option values, express to the value of preserving a natural environment in the expectation of future increased knowledge of values therein.

Figure 2 Total Economic Value (TEV) and economic values distributed over the specific components. Values in italics are not identified in this study.



There are two forms of non-use values; existence and bequest values. Existence values express the valuation of pure existence, unconnected to use, while bequest values are what humans are willing to pay to conserve an environment for future generations.

Good valuation methods exist for measuring the value of marketed goods and services, i.e. the commercially valuable resources. When it comes to goods and services that we do not pay for, e.g. recreation, nutrient cycling and habitat, the measurement methods are less straight forward and more uncertain. An aspect that further complicates the valuation of marine resources is that most of these resources are invisible and inconspicuous to humans.

In this paper we apply market methods to elicit the direct use values. The indirect use values for recreation and gas and climate regulations are derived by applying data from existing markets, which are accommodated to these non-market goods and services, while nutrient cycling and waste treatment values are derived by indirect valuation methods, such as replacement costs. Regarding the existence values we have applied the technique of benefit transfer, and use values captured by contingent valuation methods (CVM)[4] at one place and time to make inferences about the economic value of environmental goods and services at another place and time (Wilson & Hoehn 2006).

Though we have identified a wide range of values inherent to the sea area under consideration (see Figure 2) we have not been able to quantify all of them, and thus the numbers presented below represent only a selection of the identified values[5]. This is both due to constraints in data availability and the large level of uncertainty associated with many of the available valuation methods[6].

We choose not to aggregate the estimated direct and indirect use values to arrive at one single number. For one, economists are critical to the aggregation of values that are derived by different methods but there is also the issue of double counting given that many of the ecosystem services are interdependent and feed into the direct values. Our main concern, however, relates to the fact that a single aggregated TEV value would detract from the uncertainty and complexities associated with valuing ecosystem functions.

RESULTS FROM ANALYSIS OF THE SEA OFF THE LOFOTEN-VESTERÅLEN ISLANDS

We adopted and applied the TEV approach to the categorisation of the goods and services of the Lofoten-Vesterålen coastal area as shown in Figure 1. In Tables 1 and 2 we present the estimated figures for those of the values we were able to quantify. Relevant data are either drawn from area-specific statistics publicly available, or are transferred from comparable studies in other geographical areas.

Table 1 Direct use values in billion Norwegian Kroner (NOK)*, annual and present value (4%), measured as gross product based on data from 2004, constant 2008 prices

Good/Service	Monetary value per year	Present value	Assessment
Tourism	3.71	92.8	Uncertain
Fishery/aquaculture	1.66	41.6	Underestimate
Processing of marine products	0.96	24.1	Underestimate
TOTAL	6.34	158.5	

***1 USD = 5.04 NOK as of January 2008.**

Table 2 Indirect use values and existence values in billion Norwegian kroner (NOK), annual and present value (4%) , constant 2008 prices.

Good/Service	Monetary value per year	Present value	Method and measure	Assessment
Recreation	3.2	80	Implicit value	Uncertain
Nutrient cycling	31 - 193	775-4844	Opportunity cost	Underestimate
Waste treatment	0.195	4.9	Opportunity cost	Acceptable
Gas and climate regulation	0.884	22.1	Calculated CO_2 value of sequestration	Underestimate
Existence values	0.353	8.8	Willingness to pay	Underestimate

DIRECT USE VALUES

The two types of marketed goods and services for the waters around Lofoten-Vesterålen are fish and tourism. As these goods and services are traded in the market, their value is recorded by official, publicly available statistics in Norway. As an estimate for the value of marketed goods and services (fisheries, fish processing, fish farming and tourism) we use value added as measured in the regionalised Gross Domestic Product (GDP). These values are presented in Table 1, i.e. the value adjusted to 2008 prices and its estimated present value[7]. The value for tourism, with a net present value equal to 92.8 billion NOK, is based on an aggregate of the two sectors; accommodation and restaurants, and passenger transportation[8]. These sectors include services that are not only used by tourists, such as local bus and ferry companies. On the other hand, tourists use services that are not included in the estimated value such as trade (buying souvenirs) and food production. This imprecision in measurement draws in opposite directions, and thus the estimate is uncertain. The value of fish, the aggregate of harvested and cultured species, amounts to 41.6 billion NOK in net present value, whereas fish processing has a net present value equal to 24.1 billion NOK. Both numbers are considered an underestimate since they do not take into consideration the fact that these activities (harvesting, fish processing and aquaculture) spin off other economic activities, such as transportation and other supporting industries, i.e. the economic multiplier effect is omitted.

INDIRECT USE VALUES

There are a number of services provided by the sea off the coast of Lofoten-Vesterålen which are free of charge. One such service includes recreational fishing and other recreational activities such as boat trips, swimming, surfing, etc[9]. Other services can be grouped under the umbrella of ecosystem services, in this case most notably the value of nutrient cycling, waste treatment, as well as gas and climate regulation.

Recreation

In order to derive a value of the recreation services provided by the Lofoten-Vesterålen area we have used a somewhat different approach from the standard literature, which typically applies contingent valuation or the travel cost methods. Lacking such relevant studies for the study area of interest, our point of departure is that there is a trade-off between income and so-called free goods, and that people may accept a lower income for higher access to these free goods (closeness to family, cultural and natural environment). Norwegian statistics provide annual values of the average level of wages and income for each county in Norway, as well as for the country as a whole. When comparing the average wage level between Nordland county and the national average we find that the former is lower. The difference in the wage averages NOK 32 000 per household per annum, which multiplied by the number of households in Nordland county gives a present value of NOK 80 billion (see Table 2). This is likely to be indicative of what the local population is willing to forego in order to enjoy access to free recreational goods and services[10].

Nutrient cycling

Costanza *et al*. (1997) define nutrient cycling as the storage, cycling and maintenance of nutrients, such as carbon, nitrogen and phosphorus, by living marine organisms. Since the onset of industrialisation, human actions, mainly associated with agriculture, have progressively increased the annual flux of inorganic nutrients (most notably nitrogen and phosphorus) leading to a myriad of ecosystem deteriorations. Converting and adjusting Costanza *et al*.'s (1997) estimated costs of advanced treatment to remove nitrogen and phosphorous to Norwegian January 2008 prices (1.36-3.81 NOK/m^3) and multiplying by the approximate volume of the total territorial waters in Nordland (surface area × average depth = 57,439,690,000 $m^2 \times 203$ m = 1.32×10^{12} m^3), yields an approximate value of NOK 1,797-5,033 billion. This represents the estimated replacement cost value for nutrient cycling to treat the Nordland territorial waters once, according to the method used by Costanza *et al* (op cit).

Costanza *et al*.'s values for nutrient cycling should be considered with significant caution as replacement of nutrient cycling ability may have experienced technological improvements since 1991, lowering costs of operations. Furthermore, where Costanza *et al*. (1997) and Beaumont *et al*. (2008) calculate the ocean's *potential* cycling ability, we believe it is more appropriate to apply an opportunity cost approach to these services based on more recent data.

Along the sparsely populated Norwegian coastline, aquaculture is the major source of phosphorous and nitrogen emissions. Alternative treatment of these emissions would require land-based aquaculture. In such land-based production, with 0.16 and 1.0 litres of water per kg fish per minute[11], and given the production of aquaculture salmon in Nordland county in 2006 being 131.212 tons, the total amount of treated water per year would be between 9 and 56 billion m^3. Assuming treatment costs of phosphorous[12] to be NOK 2,81/m^3 we deduct that the ocean supplies a nutrient cycling service that alternatively would have cost between NOK 31 and 193 billion annually, giving a present value between NOK 775 and 4844 billion. These numbers only refer to treatment of phosphorous, while the ocean also absorbs nitrogen, ammonia and CO_2. This entails that our calculation is presumably an underestimate, though we believe our analysis improves upon the valuations by Constanza *et al*. (1997).

Waste treatment

Anthropogenic waste can be organic (e.g. oil or sewage) or inorganic (i.e. metals and synthetic chemicals). A significant proportion of this waste eventually ends up in the ocean, either chronically by directing sewage into the ocean or accidentally by shipwrecks or land-based industry releases (Beaumont et al. 2007). Marine organisms store, dilute, bury and transform much of this waste resulting in detoxification and purification. This process is highly complex and relies to a large extent on the level of biodiversity and key species in the ecosystem. We apply a similar approach to Beaumont et al. (2007) and derive the value of the Lofoten-Vesteralen coast in terms of its cleaning capacity by analysing community waste cleaning costs as described below.

When waste water is emitted in relatively clean ocean areas, and the aggregate amount of waste water is limited relative to the size of the recipient waters, as is the case in Nordland county, Norwegian legislation only requires mechanical water treatment, the lowest degree of treatment. For more heavily polluted areas, chemical water treatment is additionally required. The organisation *Norsk Vann* (Norwegian Water) provides municipal water treatment cost analyses on a regular basis. According to their data, as a rule of thumb chemical treatment per inhabitant is three times as costly as mechanical treatment. Applying this rule and multiplying by the number of inhabitants in Nordland county we find that saved treatment costs equal NOK 195 million annually, giving a present value of NOK 4.9 billion. We regard this as an acceptable estimate.

Gass and climate regulation

Beaumont and Tinch (2003) explain that biogeochemical processes maintain the chemical composition of the atmosphere and the ocean, i.e. processes such as the regulation of CO_2/O_2 balance, ozone, and SO_X are crucial to maintain breathable air and thus terrestrial life as we know it. The marine benthic environment acts as a CO_2 sequester and a carbon sink and is thus essential to the regulation of carbon fluxes. The ocean's ability to sequester carbon is primarily facilitated by its primary production of phytoplankton where carbon fixation results in the conversion of CO_2 into organic compounds.

Skogen, Budgell & Rey (2007) study primary production levels in the Nordic Seas and calculate the mean Norwegian Sea primary production at 79 gC m^{-2} (which is, according to their study, in line with previous studies' estimates of 80 gC m^{-2}, with levels highest in the Norwegian coastal current at 80-120 gC m^{-2}). This translates into a primary production of 0.004 GtC m^2 within the territorial waters of Nordland. Following Beaumont *et al* (2007) we then adjust Clarkson & Deyes's (2002) preferred carbon sequestering cost estimate based on their review of published studies (GBP 70/tC, with a lower and upper limit of GBP 35-140/tC) to Norwegian January 2008 prices (NOK 653/tC). This would give an average estimated carbon sequestering value in the Nordland territorial waters of NOK 2.96 billion (not shown in Table 2). We can derive a more updated value by using the current price of traded CO_2 permits in the European Union (NOK 195/tC, Futures Market (ECX), adjusted to January 2008 prices). This implies a present value of NOK 22.1 billion for gas and climate regulation in these waters, which is a more conservative estimate and is likely to represent an underestimate given only primary production is considered.

Figure 2 also lists option and quasi-option values under the category of use values. Typically, such values would encompass habitat and biodiversity values for bioprospecting and research/education, i.e. these values are based on the existence of a natural genetic library that pharmaceutical, agricultural and other research can draw upon in the future (i.e. for medicine, genes for resistance to plant pathogens and crop pests, etc.). However, as previously noted, due to the uncertainty associated with data and method constraints we consider it beyond the scope of this study to derive any meaningful values.

NON-USE VALUES

Bequest and existence values

The bequest value refers to the value current generations place on ensuring environmental resources are preserved for future generations. Regarding the existence value, Krutilla (1967) was the first to note that some people derive satisfaction from the knowledge that certain environmental goods and services exist even though they themselves are unlikely to ever see or utilise them.

We have not been able to ascertain a meaningful bequest value. Similarly, existence values of marine resources are difficult to determine accurately but some studies are available with regards to certain species. According to the Management Plan the Lofoten area is especially important for a number of seabird populations, such as the Lesser Black-backed Full, Stellar’s Eider and Atlantic Puffin. Anker-Nilsson (2006) points out that Røst, the outermost municipality of the Lofoten Islands, holds the largest aggregation of breeding seabirds on the European mainland and close to 20% of all seabirds breeding along the Norwegian coast. It has the status of an IBA (Important Bird Area) for breeding Atlantic Puffins and European Shags, and is important for the wintering of King Eiders. Anker-Nilsson (2006) provides the most recent population estimate of 529,580 seabirds (including a total of 11 species that either breed or winter in the total Lofoten area).

Green, Kahnemann & Kunreuther (1994) identified a WTP of US$ 10 per bird (1994 prices) to save birds from death in an oil spill in San Francisco. It should be noted that their study was a response to unusually large estimates of the total value of preventing the deaths of seabirds in offshore oil spills by previous studies, and that the article focused on examining the sensitivity of survey measures of WTP for public goods. However, the authors’ reported preliminary WTP value may give us some idea of the existence value of seabirds, and when converted and adjusted to January 2008 Norwegian prices (NOK 93.71) and multiplied by the number of seabirds in the Lofoten area, we derive an existence value of approximately NOK 49.6 million.

An existence value may also be derived for the seasonal occurrence of killer whales observed in the coastal waters of Norway. Christensen (1988) estimated a minimum of 1,500 killer whales may be present on the Norwegian coast following the migration of herring. Loomis and White (1996) provide a meta-analysis of WTP estimates per household for different rare species identified in various studies. Killer whales are not endangered and may not be adequately reflected by the values reported for Gray whales (low value US$ 17, high value US$ 33, average value US$ 26 in 1996) and/or Humpback whales (average value of US$ 173), however, no other estimates exist. Picking the lowest value of NOK 140 per household for the Gray whale species provides a conservative estimate, which might still be an overestimate. We estimate the total existence value for killer whales to be NOK 302 million per year (NOK 140 multiplied by the number or Norwegian households). Together with the existence value for seabirds, we arrive at a total of approximately NOK 353 million per annum, which gives a present value of NOK 8.8 billion. Given that seabirds and killer whales are clearly not the only species that may be valued for their existence we consider this an underestimate of the total existence values occurring in this region.

DISCUSSION AND CONCLUSIONS

Above, we have identified and quantified some of the values a clean and productive sea area, such as the coast off Lofoten-Vesterålen, may encompass. By itself such a valuation is of little practical use, but combined with an objective function for society or clear policy formulations, it can serve as a useful informational tool in setting well informed priorities with respect to multi-use options. As discussed in the introduction, pressure mounts on some of the most pristine marine ecosystems on the coast of Norway, and the increased interest for valuation of the goods and services provided by these ecosystems must be seen in lieu of the pressure from the oil companies to open for oil exploration in these sea areas. The most promising areas for oil resources off the coast of Nordland are located just off the Lofoten-Vesterålen Islands, and expected discounted resource rents to the Norwegian government from this area are estimated to be NOK 100 billion (ECON, 2008). It must be noted, however, that this figure cannot be compared directly to the direct use values estimated here, as the latter are not rents.

Regarding the ecosystem values, it is worth noting that the indirect values are at least as high as the direct values, but potentially much larger. Furthermore, we have not been able to find good estimates of option and bequest values. These may be substantial value entities that also are heavily impacted by policy decisions such as oil/gas extraction. Further studies to learn more about these values therefore seem vital.

In spite of this increased interest in valuing goods and services from the marine ecosystem off the Lofoten-Vesterålen islands, and though the Norwegian government has used vast resources on a Management Plan which covers this sea area, the economic content is limited, and it is difficult to see how the existing information is to be applied in order to make priorities with respect to the multi-faceted use of the sea area off these islands.

ACKNOWLEDGEMENTS

We wish to thank The Norwegian Ministry of Environment, which enabled and financed the work with the TEV-analysis for the Lofoten-Vesterålen area. Especially we want to thank the reference group in the Ministry of Environment, Hallvard Ødegaard, Idar Schei, Torbjorn Asgaard. Finally, we want to thank colleagues at the University of Tromsø (Institute of Economics and Norwegian Fisheries College) for comments during the work with the article. The authors are responsible for the views expressed in this article and all remaining errors.

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ENDNOTES

[1] Traditional marine management regimes are concerned with the pressure on different targeted fish species. For example, the focus of integrated coastal zone management has been on the different users in the coastal zone and their impact on commercial fishery resources rather than considering the effect on the range of incumbent values.

[2] There are also other approaches to the valuation of ecosystem goods and services (see for instance Kumar and Kumar (2008) and Chee (2004)).

[3] In addition to what is presented in Figure 2, Turner et al (2003) also point to infrastructure values, the so called *glue* in the ecosystem. The glue refers to the underlying structural effects of the ecosystem services that give the natural environment values in excess of the sum of the each service. Other values of a more ethical nature are for instance so called stewardship values.

[4] CVM is a method to determine the public's willingness to pay for the conservation of some good or willingness to accept compensation for the loss of some good. This method is based on surveys.

[5] The range of goods and services were considered following the categorisation frameworks of Beaumont *et al*. (2007) and Costanza *et al*. (1997).

[6] For example, cultural, habitat and ecological resilience values are likely to be very important to the area, however, they proved to be impossible to quantify in a satisfactory manner given the existing level of knowledge.

[7] The present value is the sum of all discounted annual values. The discount rate applied is 4%.

[8] These sectors correspond to the following NACE-codes (Nomenclature statistique des Activites Economique dans la Communaute Europeenne/European standard for industrial classification): 49.1, 49.3, 50.1, 50.3, 51.1, 55, 56.

[9] The value of recreation could alternatively be coined a direct use value since humans derive its value from the direct use of the coastal environment similar to tourism. However, as previously noted in the methods section, in this paper we categorize direct use values as values that can be measured by studying market interactions directly.

[10] We assume the income difference does not include the valuation of closeness to family and other cultural goods, as these will also be found in other parts of the country.

[11] The first measure is for a highly efficient land-based unit, while the second measure is a more standard rule of thumb.

[12] The organisation *Norsk Vann* (Norwegian Water) estimates the contribution of different variables to the costs of water provision and waste water treatment each year based on reported costs from the municipalities. We run a regression analysis based on these data and find that cleaning waste water for phosphorus implies an additional cost of NOK 205 per inhabitant per year. Assuming an average consumption of water equal to 200 litre per person per day, we calculate the phosphorus cleaning costs to be NOK 2,81 per m^3, which is within the range presented in Costanza *et al* (1997). It must, however, be noted that cleaning waste water (sewage) is not directly comparable to the recycling of water in land based aquaculture.