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# Valuing Ireland's Coastal, Marine and Estuarine Ecosystem Services

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Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

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- Office of Communications and Corporate Services

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**EPA RESEARCH PROGRAMME 2014–2020**

# Valuing Ireland's Coastal, Marine and Estuarine Ecosystem Services

## (2014-NC-MS-1)

## EPA Research Report

Prepared for the Environmental Protection Agency

by

National University of Ireland, Galway and Galway–Mayo Institute of Technology

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The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.


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# Abstract

This technical report demonstrates the data sources and methods that can be used to estimate the value of a number of coastal and marine ecosystem service benefits. In particular, the study estimated the value of waste assimilation services, coastal defence services, carbon sequestration services, recreational services, offshore and inshore capture fisheries, aquaculture and seaweed harvesting, and the contribution that proximity to the coast can make to the value of residential property. These ecosystem services occur at multiple scales, from climate regulation and carbon sequestration at the global scale, to food provision, marine recreation opportunities and waste treatment, at local and regional scales. By categorising coastal, marine and estuarine ecosystems and linking them to reliable estimates of ecosystem service value flows, this project will assist decision makers with responsibility for marine and coastal zone management as they attempt to manage developments in a manner that maximises the delivery of ecosystem service benefit value to society while minimising forgone market opportunities. The valuation of the identified ecosystem service benefits is accomplished using secondary sources of information. Guidelines for undertaking an ecosystem services assessment are also provided in an appendix.

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# Executive Summary

This technical report presents the data and methods used to estimate the value of a number of marine, coastal and estuarine ecosystem service benefits. In particular, values for waste assimilation services, coastal defence services, carbon sequestration services, recreational services, the contribution that proximity to the coast can make to the value of residential property, offshore and inshore capture fisheries, aquaculture and seaweed harvesting are presented. Marine ecosystem services are provided by the processes, functions and structure of the marine environment that directly or indirectly contribute to societal welfare, health and economic activities. The value of marine ecosystem service benefits can often be quantified in monetary terms using economic techniques. As the report *Economics of Ecosystems and Biodiversity* (Kumar, 2010) points out, ignoring the value of these ecosystem services and persisting with conventional approaches to wealth creation and development is a risky strategy if it means losing the benefits that coastal and marine ecosystems provide.

Marine ecosystem services can be classified as provisioning services, regulation and maintenance services, and cultural or supporting services.

- Provisioning services: these ecosystem services are tangible goods and there is often a direct connection between the ecosystem and the provision of these ecosystem services. Examples of the provisioning ecosystem services generated by Irish marine and coastal ecosystems are the fish and seaweed that are harvested and also the aquaculture resources around our coasts.
- Regulation and maintenance services: these ecosystem services regulate natural processes and functions in the world around us and are often consumed indirectly. Examples of these ecosystem services include carbon sequestration, which helps to mitigate climate change, treatment of wastewater and its return to the hydrological cycle, and flood and storm protection by sand dunes and saltmarsh, which lessens the damage from winter storms.
- Cultural services: the cultural ecosystem services refer to the psychical, psychological and spiritual benefits that humans obtain from contact with nature. Examples of the cultural ecosystem services in the Irish marine and coastal zones include recreational activities, such as walking along the beach and surfing, as well as the added value that having a sea view from one's house provides to the resident's well-being.

Both market and non-market methods of valuation are employed in this report. For provisioning ecosystem service benefits, such as wild fisheries and aquaculture, market prices combined with landings and production data provide a good indication of value. Similarly, estimates of the cost of providing an alternative to the service provided by the marine environment, as in the case of using hard-engineered solutions in place of the coastal defence services of saltwater marshes, can be generated and used as proxies for the value of the ecosystem service provided. However, a number of the services provided by the marine environment do not command a price in any market, and stated and revealed valuation methods are required to estimate these values. For example, using the travel cost method, we can develop a model of demand for coastal recreation from which we can estimate the recreational use value of our marine resources.

While these primary valuation methods provide detailed information on non-market value, they are often time consuming and expensive to implement. In this desk-based research, we therefore primarily rely on secondary values taken from the literature where the value is "transferred" from the original study (where the primary research has taken place) to the policy site (in this case the Irish marine environment). Table ES.1 summarises the estimated quantities and values of a number of marine and coastal ecosystem services provided by Irish waters. This is a non-exhaustive list, as there are a number of service benefits that we do not have valuation estimates for, either because they are difficult to quantify in monetary terms, such as many of the cultural ecosystem services associated with the marine environment, or because there is too high an uncertainty associated with the estimates available.

**Table ES.1. Values of Irish coastal and marine ecosystem service benefits[a]**

| Ecosystem service | CICES classification | Estimate of the quantity of ES per annum | Estimate of the value of ES per annum (€) |
|---|---|---|---|
| *Provisioning ecosystem service* | | | |
| Offshore capture fisheries | Wild animals | 469,735 tonnes | 472,542,000 |
| Inshore capture fisheries | Wild animals | 14,421 tonnes | 42,113,000 |
| Aquaculture | Animals and aquaculture | 39,725 tonnes | 148,769,000 |
| Algae/seaweed harvesting | Wild plants and algae/plants and algae from aquaculture | 29,500 tonnes | 3,914,000 |
| Genetic materials | Genetic materials from biota | Not quantified | Not valued |
| Water for non-drinking purposes | Surface water for non-drinking purposes | 1,189,493,326 $m^3$ of seawater used for cooling in power plants | Not valued |
| *Regulating and maintenance ecosystem services* | | | |
| Waste services | Mediation of waste, toxics and other nuisances | 9,350,642 kg organic waste<br>6,834,783 kg nitrogen<br>1,118,739 kg phosphorus | 316,767,000 |
| Coastal defence | Mediation of flows | 179 km of coastline protected by saltmarsh | 11,500,000 |
| Lifecycle and habitat services | Lifecycle maintenance, habitat and gene pool protection | 773,333 ha protected through SACs | Not valued |
| Pest and disease control | Pest and disease control | Not quantified | Not valued |
| Climate regulation | Atmospheric composition and climate regulation | 42,647,000 tonnes $CO_2$ absorbed | 818,700,000 |
| *Cultural services* | | | |
| Recreational services | Physical and experiential interactions | 96 million marine recreation trips per year | 1,683,590,000 |
| Scientific and educational services | Scientific and educational | Marine education and training fees | 11,500,000 |
| Marine heritage, culture and entertainment | Heritage, cultural and entertainment | Not quantified | Not valued |
| Aesthetic services | Aesthetic | Flow value of coastal location of housing | 68,000,000 |
| Spiritual and emblematic values | Spiritual and/or emblematic | Not quantified | Not valued |
| Non-use values | Existence and bequest values | Not quantified | Not valued |

**[a]The flow of ecosystem service values should not be added up, as they represent only a certain proportion of the total economic value (TEV). Aggregating the figures in an effort to give a single figure for the value of marine ecosystem services in Ireland is an overly simplistic approach that would misrepresent the TEV. In addition, the values represented for each service use different measures. For example, in some cases, such as fisheries, aquaculture and education, the value is measured as revenue, while others, such as recreation, are measured as net economic contribution, and the value of waste treatment and coastal defence is measured using a cost-based approach.**

**CICES, Common International Classification of Ecosystem Services; ES, ecosystem services; SACs, special areas of conservation.**

AIR & CLIMATE REGULATION
RESISTANCE & RESILIENCE
FOOD WEB DYNAMICS
BIOGEOCHEMICAL CYCLES
NUTRIENT CYCLING
$O_2$
$CO_2$
Climate regulation (includes climate change mitigation measures such as carbon sequestration)
Genetic materials
Marine tourism (including cruise ships)
Aesthetic services
Scientific and educational services
Recreational services
Waste treatment (i.e. wastewater treatment
Seafood processing
Oil and gas extraction
Water for non-drinking purposes (i.e. cooling for power plants)
Aquaculture (fish and shellfish based systems)
Coastal defence (storm & flood protection)
Shipping and maritime transport
Capture fisheries (including capture shellfish)
Spiritual and emblematic values
Existence & bequest values
Marine renewable energy (including offshore wind, wave and tidal devices)
Marine heritage, culture and entertainment
Lifecycle and habitat services (nursery grounds/ marine protected areas)
Provisioning Ecosystem Services
Regulating and Maintenance Ecosystem Services
Cultural Ecosystem Services
Supporting Ecosystem Services
Other Marine Services
Pest & disease control (includes management of invasive species)
Seaweed & shellfish harvesting
Seabed mining
semru
Socio-Economic Marine Research Unit

# 1 Introduction

For most of history, the oceans have been seen as a boundless source of food and raw materials from their fisheries and whaling industries (Roberts, 2010). The seas' and oceans' vastness made it seem as if they could accept unlimited amounts of waste from the shore. However, in the late 20th century, it was realised that there are limits and that humankind was beginning to test them (Meadows *et al*., 1972). The pressure on our environment was not just limited to the Earth's marine waters. The terrestrial environment has also seen increased pressures mainly due to the increase in agricultural land, increased use of water and increased exploitation of natural and mineral resources (SCBD, 2014). The main driver of these pressures on both terrestrial and marine environments is a combination of exponential increases in population and in consumption of the resources needed to sustain human life. The positive effect of this for humankind is an increased level of human welfare. Notwithstanding the recent financial crisis, the effects of which still rebound in our society to date, the past 50 years have seen incomes as measured by gross domestic product (GDP) increase. This holds true both for the world population as a whole and on a per capita basis (World Bank, 2015). The corollary of these facts is that intense pressures are being put on the Earth's ecosystems, with Steffen *et al*. (2015) finding that the planetary boundaries are starting to be breached, especially with regard to biosphere integrity and biodiversity.

Project or policy decisions often involve a cost–benefit analysis either implicitly (a policymaker or politician makes a decision) or explicitly (costs and benefits are quantified, sometimes in monetary terms, and weighted against each other). In most cases, the costs are more readily quantifiable than the benefits. When a project or policy has impacts on an ecosystem, the non-market benefits provided by the ecosystem are often unaccounted for in the cost–benefit analysis. These unaccounted for environmental benefits, known as "ecosystem services" (MEA, 2005), may result in sub-optimal decisions being made.

Often it is national and international policies that drive protection of our environment or the incorporation of environmental values into decision making. At the global level, the main policy driver for protection of biodiversity is the strategic plan arising from the 10th meeting of the Conference of Parties (COP10) to the Convention on Biological Diversity (CBD). The outcome of this strategic plan was 20 targets (Aichi Targets) (Cardinale *et al*., 2012). The targets were in addition to previous targets to protect and conserve global biodiversity (Balmford, 2005), and they added protection of ecosystem services to three of the targets (Target 11, Target 14 and Target 15).

At a European level, the European Commission (EC) aims to protect, value and where necessary restore nature both for biodiversity's intrinsic value and for its contribution to human well-being and economic prosperity through ecosystem services (EC, 2011). This commitment has led to the European Union (EU) 2020 Biodiversity Strategy. The strategy runs to 2020 and, by that time, aims to halt the loss of biodiversity and ecosystem services in EU Member States. This project contributes to achievement of Target 2 of the strategy in Ireland. Target 2 aims for the maintenance and restoration of ecosystems and their services by 2020. Under Action 5 of Target 2, each Member State will map their ecosystems and services by 2014 and assess the economic value of such services by 2020. Mapping these values will allow spatially explicit prioritisation and problem identification of threats to ecosystem services. They are also useful for communication between different stakeholders and will allow up- or down-scaling of values from national level to local level and vice versa (Maes *et al*., 2013). This will help to integrate these values into policymaking decisions. The integration of ecosystem service values into accounting and reporting systems at EU and national level by 2020 is required by the EU 2020 Biodiversity Strategy.

In addition, the EU also aims to protect the marine environment and ensure sustainable use in the future through the Marine Strategy Framework Directive (MSFD) (2008/56/EC). The overriding aim of the MSFD is to achieve "good environmental status" (GES) in all EU marine and coastal waters, as measured by 11 descriptors (Table 1.1), by 2020. It

**Table 1.1. MFSD descriptors of GES**

| No | MFSD descriptor |
|---|---|
| 1 | Biological diversity is maintained, including sufficient quality and quantity of habitats and species |
| 2 | Marine food webs occur at normal abundance and diversity and at levels capable of ensuring the long-term abundance of each species |
| 3 | Healthy stocks of all commercially exploited fish and shellfish that are within safe biological limits |
| 4 | Contaminants in fish and other seafood for human consumption do not exceed unhealthy levels |
| 5 | Concentrations of contaminants are at levels that do not give rise to pollution effects |
| 6 | Human-induced eutrophication is minimised |
| 7 | Marine litter does not cause harm to the coastal and marine environments |
| 8 | Non-indigenous species introduced by human activities have minimal effect on native ecosystems |
| 9 | Sea floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded |
| 10 | Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems |
| 11 | Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment |

is considered the first attempt by an EU directive to undertake an ecosystem approach to protect and maintain the marine ecosystems (Long, 2011). As can be seen in Table 1.1, many of the descriptors relate to ecosystem services provided by marine ecosystems, such as provision of food (descriptors 3 and 4) and regulating ecosystem services such as waste treatment (descriptors 5, 6, 7 and 11), or they relate to the overall achievement of maintaining biodiversity and functioning ecosystems upon which ecosystem services depend (descriptors 1 and 2).

Currently, Ireland is implementing the MSFD. Many of its aims overlap with the EU 2020 Biodiversity Strategy and the output of this project may contribute to helping policymakers in their assessments of the measures needed to achieve GES as required by the MSFD while ensuring the sustainable use of marine goods and services by present and future generations.

In 2012, the Irish Government launched an integrated marine plan for Ireland, "Harnessing Our Ocean Wealth" (HOOW) (GoI, 2012). The plan's primary goal is to develop a sustainable marine and maritime economy and to grow the Irish blue economy in order to increase its contribution to Ireland's GDP. However, it also aims to do this in a sustainable manner to ensure that Ireland's marine biodiversity and ecosystems are protected. One of the key actions, which this project will contribute towards, within the HOOW is Action 15, which is to "promote further research into economic values of marine biodiversity and ecosystem services to ensure best practice planning and management of the ocean resource" to ensure delivery of the goals of HOOW.

A number of national ecosystem assessments have been undertaken already across the EU. The most well-known and comprehensive of these is the UK National Ecosystem Assessment (UK NEA) (UK NEA, 2011), while Ireland has also undertaken work to assess the value of our biodiversity and ecosystem services (Bullock *et al.*, 2008). However, Brouwer *et al*. (2013) in their review of ecosystem assessments across the EU Member States noted that "marine ecosystem services are relatively less well explored", while at national level in Ireland a recent report by the National Economic and Social Council (NESC, 2014) highlighted the large gap in environmental and economic data in the area of the marine. There has been some work to overcome this, including work done as part of the initial assessment undertaken for the MSFD, and there is spatial data available in online atlases, especially Ireland's Marine Atlas (http://atlas.marine.ie), developed by the Marine Institute for Ireland's reporting for the MSFD and the Marine Irish Digital Atlas (MIDA) (http://mida.ucc.ie/) (Dwyer, 2004). The lack of marine spatial data relating to marine ecosystem services is a challenge for Ireland and for other countries (Townsend *et al.*, 2014).

## 1.1 Ecosystem Services

The ecosystem services classification system offers a way of understanding the indirect effects of decisions that affect the natural environment on human welfare. The term was first coined by Erlich and Erlich (1982) but the concept had been previously explored by others (Carson, 1962; Krutilla and Fisher, 1975; Westman, 1977). The concept gained prominence in the late 1990s, particularly following a paper published in *Nature* by Constanza *et al*. (1997), which attempted to estimate the value of the Earth's ecosystem services. This was in the same period as a number of papers started articulating the need for integrating ecosystem services into policy- and decision making (de Groot, 1987, 1992; Daily, 1997).[1] In turn, a number of ecosystem services classification systems were proposed (Daily, 1997; Constanza, 2008; Boyd and Banzhaf, 2009), which could be used in policy circles. A number of differing definitions of ecosystem services emerged (Fisher *et al*., 2009); the most common and succinct definition was that offered by the Millennium Ecosystem Assessment (MEA, 2005), which defined ecosystem services as "the benefits humans derive from nature", although there are other differing definitions, frameworks and classification systems (Nahlik *et al*., 2012).

The MEA was initiated in 2001 following a call by the United Nations (UN) Secretary-General, Kofi Annan. The objective of the MEA was to assess the effects of ecosystem change on human well-being and then provide evidence for actions needed to protect ecosystems, their ecosystem services and consequently human well-being dependent on those ecosystem services (MEA, 2005). As well as data on the linkage between biodiversity, conservation and ecosystem services and their linkages to social welfare, it provided a system for classifying ecosystem services into four broad groups. The first three – provisioning services, regulation and maintenance services, and cultural services – are all underpinned by the fourth, supporting services. Following on from the *Economics of Biodiversity and Ecosystems* or TEEB report (Kumar, 2010), it was noted that only the first three types of ecosystem services could be valued, otherwise there would be a risk of double counting (Fu *et al*., 2011) The types of ecosystem services that can be valued can be described as follows.

Provisioning services: these ecosystem services are tangible goods and there is often a direct connection between the ecosystem and the provision of these ecosystem services. Examples of the provisioning ecosystem services generated by Irish marine and coastal ecosystems are the marine fish and seaweed harvested and also the aquaculture resources around our coasts.

Regulation and maintenance services: these ecosystem services regulate natural functions and processes in the world around us and are often consumed indirectly. Examples of these ecosystem services include carbon sequestration, which helps to mitigate climate change, treatment of our wastewater and its return to the hydrological cycle, and flood and storm protection by sand dunes and saltmarsh, which lessens the damage done by winter storms.

Cultural services: the cultural ecosystem services refer to the psychical, psychological and spiritual benefits that humans obtain from contact with nature. Examples of the cultural ecosystem services in the Irish marine and coastal zones include recreational activities, such as walking along the beach and surfing, as well as the added value that having a sea view from your house provides for your well-being.

A thorough understanding of ecosystem functioning and how these functions provide benefits is needed in order to determine the change in service flow that might occur following a disturbance to an ecosystem. Analysts can then use a number of techniques to estimate the welfare impact that may result from changes in the supply or quality of these ecosystem services. Böhnke-Henrichs *et al*. (2013) emphasised the need to differentiate between different elements of the ecosystem service cascade (processes, functions, services, benefits and values) (Figure 1.1) so that different elements are not confused, noting that one service can deliver multiple benefits and confusing services and benefits could lead to double counting. This is why a classification system is needed for the assessment of ecosystem values in addition to the need to classify ecosystem services and identify gaps in knowledge. In many cases, each new study develops its own concepts and classifications or develops a variation on a previously used ecosystem service classification system. However, the UN (UN *et al*., 2014) has advocated a move towards a standard approach to an environmental–economic assessment classification system, especially for integrating environmental accounts with national accounts. This has led in recent years to a proposed

1 For further discussion of the history of the development of the ecosystem service concept the interested reader is directed towards Gómez-Baggethun *et al*. (2010).

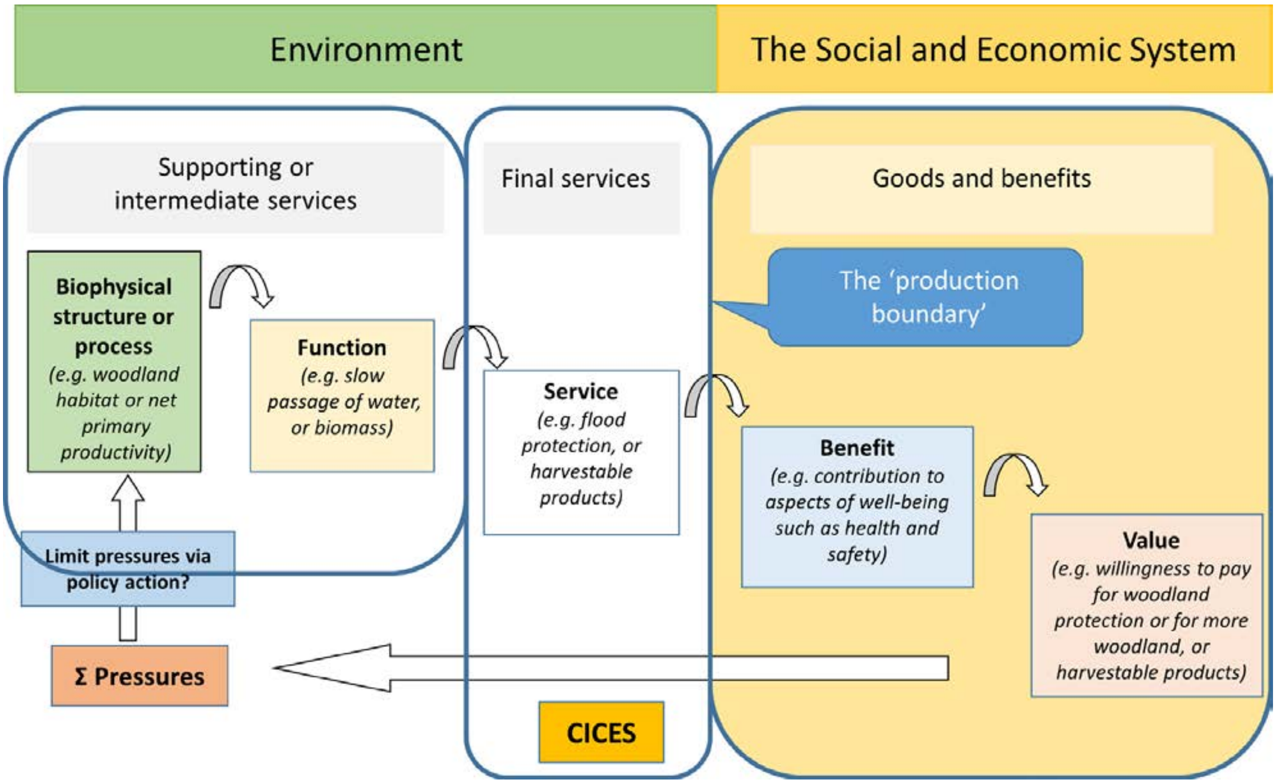


**Figure 1.1. An example of an ecosystem service cascade (adapted from Potschin and Haines-Young, 2011).**

new international classification system known as the Common International Classification of Ecosystem Services (CICES).

CICES was originally proposed by Haines-Young and Potschin (2010). Although it was originally envisaged as a method to facilitate the construction of ecosystem accounts, the hierarchical and flexible structure built on the three main ecosystem service types (provisioning, regulation and maintenance, and cultural) make it an ideal classification system for the assessment of ecosystem services (Maes *et al*., 2013). Since the original report, it has been updated as part of the revision of the System of Environmental–Economic Accounting (SEEA) by the UN Statistical Commission (UN *et al*., 2014). This process has led to debate within the review process reflecting the wider literature on aspects of measuring and valuing ecosystem services. Such topics include defining the boundary between abiotic and biotic services, the role of water as a service and whether ecosystem services are benefits or contribute to benefits.

This project will use CICES 4.3, the most up-to-date version of the classification system to classify the ecosystem services to be valued in this report. There are three main ecosystem services, provisioning, regulation and maintenance, and cultural. Figure 1.2 shows an example of how the hierarchical nature of CICES works for the breakdown of the provisioning ecosystem services. CICES is built upon the previous classification systems of the MEA and TEEB and this allows comparability between the classification systems used.

## 1.2 Valuing Ecosystem Services

The valuation of ecosystem services has been widely discussed. What is meant by valuation or values is the change in economic value that is measured as the amount of goods or services (typically measured in monetary terms) someone is willing to give up to accept a change in an ecosystem service or the amount that they are willing to receive to avoid a change in an ecosystem service. The former willingness to give up an amount is known as willingness to pay (WTP) and the latter is known as willingness to accept (WTA). In a market situation, the amount that is paid by a consumer may be less than the consumer's WTP and the excess value they did not pay is known as the consumer surplus. The

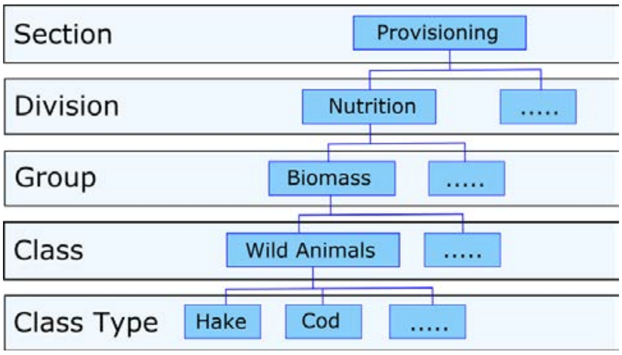


**Figure 1.2. Example of the hierarchical structure of the provisioning ecosystem services (from Haines-Young and Potschin, 2012).**

economic value of a good is therefore the WTP or, where there is a market price, it is the market price plus the consumer surplus (Hanley and Barbier, 2009).

To find the economic values of various types of ecosystem services, there are a variety of methods available. The type of methodology used depends on the types of services, whether the benefit being valued has use value or non-use value and if the data are sufficient to use a revealed or stated preference technique. As many ecosystem services are non-market goods and services, we have to use proxies to estimate the economic value of those. These proxies serve in the absence of formal markets and give some signals of value. Even in the case where we do have market prices, as is the case for provisioning goods, these do not reflect the true economic values, as they omit the consumer surplus element of value and may be affected by taxes or subsidies. There are three main types of valuation techniques: market-based, revealed preference and stated preference techniques.

Market-based techniques are based on data that are relatively readily available in the form of established market prices. Although market prices do not include consumer surplus, they are more readily available compared with non-market-based prices and serve as a good proxy for the change in value of certain ecosystem services, in particular the provisioning ecosystem types. An alternative is to use costs. Avoided costs is a measure of the value of a service that an ecosystem provides, often for no cost, which would otherwise have to be borne by human society. An extreme example would be the cost to pay someone to pollinate fruit if no bees or other pollinators were available. This is closely related to replacement costs, which are an estimate of how much it would cost to replace a service that an ecosystem had previously provided for free.

Another market-related technique is the production function approach. Production functions are statistical models that relate how changes in some ecosystem functions affect production of another good or service. These goods or services may have a market price, or the alternative methods described below can be used. This method may be able to account for non-linearity in the relationship between ecosystem functioning and services. The main challenge to this method is the need for good enough data describing the relationship and, even with such data, it can be very site specific.

Revealed preference (RP) techniques are used where people’s choices can be observed and related back to market prices or where consumer surplus can be estimated from their behaviour. The travel cost method is used to estimate the value of sites to which people travel for recreation (including hunting, fishing and wildlife viewing). It is based on the theory that travel cost represents the price of access to the site. The distance travelled and number of trips can be modelled to represent the WTP of individuals for the site. Undertaking the survey may be costly. Hedonic pricing is a statistical modelling technique, which is most commonly used with house or land prices to determine the values of the surrounding environmental levels, such as air quality, distance to amenities or a clean water body, and to estimate the value of changes in these ecosystem services to the change in value of the house or land. Getting data of sufficient quality and reliability is often the biggest problem with using this technique.

Stated preference techniques are often used to estimate non-use values. For example, an individual may gain utility from the knowledge that the blue whale is protected and be willing to pay towards that protection, even though they may never even see or use a blue whale themselves. Stated preference techniques are based on constructed hypothetical markets through which individuals are asked to express their WTP for environmental goods and services. Contingent valuation is a stated preference method of valuing a single change to an environmental good or service. The change is described and the respondent is asked to pay via a charge or tax (the respondent is asked their WTP for positive changes or their WTA for negative changes). In contrast, choice experiments are based on breaking a good or service down into a number of attributes and can be used to measure how respondents trade off between the various attributes. The values of different types and levels of attributes are measured by including a cost attribute.

These stated and revealed primary valuation methods can take time to implement and are often expensive to conduct. However, there is a secondary methodology known as value transfer that is both time and cost efficient (Brouwer, 2000). In this method, values are taken from the literature and their value is transferred from the original study site (where the primary research took place) to the policy site (where the value of the benefits is to be estimated). While the values can often be adjusted for differences between the sites (income differences, temporal differences, differences in affected population, etc.), there is still the possibility of an error in the estimated value. However, it can still provide a broad estimate of the value of the benefits delivered by ecosystem services (Johnston and Rosenberger, 2010).

For a more detailed examination of the different types of economic valuation techniques that are applicable to valuing ecosystem services, the reader is directed towards de Groot *et al*. (2002) or Hanley and Barbier (2009).

While more primary valuation studies need to be undertaken for all ecosystem typologies, especially within Europe, at a global scale terrestrial ecosystems have been studied more than coastal and marine ecosystems. There is often a clearer relationship between terrestrial ecosystems and the benefits they produce compared with marine or some coastal ecosystems, which tend to involve more non-linear (i.e. more complex) relationships between ecosystem functioning and the benefits they produce. Ecosystem services, their benefits and the relationships between ecosystem functioning and the benefits produced have been extensively studied for terrestrial ecosystems such as forests (Garrod and Willis, 1992; Cullinan *et al*., 2011) and wetlands (Bateman and Langford, 1997; Ghermandi *et al*., 2010).

Despite there being a low number of marine and coastal valuation studies relative to those for terrestrial ecosystems, there have been increased attempts to put values on the benefits generated by marine and coastal ecosystem services in recent years. One of the first attempts was a paper by Costanza *et al*. (1997). They made an attempt to value the ecosystem services provided by all the ecosystems in the world and estimated a total value of US\$33 trillion$^{1997}$ per year (1997 prices). They estimated that the "total economic value" of coastal and marine ecosystems was \$20.9 trillion$^{1997}$ and it accounted for 63% of the world's ecosystems "total economic value", of which coastal systems alone contributed \$10.6 trillion$^{1997}$.

More recently, Barbier *et al*. (2011) undertook a review of five different estuarine and coastal ecosystems (coral reefs, seagrass beds, saltmarshes, mangroves, and sand beaches and dunes) and showed numerous examples of the various benefits produced by the ecosystems. Coral reefs generate US\$15,000–45,000 km$^{-2}$ of healthy coral reef in the Philippines from sustainable fish production (White *et al*., 2000), while, in the Seychelles, an estimate of US\$88,000 total consumer surplus was generated for 40,000 tourist visits to its marine parks (Mathieu *et al*., 2003). Examining saltmarshes, King and Lester (1995) estimated £15.27 ha$^{-1}$ year$^{-1}$ net income from livestock grazing in the UK, while, for the ecosystem service of lifecycle maintenance, US saltmarsh had values of US\$6471 per acre and \$981 per acre for recreational fishing for the east and west coasts, respectively, of Florida (Bell, 1997) and a marginal value product of US\$0.19–1.89 per acre in a Gulf Coast blue crab fishery (Freeman, 1991). For sand beaches and dunes, Huang *et al*. (2007) estimated a WTP of US\$4.45 per household for an erosion control programme to preserve 8 km of beach in Maine and New Hampshire. For recreation, a value of US\$166 per trip or US\$1574 per household/year was estimated for North Carolina beaches in the USA (Landry and Liu, 2009). This review showed that the various ecosystem services provided by marine and coastal ecosystems have high values associated with the benefits they produce.

Brenner *et al*. (2010) undertook a benefit transfer for the coastal zone of the Catalan coast, which examined four coastal and marine ecosystem types that covered 22% of the area under consideration. The yearly ecosystem value was estimated to be US\$3.2 billion (2004) for the coastal area of Catalan. In the UK, Lusetti *et al*. (2011) considered the value of managed coastal realignment scenarios (Humber estuary and Blackwater estuary) from an ecosystem services perspective. The study found that for the Blackwater estuary there was a deep greening scenario that involved the creation of 10 times as much intertidal habitat (much of it saltmarsh, which could produce estimated net benefits of £74.83 million).

Looking at non-use values, Eggert and Olsson (2009) used a choice experiment with the attributes of coastal cod stock levels, bathing water quality levels and biodiversity levels to estimate the values traded off between these aspects of a marine ecosystem. McVittie and Moran (2010) also used a choice experiment to estimate the non-use values associated with the introduction of marine conservation areas within the UK. The McVittie and Moran study (2010) attributes included biodiversity, environmental benefits (such as carbon sequestration, water treatment and recreation) and restrictions to fishing and marine extractive industries. They also argued that non-use values compose a large segment of the values associated with changes to the marine environment because of their spatial remoteness relative to other ecosystems.

Also in the UK, Beaumont *et al*. (2010) included an economic valuation of the benefits of many marine and coastal ecosystem services as part of the UK NEA. For carbon sequestration, it was estimated that the current (2010) value is £19.9 million per year for ecosystems within the coastal margin and, for the marine waters in 2004, it was estimated to be worth £6.7 billion per year. For fisheries, the estimated value was £596 million per year in 2008, while recreational services were worth £17 billion based on 2002 data.

In Ireland, Bullock *et al*. (2008) undertook a valuation mainly of terrestrial ecosystem services particularly related to biodiversity but also included a section on marine and coastal ecosystems. Bullock *et al*. (2008) examined the provisioning services of fisheries noting that, although the amounts of landings were declining, the value of landings had been maintained at about €180 million. In the same report, the provisioning services of aquaculture production were valued (€125 million) but, while seaweed and mäerl production and the regulating service related to the prevention of harmful algal blooms were commented on, no value specific to an Irish context was available. Hynes *et al*. (2012) undertook a valuation exercise for Galway Bay, which used value transfer combined with an ecosystem approach to estimate the values of different ecosystems and the services they provide. The paper included a novel cultural adjustment approach, which showed that the lowest transfer error was 50% of the tests when the cultural adjustment was combined with a gross national income (GNI) adjustment. This study showed that the sea and beaches were the two most valuable ecosystems at €137.6 million and €45.3 million, respectively, using the combined GNI and cultural adjustment. The study also estimated, using the combined approach for the benefit transfer, that waste treatment (€136.8 million), non-use value (€34.8 million) and recreation (€34.5 million) were the most valuable ecosystem services for the area studied.

In what follows, an assessment of Ireland's marine and coastal ecosystem services and their values are presented. Using the CICES system as a guide, estimates for the quantity and value of provisioning, regulation and maintenance, and cultural ecosystem services were generated. In each case, those service benefits that can be valued are presented under the headings of data source, methodology used and results. We do not review those ecosystem services in this technical report where insufficient data are available to estimate the quantity of the ecosystem service or the value. We also provide some overarching guidelines for carrying out an ecosystem services assessment in Appendix 2.

# 2 Ireland's Provisioning Marine Ecosystem Services

## 2.1 Offshore Capture Fisheries

Ireland is located in UN Food and Agriculture Organization (FAO) major fishing area 27 (Atlantic, Northeast), which covers 4% of the world's ocean surface area and accounts for 10% of the world's capture fisheries, making it the second most productive area in the world (OSPAR Commission, 2009). The capture fisheries ecosystem service is measured in tonnes of fish landings and valued using market price data.

### *2.1.1 Data source*

The main data source for the capture fisheries is from the Scientific, Technical and Economic Committee for Fisheries (STECF), which is the advisory body for the European Commission on fisheries management. The STECF in conjunction with the Joint Research Centre (JRC) and Member States under the Data Collection Framework (DCF) collects, manages and makes available a wide range of fisheries data needed for scientific advice. This disseminated data collected for the evaluation of the fishing effort regimes is the main source of data for the analysis of offshore capture fisheries and can be downloaded from the JRC Data Dissemination for Fisheries Dependent Information web page.[2]

It is also noted that the STECF dataset covers only data for EU landings. To look at non-EU fisheries taking place in the Irish Exclusive Economic Zone (EEZ), the International Council for the Exploration of the Sea (ICES) data for ICES areas VI and VII was examined using the ICES Official Nominal Catches 2006–2013 dataset.[3]

### *2.1.2 Methodology*

There are a number of STECF datasets that cover the north-east Atlantic area and include Ireland. The data are available across various EU Member States and are available at the spatial scale of ICES statistical rectangles (0.5° latitude by 1.0° longitude). As there is spatial overlap between datasets and they cannot be aggregated, it was decided to follow the approach taken by Gerristen and Lordan (2014).

The data used for the ICES statistical areas VIa and VIIa were taken from the Annex IIa dataset and the data used for ICES statistical areas VIb and VIIb–k were taken from the Western Waters dataset. The Western Waters data were stripped of the BSA (biologically sensitive area) data to avoid double counting. Owing to concern about the quality of data from boats under 15 m, which were traditionally not required to have vessel monitoring systems (VMS, used to allocate landings data across the rectangles), and boats under 10 m, which are not required to log their landings, only data from boats over 15 m were used for the offshore capture fisheries. Boats under 15 m are known as the inshore fleet and the vast majority work in Irish territorial waters (less than 12 nautical miles from the coast). The prices are based on those reported by Gerristen and Lordan (2014) and the Marine Institute Stock Book (MI and BIM, 2015). The reference year used is 2014. The Irish EEZ and the ICES rectangles used to estimate the Irish wild fisheries ecosystem services can be seen in Figure 2.1, and it is noted that some of these straddle the EEZ border between Ireland and the UK, which might lead to a slight overestimate of the offshore capture fisheries caught by boats longer than 15 m in the Irish EEZ.

For non-EU fisheries, the total tonnage for all offshore capture fisheries for ICESs areas VI and VII was examined in 2014 and is estimated at 1,690,622 tonnes. The EU took 1,138,595 tonnes and the non-EU states (Russia, Norway, Faroe Islands, Iceland and Greenland) took 546,076 tonnes. Of this, 538,977 tonnes were blue whiting (*Micromesistius poutassou*; FAO code: WHB), making up 99% of the non-EU catch in ICES areas VI and VII. No other species was therefore considered.

2 https://stecf.jrc.ec.europa.eu/dd/effort

3 http://www.ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

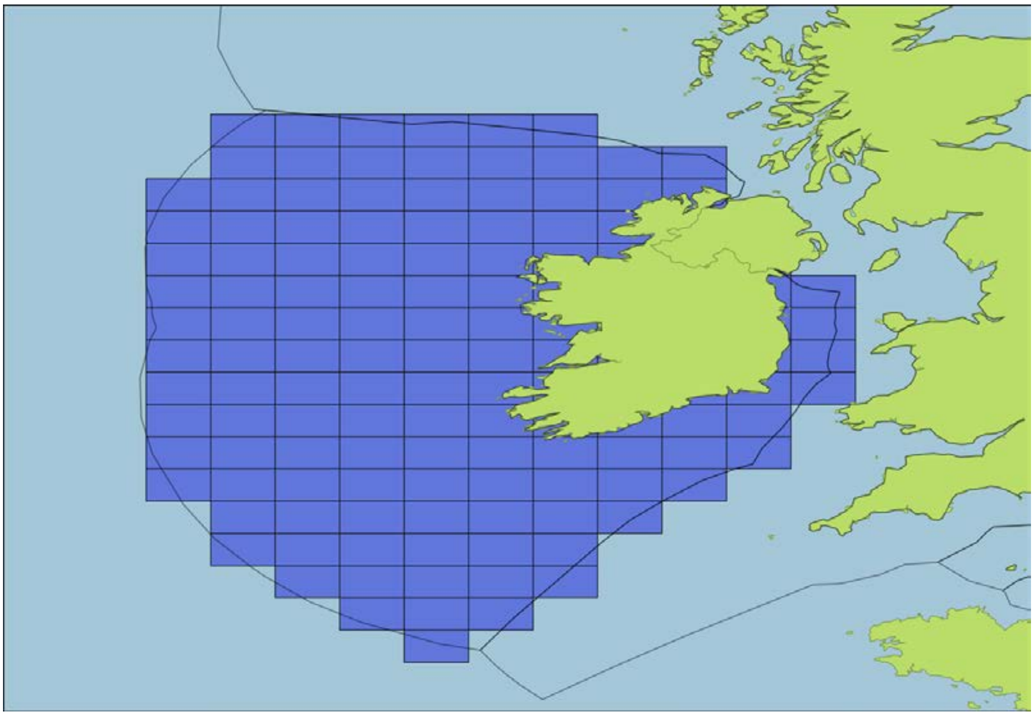

**Figure 2.1. The dark blue rectangles show which ICES rectangles were included in estimating the value of Ireland's offshore fisheries.**

To estimate the non-EU blue whiting catch within the Irish EEZ, maps of where blue whiting were caught showed that the vast bulk of the activity that occurred within the Irish EEZ was in ICES rectangles VII c2 and VI b2. ICES data for these areas showed that the only non-EU fishing nation catching blue whiting was Norway. From this data, it is estimated that approximately 80,000 tonnes of blue whiting was caught by Norway in the Irish EEZ in 2014. Note that non-EU catches are not accounted for in the maps in this report, which rely on STECF data alone.

### *2.1.3 Results*

Table 2.1 shows a breakdown of the species landed from waters within the Irish EEZ for all vessels greater than 15 m, ordered by value. As there were no individual-level prices available for some species, these were aggregated with "other species" from the STECF data, which means that the category "other species" is not included in the value of landings. This group makes up less than 0.3% of the offshore capture fisheries by landings and its value would be expected to be less than 2% of the total value of the offshore capture fisheries by boats longer than 15 m. It is estimated that the top 10 valued species make up over 90% of the total value.

**Table 2.1. Estimated annual landings and value for capture fisheries within the Irish EEZ for vessels longer than 15 m**

| Species | Landings (tonnes) | Estimated value (€) |
|---|---|---|
| Hake | 33,496 | 81,033,688 |
| Blue whiting | 159,398 | 77,784,715 |
| Mackerel | 101,522 | 75,123,471 |
| Nephrops | 9639 | 52,459,978 |
| Anglerfish/monkfish | 15,757 | 51,296,108 |
| Horse mackerel | 67,266 | 42,684,084 |
| Megrim | 8098 | 24,379,551 |
| Albacore tuna | 9864 | 18,279,184 |
| Whiting | 7415 | 8,439,412 |
| Haddock | 4718 | 7,818,730 |
| Herring | 19,111 | 5,749,079 |
| Cod | 1868 | 4,518,946 |
| Scallop | 1357 | 2,683,604 |
| Saithe | 1196 | 2,196,076 |
| Witch | 1064 | 2,093,086 |
| Ling | 1696 | 2,074,902 |
| Boarfish | 16,491 | 2,020,027 |
| Sole | 221 | 1,973,941 |
| Ray and skate | 1435 | 1,850,055 |
| Turbot | 194 | 1,535,826 |
| Lemon sole | 518 | 1,363,738 |

**Table 2.1. Continued**

| Species | Landings (tonnes) | Estimated value (€) |
|---|---|---|
| Pollack | 783 | 1,255,350 |
| Squid | 539 | 870,419 |
| Plaice | 386 | 709,622 |
| Sprat | 2381 | 433,247 |
| Black scabbardfish | 496 | 343,286 |
| Blackbelly rosefish | 429 | 331,057 |
| Conger eel | 261 | 286,869 |
| Grenadiers | 155 | 130,964 |
| Blue ling | 86 | 73,230 |
| Crab | 483 | 739,204 |
| Tusk | 13 | 10,468 |
| Other species | 1399 | – |
| Totals | 469,735 | 472,541,917 |

As shown in Table 2.1 and in the map of ICES rectangle values (Figure 2.2), there is significant heterogeneity in the value that each species contributes. Looking at ICES rectangle value maps of some of the top 10 species by value (Figure 2.3), patterns can be distinguished for certain species, which are linked to their characteristics and the characteristics of the ecosystem types they inhabit. For example, megrim is landed predominantly from the southern Irish EEZ, while blue whiting is more commonly caught in the north-west area of the EEZ.[4] Nephrops is also very region specific, with major resources to the west of the Aran Islands, the south east and in Dublin Bay, while albacore tuna is mostly caught far off the south-western shores of Ireland. Table 2.2 shows the main beneficiaries from this provisioning service in terms of Member States' share in the resource by value and landings.

## 2.2 Inshore Capture Fisheries

The inshore capture fisheries are mainly based in the territorial waters that extend out to 12 nautical miles from the coast and are mainly composed of boats less than 15 m. The vast majority of these target shellfish stocks (MI and BIM, 2015).

4 Note that only blue whiting caught by EU Member States is mapped.

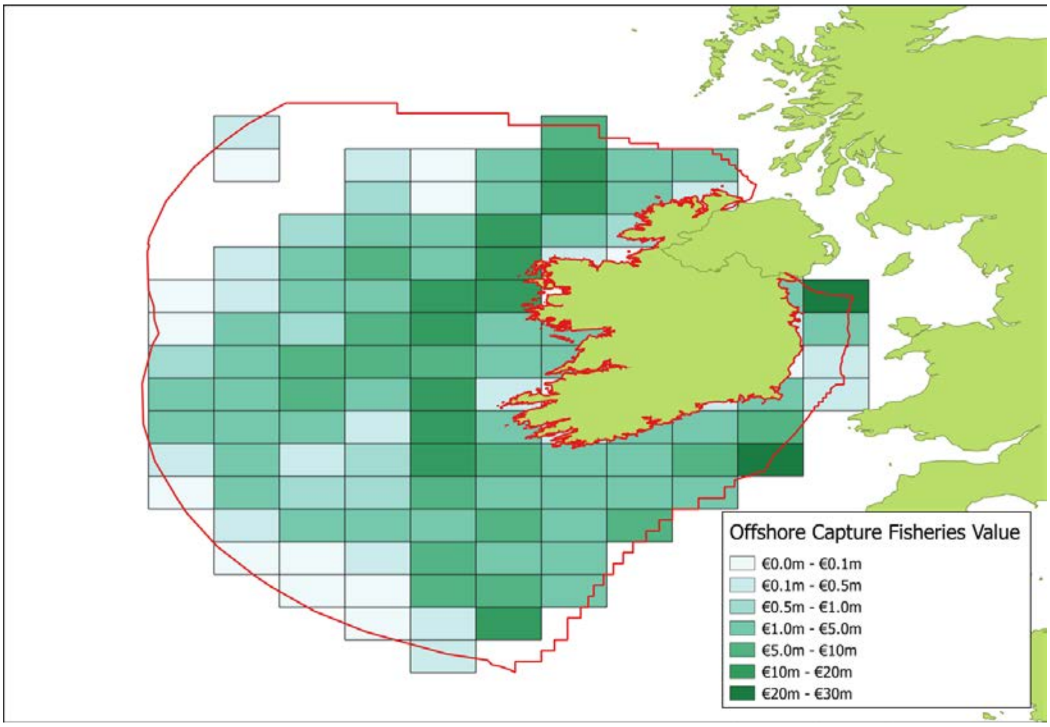


**Figure 2.2. The estimated total landings value per ICES rectangle in millions of euros.**

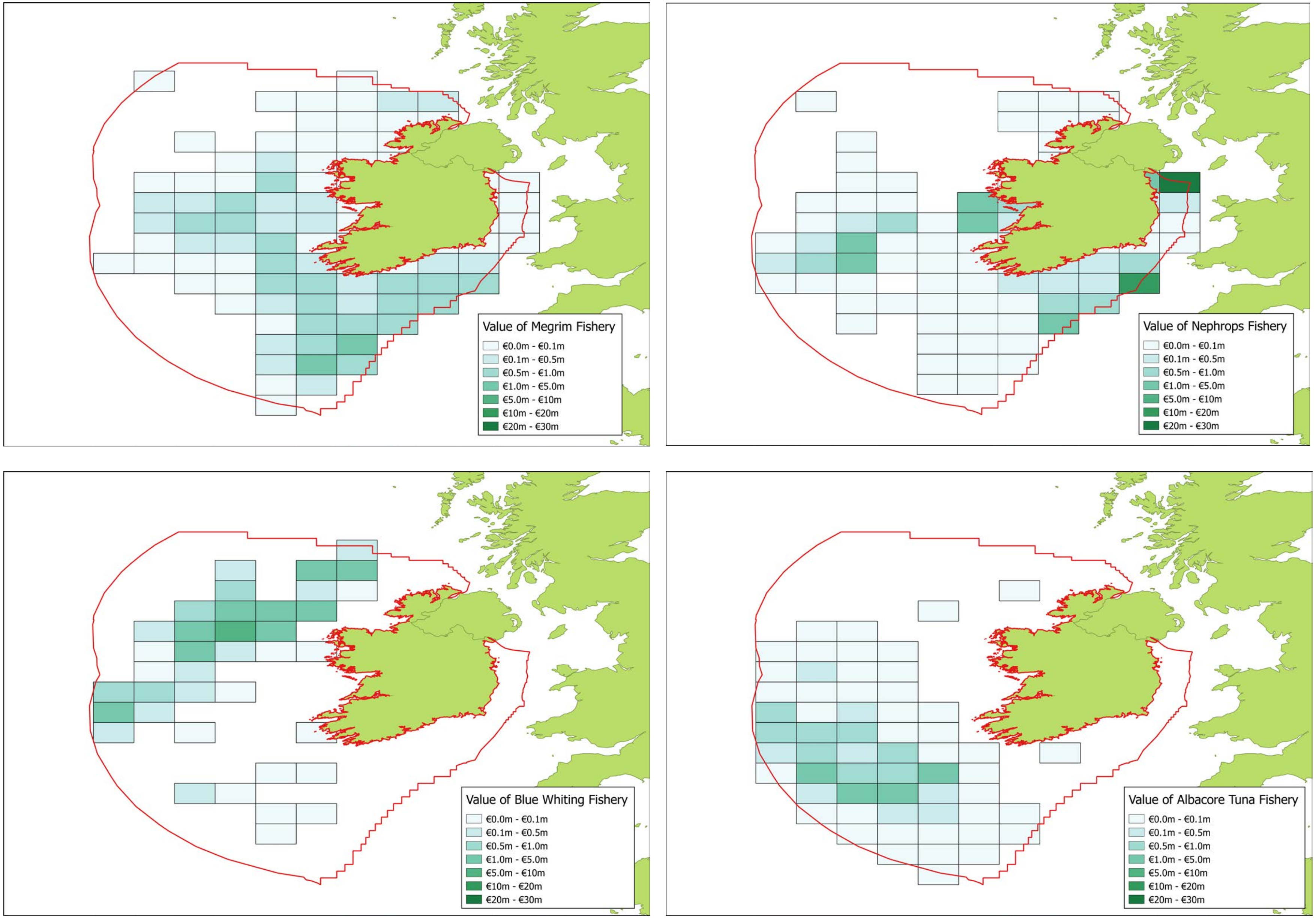


**Figure 2.3. Value maps for megrim (top left), nephrops (top right), blue whiting (bottom left) and albacore tuna (bottom right).**

**Table 2.2. Offshore landings and value by Member State fishing in the Irish EEZ, 2014**

| | Estimated landings (tones) | Estimate value of landings (€) | % of total value | % of total landings |
|---|---|---|---|---|
| Belgium | 417 | 1,546,003 | 0.3 | 0.1 |
| Denmark | 22,375 | 12,758,888 | 2.7 | 4.8 |
| England | 16,523 | 24,183,039 | 5.1 | 3.5 |
| Spain | 23,239 | 55,057,710 | 11.7 | 4.9 |
| France | 41,704 | 86,720,080 | 18.4 | 8.9 |
| Germany | 27,981 | 18,551,512 | 3.9 | 6.0 |
| Ireland | 156,735 | 155,879,060 | 33.0 | 33.4 |
| Netherlands | 34,453 | 20,774,560 | 4.4 | 7.3 |
| Northern Ireland | 7765 | 14,014,175 | 3.0 | 1.7 |
| Scotland | 58,543 | 44,017,690 | 9.3 | 12.5 |
| Total EU | 389,735 | 433,502,717 | 91.7 | 83.0 |
| Non-EU | 80,000 | 39,039,200 | 8.3 | 17.0 |
| Total | 469,735 | 472,541,917 | 100 | 100 |

### *2.2.1 Data source*

The data for the shellfish and crustacean fisheries are based on the Shellfish Stocks and Fisheries Review 2014 (MI and BIM, 2015), using figures for the year 2013. This report focuses on selected shellfish and crustacean stocks in Ireland that are mainly distributed inside the national 12-nautical-mile territorial limit (except for crab and scallop, which are also fished outside the 12-nautical-mile limit) and that are nearly all targeted by vessels less than 15 m.

### *2.2.2 Methodology*

Both landings and price figures for the latest year with complete data (2013) were reproduced from the Shellfish Stocks and Fisheries Review 2014 (MI and BIM, 2015).

### *2.2.3 Results*

Table 2.3 shows the estimated landings and the value of those landings at 2013 prices for the Irish inshore capture fisheries with estimated inshore landings of 14,421 tonnes valued at €42,112,820. Crayfish and lobster are the most valuable per tonne, with king scallop being the most valuable overall. Edible crab is the largest fishery by landings.

**Table 2.3. Estimated landings and value for the selected inshore fisheries in Ireland**

| Common name | 2013 tonnes | 2013 price per tonne (€) | 2013 value (€) |
|---|---|---|---|
| King scallop | 2584 | 5900 | 15,245,600 |
| Edible crab | 6510 | 1490 | 9,699,900 |
| Lobster | 374 | 12,720 | 4,757,280 |
| Whelk | 2660 | 1200 | 3,192,000 |
| Shrimp | 157 | 16,430 | 2,579,510 |
| Razor clams | 723 | 3540 | 2,559,420 |
| Crayfish | 34 | 35,000 | 1,190,000 |
| Native oyster | 214 | 4000 | 856,000 |
| Velvet crab | 365 | 1990 | 726,350 |
| Queen scallop | 285 | 1700 | 484,500 |
| Periwinkle | 218 | 2040 | 444,720 |
| Spider crab | 229 | 1080 | 247,320 |
| Surf clam | 37 | 3000 | 111,000 |
| Shore crab | 31 | 620 | 19,220 |
| Total | 14,421 | | 42,112,820 |

**Source: MI and BIM (2015). These values do not represent the total amounts or total value of Ireland's inshore fishery, as finfish capture by the inshore fleet is not recorded.**

## 2.3 Aquaculture

Aquaculture is an important sector particularly in rural areas of the west of Ireland. Most of the aquaculture output produced relates to salmon, oyster and mussel farming and is mainly based on the west coast of Ireland. Salmon farming is generally carried out using cages suspended in the water. Oyster and mussel aquaculture operations usually use either bottom production methods (on the low shoreline or seabed) or, for mussels, suspended rope cultures.

### *2.3.1 Data source*

The main data source for the aquaculture fisheries is the Bord Iascaigh Mhara (BIM) Annual Aquaculture Survey 2016 (BIM, 2016). It has data for both production and market price for aquaculture species in Ireland.

### *2.3.2 Methodology*

The figures for the latest year with complete data (2015) are reproduced from the BIM Annual Aquaculture Survey 2016 (BIM, 2016).

### *2.3.3 Results*

As can be seen from Table 2.4, Atlantic salmon is the most valuable farmed marine species in Ireland, while the Pacific oyster is the most valuable farmed shellfish, even though the quantity of blue mussels farmed is nearly double that of pacific oysters.

**Table 2.4. Irish aquaculture production and value 2015**

| Common name | Production (tonnes) | Value (€) |
|---|---|---|
| Atlantic salmon | 14,004 | 97,111,893 |
| Pacific cupped oyster | 9018 | 35,252,032 |
| Blue mussel | 16,009 | 12,846,147 |
| European flat oyster | 471 | 2,583,000 |
| Great Atlantic scallop | 50 | 233,550 |
| Other marine species | 173 | 742,500 |
| Total | 39,725 | 148,769,122 |

**Source: BIM Annual Aquaculture Survey 2016 (BIM, 2016).**

Figure 2.4 shows the distribution of salmon, oyster and mussel aquaculture by county around the coast of Ireland (BIM, 2016). These figures are presented in Table 2.5 and demonstrate the importance of this provisioning service to counties on the west coast in particular.

**Table 2.5. Aquaculture by type and county in 2015**

| County | Atlantic salmon (tonnes) | Pacific cupped oyster (tonnes) | European flat oyster (tonnes) | Blue mussel (tonnes) |
|---|---|---|---|---|
| Donegal | 2873 | 2002 | 200 | 855 |
| Sligo | – | 142 | – | – |
| Mayo | 2128 | 1128 | 16 | 1286 |
| Galway | 5371 | 323 | 80 | 1043 |
| Clare | – | 240 | – | 20 |
| Limerick | – | 15 | – | – |
| Kerry | – | 533 | 175 | 2948 |
| Cork | 3601 | 816 | – | 6193 |
| Waterford | – | 2969 | – | – |
| Wexford | 31 | 432 | – | 2211 |
| Louth | – | 418 | – | 1453 |
| Totals | 14,004 | 9018 | 471 | 16,009 |

**Source: BIM Annual Aquaculture Survey 2016 (BIM, 2016).**
**"–", no production.**

## 2.4 Algae/Seaweed Harvesting

Seaweeds, also known as macro-algae, are plant-like marine species and are generally found attached to hard substrates along the coast. They can be categorised on the basis of colour into three divisions: brown algae (Phaeophyceae), red algae (Rhodophyta) and green algae (Chlorophyta). In Ireland, seaweed is mainly harvested on the western seaboard, focused mainly on the counties of Donegal, Sligo, Mayo, Galway, Clare and Cork. There are many uses of the seaweed harvested in Ireland, but, following processing, it is primarily used as a food additive, for agriculture and aquaculture feed, as fertiliser and as an additive in the cosmetics industry (O'Toole and Hynes, 2014).

### *2.4.1 Data source*

There are a variety of estimates for the volume of seaweed production in Ireland. It is estimated that there is an annual harvest of approximately 30,000 tonnes of

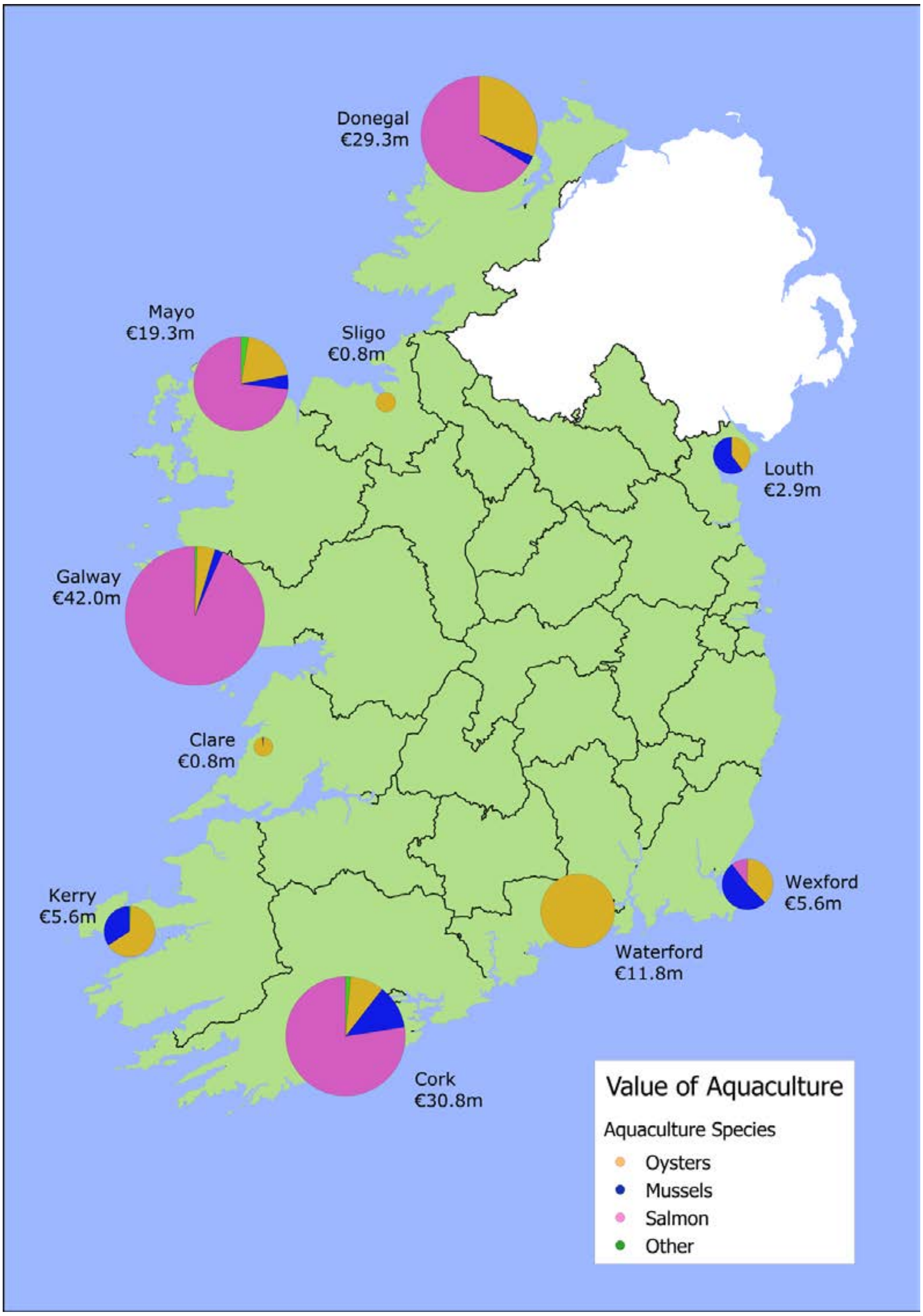


**Figure 2.4. Value of Irish aquaculture activity by county.**

seaweed in Ireland (FAO, 2014 ; O'Toole and Hynes, 2014) but it could be as high as 36,000–40,000 tonnes (Morrissey *et al*., 2011; JCECG, 2015).

### *2.4.2 Methodology*

For this report, the quantity of the estimated harvest for the main types of seaweed was based on the UN FAO estimates for 2012 (FAO, 2014) and the value estimated for 2012 was based on the figures from O'Toole and Hynes (2014).

### *2.4.3 Results*

The main species harvested is *Ascophyllum nodosum* (brown algae) and its main areas of production are in the western bays and islands of Galway, Rutland Island, Sound in County Donegal, and Clew Bay in County Mayo (O'Toole and Hynes, 2014). The other less harvested species are *Fucus serratus* (brown algae), *Laminaria digitata* (brown algae), *Chondrus crispus* (red algae) and *Palmaria palmate* (red algae). Table 2.6 shows the estimated harvest production and value for the main types of seaweed for 2012.

## 2.5 Water for Non-drinking Purposes

The most significant type of non-drinking use for marine water identified in coastal, marine and estuarine ecosystems was the use of water for cooling a number of electricity generating stations in a number of estuaries around Ireland. Only the volume of seawater used is calculated. No monetary value is assigned to the use of this water.

### *2.5.1 Data source*

Six power plants were identified as using cooling water in estuaries in Ireland. Data for each were based on Annual Environmental Reports (AERs) from the EPA, inspector reports by the EPA, grey literature on certain plants and some calculations made by the authors of the report. Details of the source for each plant are described in more detail in the methodology section (section 2.5.2).

### *2.5.2 Methodology*

The method and further details for each power plant are given below.

*Aghada generating station*

The value for cooling water for Aghada generating station was estimated from the 2012 AER (http://www.epa.ie/licences/lic_eDMS/090151b280493736.pdf); 2012 was the only year cooling water volumes were detailed in an AER. It was based on discharges from PE4 and PE19, which were identified in Aghada Generating Station Integrated Pollution Prevention and Control (IPPC)/Waste Licensing Review Form and Guidance Note for the purposes of EC Environmental Objectives (Surface Waters) Regulations 2009 (http://www.epa.ie/licences/lic_eDMS/090151b2804250a8.pdf) as cooling water outfall (Unit 1) and condenser cooling water, respectively. In 2012, the discharge of cooling water from PE4 was 57,840,000 $m^3$ and from PE19 was 173,780,000 $m^3$, giving a total of 231,620,000 $m^3$ which is below the ELV (emission limit value) trigger of 280,320,000 $m^3$.

**Table 2.6. Estimated seaweed harvest in Ireland**

| Species | 2012 production (tonnes) | 2012 value (€) |
|---|---|---|
| *Ascophyllum nodosum* | 28,000 | 3,706,000 |
| *Laminaria hyperborea* | 1400 | 23,000 |
| Red seaweeds | 100 | 185,000 |
| Total | 29,500 | 3,914,000 |

*Poolbeg generating station*

The value for cooling water for Poolbeg generating station was estimated from the 2015 AER (http://www.epa.ie/licences/lic_eDMS/090151b28059c3e4.pdf). It was based on discharges from SW1, which was identified as a discharge for condenser cooling water in the inspector's report on a review of the licence in September 2012 (http://www.epa.ie/licences/lic_eDMS/090151b28045faf0.pdf). The value for 2015 was 50,642,736 $m^3$.

*Dublin Bay power plant*

The value for cooling water for Dublin Bay power plant was estimated from the 2015 AER (http://www.epa.ie/licences/lic_eDMS/090151b2805acaaa.pdf). It was based on discharges from SW1, which was identified as a cooling water emission point in the inspector's report on a review of the licence in June 2012 (http://www.epa.ie/licences/lic_eDMS/090151b2804446b8.pdf). The value for 2015 was reported as 584,618 $m^3\,day^{-1}$, which was multiplied by 365 to give an annual estimate of 213,385,570 $m^3$.

*Tarbert*

There was insufficient information available to estimate the cooling water used by Tarbet generating station.

*Great Island*

The value for cooling water for Great Island power station was estimated based on running hours and an estimate of cooling water used per hour from an environmental impact statement (EIS) for the new combined cycle gas turbine (CCGT) power plant. This was because there were no volumetric values reported for the volume of cooling water used in any recent AER. The estimated volume of cooling water used per hour was based on values reported in Table 14.8 in the EIS for the CCGT power plant (http://www.epa.ie/licences/lic_eDMS/090151b28035fbfd.pdf). For the existing heavy fuel oil (HFO) power plant units, it was reported that condenser cooling water used was 50,170 $m^3 h^{-1}$ and for the newer CCGT plant it was 25,000 $m^3 h^{-1}$. In the 2015 AER (http://www.epa.ie/licences/lic_eDMS/090151b2805b5cd1.pdf) the running hours for the HFO plant was 146 hours and for the CCGT plant was 4132 hours. Multiplying these figures by the estimates from Table 14.8 of the EIS gives an estimate of 89,964,820 $m^3$ of cooling water used in 2015.

*Moneypoint*

The value for cooling water for Moneypoint power station was estimated based on running hours and estimate of cooling water used per hour from a report by Connolly and Rooney (1997). The inspector's report on a review of the licence in October 2012 (http://www.epa.ie/licences/lic_eDMS/090151b2804610f2.pdf) identified discharge point SW8 as the discharge point for cooling water. However, there were no volumetric values reported for the volume of cooling water used in any recent AER. Therefore, the volume was estimated based on average running hours output (7261.7 h) for the three units reported for 2015 from the AER (http://www.epa.ie/licences/lic_eDMS/090151b2805b804d.pdf) and a figure of 83,160 $m^3 h^{-1}$ cooling water used when Moneypoint was generating based on a report by Connolly and Rooney (1997). This produced an annual estimate of 603,880,200 $m^3$.

### 2.5.3 Results

Table 2.7 shows the estimated annual amount of cooling water used by each of six power plants in estuaries in Ireland. The total amount of water used was estimated at nearly 1200 million $m^3$.

**Table 2.7. Details of water abstraction for cooling in Irish estuaries**

| Station name | Operator | Estimated maximum output (MW) | Cooling water source | Estimated volume ($m^3$) |
|---|---|---|---|---|
| Aghada generating station | ESB | 960 | Cork Harbour Estuary | 231,620,000 |
| Poolbeg generating station | ESB | 463 | Liffey Estuary | 50,642,736 |
| Dublin Bay power plant | Synergen Power Limited | 403 | Liffey Estuary | 213,385,570 |
| Tarbert generating station | SSE Generation Ireland Limited | 626 | Shannon Estuary | Not estimated |
| Great Island | SSE Generation Ireland Limited | 240 | Barrow/Suir Estuary | 89,964,820 |
| Moneypoint generating station | ESB | 849 | Shannon Estuary | 603,880,200 |
| Estimated total | | | | 1,189,493,326 |

# 3 Ireland's Regulation and Maintenance Marine Ecosystem Services

## 3.1 Waste Services

Wastewater discharged from urban wastewater treatment plants (WWTPs) is used as a part-measure of the ecosystem services of waste treatment in Irish coastal and estuarine waters. Wastewater is not the only waste that is discharged to Irish coastal and estuarine waters and urban WWTPs are not the only sources, but they are the sources with the most available information. Wastewater is treated to different levels before discharge to the aquatic environment where it undergoes dilution and further biological processes to clean the water of pollutants such as organic waste, nitrogen and phosphorus. Too much of these pollutants can lead to excess algal growth and in turn anoxic conditions in the water. It is noted that there are limits to what the aquatic environment can process in terms of our wastewater and it is also noted that, when thresholds are exceeded, ecosystems and the services they generate can decline or cease.

### *3.1.1 Data source*

The data for wastewater treatment were based mainly on AERs for 2015 and, where there was not enough data from the AERs, EPA inspectors' reports and applications for wastewater discharge licences were used to estimate the population equivalent (PE) of the agglomerations; estimates were generated as detailed in the methodology section (section 3.1.2). The sources for each of the 143 agglomerations are available in Appendix 1. Estimated values are shown in italics in Appendix 1.

The method of valuing this ecosystem service is based on the cost avoided if society had to provide the same water treatment services, such as the removal of excess nitrogen and phosphorus from the wastewater and the reduction of biochemical oxygen demand (BOD; a measure of organic waste), here treated as a pollutant. Hernandez-Sancho *et al*. (2010) estimated the shadow price of treating a kilogram of each of the examined pollutants to a level suitable for reuse of the water. The values have been adjusted for inflation and are shown in Table 3.1. Note that these values are based on operating costs and do not include capital expenditure.

### *3.1.2 Methodology*

Using the coastal and transitional water bodies defined in the Water Framework Directive (WFD, 2000/60/EC) and the EPA urban wastewater treatment spatial databases (available online: http://gis.epa.ie/), WWTPs near the coast that had wastewater discharge licences (required for agglomerations over 500 PE) or had applied for licences were chosen and this produced 182 agglomerations. An examination of the licence application files, EPA inspectors' reports and AERs (available online: http://www.epa.ie/terminalfour/wwda/index.jsp) reduced the number directly discharging into coastal and estuarine waters to 143 agglomerations (see Figure 3.1). Details of these agglomerations are shown in Appendix 1 along with the estimated effluent flows and estimates of the yearly $BOD_5$ (5-day BOD, a measure of organic waste), total nitrogen and total phosphorus with the receiving WFD water body and type of water body (coastal or estuarine).

For those agglomerations with no or only preliminary treatment, the figures in Table 3.2 (based on Kiely, 2007) were used to estimate the yearly emissions based on PE reported in the AER, application or the EPA inspector's report. For those agglomerations with primary treatment, the figures in Table 3.3 were used, which assume, as per Kiely (2007), that BOD is reduced by 30% and total nitrogen and total phosphorus are both reduced by 10%.

**Table 3.1. Shadow prices of removing a kilogram of each pollutant (values from Hernández-Sancho *et al.*, 2010)**

| Pollutant removed | Shadow price (€ per kg removed) (2015 prices) |
|---|---|
| BOD | €0.07/kg |
| Nitrogen | €30.93/kg |
| Phosphorus | €93.63/kg |

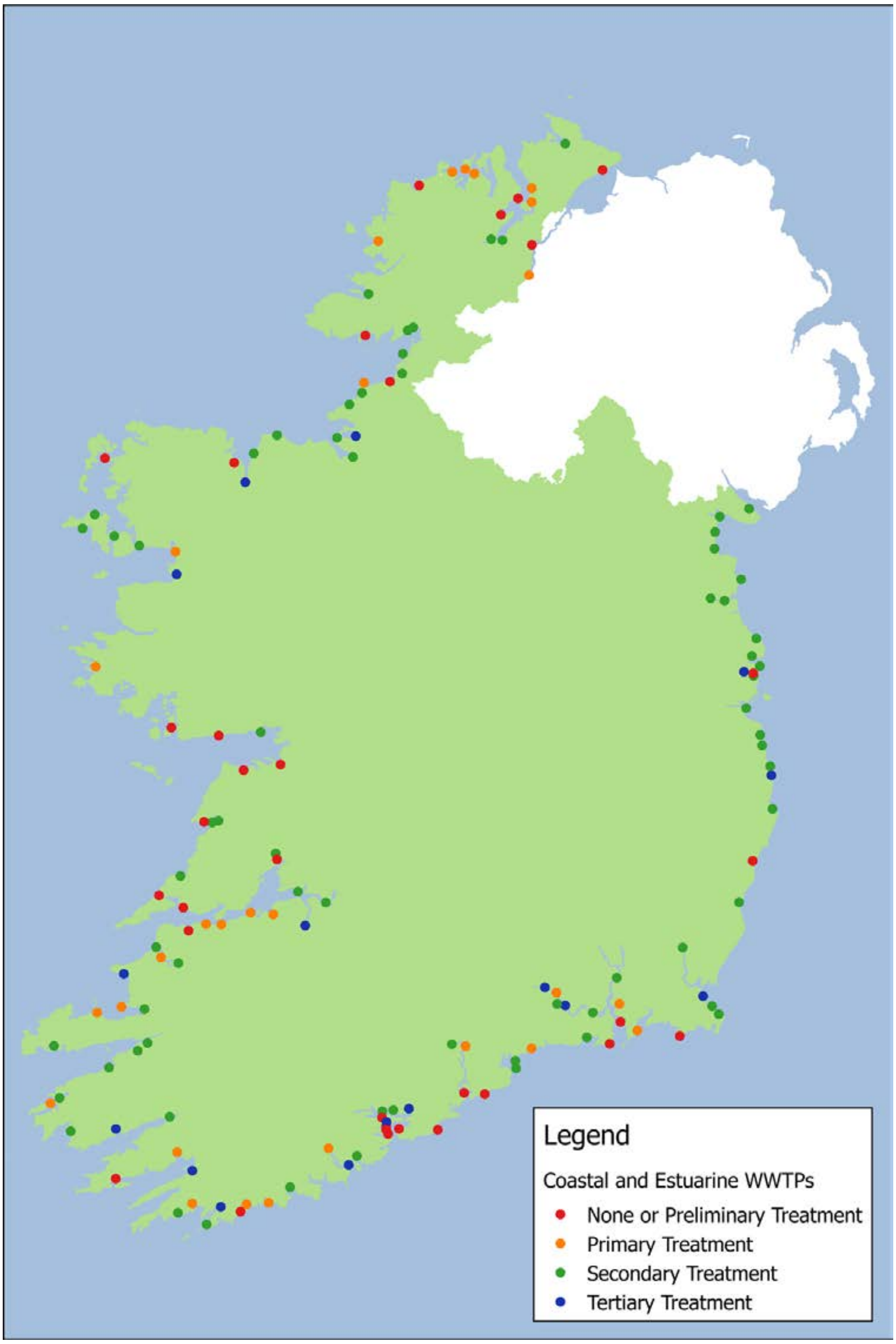


**Figure 3.1. Coastal and estuarine WTTPs in Ireland.**

**Table 3.2. Assumptions for untreated wastewater discharges quantities (Kiely, 2007)**

| Pollutant | kg PE$^{-1}$ day$^{-1}$ |
|---|---|
| cBOD | 0.06 |
| Nitrogen | 0.01 |
| Phosphorus | 0.002 |

**cBOD, carbonaceous BOD.**

**Table 3.3. Assumptions for primary treated wastewater discharges quantities (Kiely, 2007)**

| Pollutant | kg PE$^{-1}$ day$^{-1}$ |
|---|---|
| cBOD | 0.042 |
| Nitrogen | 0.009 |
| Phosphorus | 0.0018 |

For the agglomerations treated to secondary and tertiary levels, regression analysis was used to estimate the emissions for total nitrogen and total phosphorus based on PE and BOD emissions for the year. This led to the six regressions detailed below. The data for each were based on the details gathered through the AERs and were separated into three groups based on the level of treatment: secondary treatment; tertiary nitrogen removal and tertiary nitrogen and phosphorous removal; and, finally, tertiary phosphorous removal.

The total emissions of nitrogen and total phosphorus were estimated for Sneem WWTP (licence D0285) based on an ordinary least squares (OLS) regression analysis using the information from other plants with tertiary phosphorus removal (Tables 3.4 and Table 3.5) and without an intercept term. The results are shown below.

The emissions of total nitrogen and total phosphorus were estimated for Midleton WWTP (licence D0056), Ballyheigue (licence D0186) and Bantry (licence D0168) based on an OLS regression analysis using the information from other plants with tertiary nitrogen removal and tertiary nitrogen and phosphorus removal and without an intercept term (Tables 3.6 and Table 3.7). The results are shown below.

The total nitrogen and total phosphorus emissions were estimated for 15 WWTPs that were missing data for secondary treatment based on an OLS regression analysis using the information from other WWTPs treating to secondary treatment level and without the

**Table 3.4. Regression for estimating nitrogen emissions for plants with tertiary phosphorus removal**

| **Dependent variable: kg N year$^{-1}$** | | | | |
|---|---|---|---|---|
| *Coefficients* | *Estimate* | *Standard error* | *t-value* | *p-value* |
| PE (2015) | 3.7763 | 0.5552 | 6.802 | 0.00244 |
| kg BOD year$^{-1}$ | –1.025 | 0.3308 | –3.099 | 0.03627 |
| Adjusted $R$-squared statistic | 0.9466 | | | |
| $F$-statistic | 54.16 | | | |
| $n$ | 6 | | | |

**Table 3.5. Regression for estimating phosphorus emissions for plants with tertiary phosphorus removal**

| **Dependent variable: kg P year$^{-1}$** | | | | |
|---|---|---|---|---|
| *Coefficients* | *Estimate* | *Standard error* | *t-value* | *p-value* |
| kg BOD year$^{-1}$ | 0.41336 | 0.06608 | 6.255 | 0.00333 |
| PE (2015) | –0.11086 | 0.03937 | –2.816 | 0.04803 |
| Adjusted $R$-squared statistic | 0.938 | | | |
| $F$-statistic | 46.42 | | | |
| $n$ | 6 | | | |

**Table 3.6. Regression for estimating nitrogen emissions for plants with tertiary nitrogen removal**

| **Dependent variable: kg N year$^{-1}$** | | | | |
|---|---|---|---|---|
| *Coefficients* | *Estimate* | *Standard error* | *t-value* | *p-value* |
| PE (2015) | –0.08292 | 0.22136 | –0.375 | 0.7233 |
| kg BOD year$^{-1}$ | 2.56201 | 0.687 | 3.729 | 0.0136 |
| Adjusted $R$-squared statistic | 0.9784 | | | |
| $F$-statistic | 159.2 | | | |
| $n$ | 7 | | | |

**Table 3.7. Regression for estimating phosphorus emissions for plants with tertiary nitrogen removal**

| **Dependent variable: kg P year$^{-1}$** | | | | |
|---|---|---|---|---|
| *Coefficients* | *Estimate* | *Standard error* | *t-value* | *p-value* |
| PE (2015) | 0.05247 | 0.05517 | 0.951 | 0.395 |
| kg BOD year$^{-1}$ | –0.01382 | 0.17129 | –0.081 | 0.94 |
| Adjusted *R*-squared statistic | 0.7574 | | | |
| *F*-statistic | 10.37 | | | |
| *n* | 6 | | | |

**Table 3.8. Regression for estimating nitrogen emissions for plants with secondary treatment level**

| **Dependent variable: kg N year$^{-1}$** | | | | |
|---|---|---|---|---|
| *Coefficients* | *Estimate* | *Standard error* | *t-value* | *p-value* |
| PE (2015) | 1.1008 | 0.2365 | 4.655 | 0.0000234 |
| kg BOD year$^{-1}$ | 0.2911 | 0.1198 | 2.429 | 0.0187 |
| Adjusted *R*-squared statistic | 0.9746 | | | |
| *F*-statistic | 1016 | | | |
| *n* | 53 | | | |

**Table 3.9. Regression for estimating phosphorus emissions for plants with secondary treatment level**

| **Dependent variable: kg P year$^{-1}$** | | | | |
|---|---|---|---|---|
| *Coefficients* | *Estimate* | *Standard error* | *t-value* | *p-value* |
| PE (2015) | 0.105243 | 0.013491 | 7.801 | 0 |
| kg BOD year$^{-1}$ | 0.105919 | 0.006836 | 15.494 | 0 |
| Adjusted *R*-squared statistic | 0.9976 | | | |
| *F*-statistic | 10990 | | | |
| *n* | 53 | | | |

intercept term (Tables 3.8 and Table 3.9). The results are shown in italics in Appendix 1.

### *3.1.3 Results*

Based on the AERs shown in Appendix 1 and including the missing data as estimated above (section 3.1.2), the estimated totals for pollutants discharged into Irish coastal and estuarine waters for 2015 are shown in Table 3.10.

The shadow prices of Hernandez-Sancho *et al*. (2010) were used as an estimate of the cost avoided by not having to bring the discharged water from these water treatment services up to full re-use quality. By multiplying the shadow prices represented in Table 3.1 by the total amount of wastewater pollutants discharged (Table 3.10), the value of the ecosystem service of wastewater treatment in Irish waters is estimated as shown in Table 3.11.

**Table 3.10. Estimated totals for pollutants discharged into Irish coastal and estuarine waters for 2015**

| **Pollutant** | **Total (kg)** |
|---|---|
| BOD | 9,350,642 |
| Total nitrogen | 6,834,783 |
| Total phosphorus | 1,118,739 |

It should be noted that the values estimated in Table 3.11 are likely to be an underestimate of the value of the waste treatment service performed by the coastal and marine ecosystems because of other sources of wastewater, including agricultural run-off, septic tanks in rural coastal areas and discharges from rivers. It

**Table 3.11. The estimated annual value of the waste treatment ecosystem service for each pollutant**

| Pollutant removed | Total amount discharged (kg) | Estimated value of ecosystem service (€) |
|---|---|---|
| BOD | 9,350,642 | 638,252 |
| Nitrogen | 6,834,783 | 211,377,302 |
| Phosphorus | 1,118,739 | 104,751,290 |
| Total | | **316,766,844** |

should also be noted that there are many other types of waste that are discharged to the seas, such as accidental spillage of chemicals and litter, which were not accounted for in this analysis.

## 3.2 Coastal Defence

The ecosystem service of coastal defence (also known as mediation of flows under CICES) is the preventative or moderating effect that certain ecosystems can have on infrequent natural hazards, thus reducing the level of harm imposed on life, health or property. For coastal areas, these natural hazards often take the form of storms, storm surges and/or flooding. Many ecosystems can act as physical barriers to dampen or reduce the energy hitting the inland portion of the seashore. Such ecosystems include reefs, seagrasses, kelp beds/forests, dunes and saltmarshes.

### *3.2.1 Data source*

Based on Coordination of Information on the Environment (CORINE) data, saltmarsh area was available for saltmarshes larger than 25 ha.[5] Sixty-four sites were identified from the CORINE dataset and, using QGIS software, the land use of the land bordering each of the 64 saltmarsh sites was measured to determine the defensive length of the saltmarsh. Where saltmarsh bordered water or intertidal flats, no coastal protection service was deemed to be present. In addition, four sites were deemed not to provide a coastal defence ecosystem service, as they were adjoining coastal lagoons and were not exposed directly to the sea. Another site was also omitted on Inishmurray Island off County Sligo, as there were no inhabitants on the island. This left 59 sites (details of each of these sites are shown in Table 3.12).

### *3.2.2 Methodology*

Following the approach taken by Beaumont *et al*. (2010), only one ecosystem (saltmarsh) was examined in relation to its role in reducing disturbance related to waves and storms. Saltmarsh attenuates both waves and storm surges thereby reducing the energy hitting the seashore, which in turn means that the flood defences needed are lower than those required on an exposed shoreline. This method of valuation is known as the "replacement cost" approach, as it assumes that the seashore defences would have to be replaced or upgraded to provide the same function as a saltmarsh-protected seashore.

King and Lester (1995) estimated that a saltmarsh of minimum 80 m width would reduce the capital cost of a sea wall by between €400,000 and €800,000 per hectare (2015 prices) and incurred maintenance costs of €8000 per hectare per year (2015 prices). However, to multiply this by the total area of Irish saltmarsh, as was done by Beaumont *et al*. (2010), would overestimate this ecosystem service, as the average estimated width of the Irish saltmarsh for which data are available is about 400 m. Dividing 1 ha (10,000 $m^2$) by 80 m gives 125 m, which, divided by the per hectare figure above, gives a capital cost per linear metre of seashore protected by saltmarsh of €3200 to €6400. This compares to the King and Lester (1995) linear per metre costs of €3500 to €6200. Using the midpoint of these figures gives a value for capital cost (i.e. the value of putting in coastal defences if there was no saltmarsh) of €4800 and maintenance costs of €64 per metre length per year.

5 King and Lester's (1995) values are based on a minimum saltmarsh width of 80 m. In the analysis presented here, no saltmarshes were found to be have an average width less than 80 m, but some smaller saltmarshes not classified using the CORINE data, either in area (because of the linear nature of saltmarsh creation) or in width, may still provide valuable coastal defence ecosystem services in certain areas. This is highlighted as a limitation to the methodology used here and an area for future research.

Table 3.12. Breakdown of estimated protected lengths of CORINE landcover types by saltwater marsh in Ireland

| CORINE ID | County | Location | Area (ha) | Total estimated protected length (m) | Protected CORINE code | Protected CORINE length (m) | Protected CORINE code | Protected CORINE length (m) | Protected CORINE code | Protected CORINE length (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| IE_4754 | Cork | Inchydoney | 43 | 2003 | 231 | 2003 | | | | |
| IE_4755 | Cork | Lislevane | 61 | 4365 | 231 | 4365 | | | | |
| IE_4756 | Kerry | Waterville | 97 | 4045 | 231 | 3476 | 412 | 569 | | |
| IE_4757 | Cork | Cork City, Tivoli | 41 | 3620 | 243 | 1393 | 211 | 1085 | 122 | 891 |
| IE_4758 | Kerry | Cahersiveen | 26 | 1594 | 231 | 953 | 243 | 641 | | |
| IE_4759 | Kerry | Killorglin | 58 | 3954 | 231 | 3954 | | | | |
| IE_4760 | Kerry | Killorglin | 60 | 2449 | 243 | 1895 | 231 | 554 | | |
| IE_4761 | Kerry | Cromane | 29 | 524 | 231 | 524 | | | | |
| IE_4762 | Kerry | Inch Beach | 163 | 6847 | 331 | 4498 | 331 | 2348 | | |
| IE_4763 | Kerry | Tralee Bay | 59 | 3306 | 231 | 3306 | | | | |
| IE_4764 | Kerry | Tralee Bay | 122 | 413 | 231 | 413 | | | | |
| IE_4765 | Kerry | Tralee | 53 | 2921 | 231 | 2551 | 112 | 371 | | |
| IE_4766 | Kerry | Fenit | 56 | 3579 | 231 | 1684 | 331 | 1295 | 211 | 443 |
| IE_4767 | Kerry | Ballylongford | 33 | 2890 | 231 | 2890 | | | | |
| IE_4768 | Kerry | Ballylongford | 26 | 2003 | 324 | 1207 | 231 | 797 | | |
| IE_4769 | Clare | Carrigaholt | 29 | 1990 | 112 | 1066 | 231 | 924 | | |
| IE_4770 | Clare | Querrin | 75 | 2117 | 231 | 2117 | | | | |
| IE_4771 | Limerick | Limerick City | 128 | 7133 | 231 | 7133 | | | | |
| IE_4772 | Clare | Termon | 137 | 8794 | 231 | 7658 | 243 | 1136 | | |
| IE_4773 | Clare | Moyasta | 97 | 4508 | 231 | 4508 | | | | |
| IE_4774 | Clare | Two Mile Inn | 149 | 9869 | 231 | 9254 | 122 | 615 | | |
| IE_4775 | Clare | Shannon | 27 | 1925 | 231 | 1925 | | | | |
| IE_4776 | Clare | Shannon | 194 | 4839 | 231 | 2491 | 321 | 2146 | 243 | 202 |
| IE_4777 | Clare | Ballynacally | 87 | 1358 | 231 | 1358 | | | | |
| IE_4778 | Clare | Lisheen | 71 | 6924 | 231 | 6924 | | | | |
| IE_4779 | Clare | Clarecastle | 328 | 4462 | 231 | 4462 | | | | |
| IE_4780 | Clare | Latoon | 37 | 2197 | 231 | 2197 | | | | |
| IE_4781 | Clare | Lahinch | 293 | 10,834 | 231 | 9337 | 142 | 1497 | | |
| IE_4782 | Galway | Kinvarra | 45 | 3521 | 231 | 3521 | | | | |
| IE_4783 | Galway | Kilcolgan | 33 | 3849 | 231 | 3849 | | | | |
| IE_11172 | Cork | Redbarn | 183 | 8321 | 231 | 5773 | 112 | 1722 | 324 | 827 |
| IE_11173 | Cork | Youghal | 69 | 2782 | 121 | 1079 | 112 | 937 | 231 | 766 |

**Table 3.2. Continued**

| CORINE ID | County | Location | Area (ha) | Total estimated protected length (m) | Protected CORINE code | Protected CORINE length (m) | Protected CORINE code | Protected CORINE length (m) | Protected CORINE code | Protected CORINE length (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| IE_11174 | Waterford | Clashmore | 64 | 2878 | 231 | 2878 | | | | |
| IE_11175 | Waterford | Ballinatray | 38 | 2294 | 211 | 1289 | 311 | 1006 | | |
| IE_11176 | Wexford | Lady's Island | 72 | 0 | | | | | | |
| IE_11177 | Wexford | Tacumshin | 82 | 0 | | | | | | |
| IE_11178 | Wexford | Mountpill | 213 | 0 | | | | | | |
| IE_11179 | Kilkenny | Rochestown | 26 | 1535 | 231 | 1535 | | | | |
| IE_11180 | Wexford | Castlebridge | 78 | 3453 | 112 | 1715 | 231 | 1492 | 313 | 245 |
| IE_11181 | Wicklow | Wicklow Town | 31 | 2092 | 231 | 1805 | 211 | 287 | | |
| IE_11182 | Wicklow | Newcastle | 161 | 5154 | 231 | 2673 | 211 | 1686 | 242 | 638 |
| IE_11183 | Dublin | Bull Island | 108 | 4597 | 142 | 3572 | 331 | 1025 | | |
| IE_13837 | Mayo | Murrisk | 56 | 3223 | 243 | 2091 | 324 | 1132 | | |
| IE_13838 | Mayo | Mullranny | 25 | 952 | 243 | 952 | | | | |
| IE_13839 | Sligo | Ballysadare | 40 | 1805 | 231 | 1482 | 122 | 323 | | |
| IE_13840 | Sligo | Ballysadare | 49 | 1689 | 231 | 1689 | | | | |
| IE_13841 | Mayo | Castlelacken | 140 | 4957 | 231 | 4957 | | | | |
| IE_13842 | Sligo | Drumcliff | 35 | 1708 | 231 | 1708 | | | | |
| IE_13843 | Sligo | Inishmurray | 36 | 0 | | | | | | |
| IE_13844 | Sligo | Mullaghmore | 72 | 2671 | 231 | 2210 | 324 | 461 | | |
| IE_13845 | Donegal | Ardara | 75 | 3065 | 412 | 2107 | 231 | 688 | 331 | 271 |
| IE_18754 | Dublin | Portmarnock | 65 | 3462 | 211 | 1160 | 142 | 1007 | 112 | 766 |
| IE_18755 | Dublin | Malahide | 56 | 1400 | 142 | 1400 | | | | |
| IE_18756 | Dublin | Lusk | 77 | 3696 | 211 | 3696 | | | | |
| IE_18757 | Louth | Drogheda | 33 | 1294 | 313 | 374 | 211 | 818 | 112 | 101 |
| IE_18758 | Louth | Dromiskin | 130 | 3049 | 211 | 3049 | | | | |
| IE_18759 | Louth | Dundalk | 220 | 4525 | 231 | 2833 | 211 | 1009 | 112 | 682 |
| IE_18760 | Louth | Dundalk | 93 | 2517 | 231 | 2517 | | | | |
| IE_18761 | Donegal | Ballyshannon | 27 | 1421 | 331 | 775 | 231 | 646 | | |
| IE_18762 | Donegal | Burnfoot | 38 | 1651 | 231 | 1651 | | | | |
| IE_18763 | Donegal | Derrybeg | 36 | 2899 | 112 | 1529 | 242 | 1010 | 331 | 360 |
| IE_18764 | Donegal | Ards | 39 | 2110 | 313 | 1822 | 243 | 287 | | |
| IE_18765 | Donegal | Dunfanaghy | 32 | 0 | | | | | | |
| IE_18766 | Donegal | Ballyliffen | 28 | 1799 | 231 | 1799 | | | | |

### *3.2.3 Results*

Based on the 59 sites listed in Table 3.12 with a total area of 4744 ha, the total protected length was estimated at 201,830 m with an average length of protected area of 3420 m. Table 3.13 shows the breakdown of the land use protected by saltmarsh. The majority of land use is extensive, with agricultural and pastures making up 67% of the land use protected.

Two types of protected land are considered: the first is CORINE level 1 "artificial surfaces" land use type (a protected length of 19,379 m) and the second is CORINE level 1 "agricultural areas" (a protected length of 159,860 m), giving a protected length of 179,239 m.

Multiplying the above protected length estimate bordered by saltmarsh by the estimated values generated above for the capital costs gives a value of €860 million, and multiplying the protected lengths by the value for maintenance costs gives an estimated reduction in the cost of maintaining coastal defences fronted by saltmarsh of €11.5 million per year.

## 3.3 Lifecycle and Habitat Services

Usages of certain habitats are temporally defined and support species only for specific stages of their lifecycles (e.g. as breeding or spawning areas for adults or as nursery areas for juvenile animals). Failing to account for this when examining the value of an ecosystem may have potentially negative effects for benefits arising in other ecosystems.

The BSA located off the southern Irish coast is a limited Marine Protected Area, which aims to protect the nursery and spawning grounds of a number of commercial fish species, particularly hake, but also cod, haddock and herring. This protection is provided by restricting fishing effort within the BSA (MI, 2006). Another example is the EU Birds Directive (2009/147/EC), which designates Special Protection Areas (SPAs) for the protection of endangered species of wild birds; particularly protecting migratory species. In Ireland, there are many coastal SPAs including those protecting the breeding grounds of the Manx shearwater and the storm petrel. The SPAs form part of the Natura 2000 network of protected sites and these can overlap with Special Areas of Conservation (SACs), which provide protection to habitats and species under the EU Habitats Directive (92/43/EEC).

### *3.3.1 Data source*

In Ireland, 60 habitats and 25 species are protected under the Habitats Directive and there are 423 protected sites covering 1,355,624 ha. While the BSA and SPAs are discussed, only SACs were used

**Table 3.13. Land cover type protected by saltmarsh in Ireland**

| Land use type protected (CORINE level 2 codes) | CORINE level 1 code | Estimated length of coast protected (m) | Percentage of total land use type protected |
|---|---|---|---|
| Pastures (231) | Agricultural areas | 134,957 | 67 |
| Non-irrigated arable land (211) | Agricultural areas | 14,601 | 7 |
| Beaches, dunes, sands (331) | Forest and semi-natural areas | 10,630 | 5 |
| Discontinuous urban fabric (112) | Artificial surfaces | 8938 | 4 |
| Land principally occupied by agriculture, with significant areas of natural vegetation (243) | Agricultural areas | 8645 | 4 |
| Sport and leisure facilities (142) | Artificial surfaces | 7517 | 4 |
| Transitional woodland–shrub (324) | Forest and semi-natural areas | 3646 | 2 |
| Peat bogs (412) | Forest and semi-natural areas | 2691 | 1 |
| Mixed forest (313) | Forest and semi-natural areas | 2455 | 1 |
| Natural grasslands (321) | Forest and semi-natural areas | 2158 | 1 |
| Road and rail networks and associated land (122) | Artificial surfaces | 1839 | 1 |
| Complex cultivation patterns (242) | Agricultural areas | 1657 | 1 |
| Industrial or commercial units (121) | Artificial surfaces | 1085 | 1 |
| Broad-leaved forest (311) | Forest and semi-natural areas | 1011 | 1 |

as a proxy indicator for the ecosystem services of lifecycle and habitat services to avoid double counting of protected areas. To identify SACs that offered protection to coastal, marine and estuarine ecosystems, habitat types associated with these based on Annex I of the EU Habitats Directive were identified. These are shown in Table 3.14.

### *3.3.2 Methodology*

Based on the Annex 1 habitat types in Table 3.14, a search of SAC sites that included these habitat types produced 126 sites that protect all or part of a coastal, marine or estuarine ecosystem, listed in Table 3.15. The SAC search was based on sites listed in the Natura 2000 database for Ireland (NPWS, 2016).

### *3.3.3 Results*

An examination of sites that protect all or part of a coastal, marine or estuarine ecosystem identified 126 sites (30% of total sites) covering 844,383 ha (62% of the total protected area) and are shown in Table 3.15.

## 3.4 Climate Regulation

The oceans help to moderate the effects of climate change on the atmosphere and terrestrial ecosystems by having absorbed about 90% of excess heat input between 1961 and 2003 (Nolan *et al*., 2010) and also by absorbing greenhouse gases. The most important greenhouse gases are water vapour, carbon dioxide, methane and nitrous oxide. In this report, only the value of marine and coastal ecosystems absorbing carbon dioxide ($CO_2$) (also known as carbon absorption) is examined. As in the case of Canu *et al*. (2015), the air–sea $CO_2$ exchanges are regarded in this study as "additional, spatially distributed, sources (or sinks) of the ecosystem service which translate into a cost (or benefit) for society by building up (or reducing) the concentration of greenhouse gases in the atmosphere that are responsible for climate change".[6]

**Table 3.14. Coastal, marine and estuarine habitat types based on Annex I of the EU Directive on the Conservation of Habitat, Flora and Fauna (92/43/EEC)**

| Habitat Code | Coastal, marine or estuarine habitat type protected under Annex I of the Habitats Directive |
|---|---|
| 1210 | Annual vegetation of drift lines |
| 2150 | Atlantic decalcified fixed dunes (*Calluno-Ulicetea*) |
| 1330 | Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) |
| 1150 | Coastal lagoons |
| 2140 | Decalcified fixed dunes with *Empetrum nigrum* |
| 2170 | Dunes with *Salix repens* subsp. *argentea* (*Salix arenariae*) |
| 2110 | Embryonic shifting dunes |
| 1130 | Estuaries |
| 2130 | Fixed coastal dunes with herbaceous vegetation (grey dunes) |
| 2190 | Humid dune slacks |
| 1160 | Large shallow inlets and bays |
| 21a0 | Machairs (in Ireland) |
| 1420 | Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) |
| 1410 | Mediterranean salt meadows (*Juncetalia maritimi*) |
| 1140 | Mudflats and sandflats not covered by seawater at low tide |
| 1220 | Perennial vegetation of stony banks |
| 1170 | Reefs |
| 1310 | Salicornia and other annuals colonising mud and sand |
| 1110 | Sandbanks which are slightly covered by sea water all the time |
| 2120 | Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) |
| 1320 | Spartina swards (*Spartinion maritimae*) |
| 8330 | Submerged or partly submerged sea caves |
| 1230 | Vegetated sea cliffs of the Atlantic and Baltic coasts |

6 The reason for the use of absorption in this report is that $CO_2$ transfer across the water/air boundary for some ecosystems was used to measure the removal of $CO_2$ from the atmosphere. This $CO_2$ is not locked away from the ecological system but instead can contribute to ocean acidification, which itself is an ecosystem disservice or cost. In addition, we are focused on the flow of the service in just one year, which is reflected to some extent by the net flux (air–sea gas exchange) over the period. The contribution of physical (abiotic) processes to carbon sequestration could be either positive or negative in any given period and is only one element in the carbon cycle. The locking of the carbon away in true sequestration will take place through a more complex process over a much longer time. Therefore, the estimates presented here will be an underestimate of the total carbon sequestration value of the marine environment.

**Table 3.15. SAC site name protecting all or part of a coastal, marine or estuarine ecosystem**

| Site code | SAC site name protecting all or part of a coastal, marine or estuarine ecosystem | Area (ha) |
|---|---|---|
| IE0000020 | Black Head-Poulsallagh Complex | 7805 |
| IE0000036 | Inagh River Estuary | 391 |
| IE0000077 | Ballymacoda (Clonpriest and Pillmore) | 487 |
| IE0000091 | Clonakilty Bay | 508 |
| IE0000097 | Lough Hyne Nature Reserve and Environs | 451 |
| IE0000101 | Roaringwater Bay and Islands | 14,259 |
| IE0000109 | Three Castle Head to Mizen Head | 342 |
| IE0000111 | Aran Island (Donegal) Cliffs | 518 |
| IE0000133 | Donegal Bay (Murvagh) | 1810 |
| IE0000138 | Durnesh Lough | 357 |
| IE0000147 | Horn Head and Rinclevan | 2344 |
| IE0000154 | Inishtrahull | 471 |
| IE0000164 | Lough Nagreany Dunes | 221 |
| IE0000181 | Rathlin O'Birne Island | 812 |
| IE0000189 | Slieve League | 3926 |
| IE0000190 | Slieve Tooey/Tormore Island/Loughros Beg Bay | 9435 |
| IE0000191 | St. John's Point | 1079 |
| IE0000194 | Tranarossan and Melmore Lough | 654 |
| IE0000197 | West of Ardara/Maas Road | 6739 |
| IE0000199 | Baldoyle Bay | 539 |
| IE0000202 | Howth Head | 375 |
| IE0000204 | Lambay Island | 405 |
| IE0000205 | Malahide Estuary | 810 |
| IE0000206 | North Dublin Bay | 1475 |
| IE0000208 | Rogerstown Estuary | 586 |
| IE0000210 | South Dublin Bay | 742 |
| IE0000212 | Inishmaan Island | 793 |
| IE0000213 | Inishmore Island | 14,666 |
| IE0000268 | Galway Bay Complex | 14,409 |
| IE0000278 | Inishbofin and Inishshark | 2795 |
| IE0000328 | Slyne Head Islands | 2385 |
| IE0000332 | Akeragh, Banna and Barrow Harbour | 1204 |
| IE0000335 | Ballinskelligs Bay and Inny Estuary | 1629 |
| IE0000343 | Castlemaine Harbour | 8687 |
| IE0000370 | Lough Yganavan and Lough Nambrackdarrig | 272 |
| IE0000375 | Mount Brandon | 14,355 |
| IE0000455 | Dundalk Bay | 5236 |
| IE0000458 | Killala Bay/Moy Estuary | 2182 |
| IE0000470 | Mullet/Blacksod Bay Complex | 14,066 |
| IE0000472 | Broadhaven Bay | 9075 |
| IE0000484 | Cross Lough (Killadoon) | 57 |
| IE0000500 | Glenamoy Bog Complex | 12,902 |
| IE0000507 | Inishkea Islands | 1230 |
| IE0000516 | Lackan Saltmarsh and Kilcummin Head | 540 |
| IE0000622 | Ballysadare Bay | 2145 |
| IE0000625 | Bunduff Lough and Machair/Trawalua/Mullaghmore | 4389 |
| IE0000627 | Cummeen Strand/Drumcliff Bay (Sligo Bay) | 4919 |
| IE0000665 | Helvick Head | 205 |

**Table 3.15. Continued**

| Site code | SAC site name protecting all or part of a coastal, marine or estuarine ecosystem | Area (ha) |
|---|---|---|
| IE0000671 | Tramore Dunes and Backstrand | 753 |
| IE0000696 | Ballyteige Burrow | 703 |
| IE0000697 | Bannow Bay | 1326 |
| IE0000700 | Cahore Polders and Dunes | 265 |
| IE0000704 | Lady's Island Lake | 540 |
| IE0000707 | Saltee Islands | 15,809 |
| IE0000709 | Tacumshin Lake | 559 |
| IE0000710 | Raven Point Nature Reserve | 595 |
| IE0000714 | Bray Head | 264 |
| IE0000729 | Buckroney-Brittas Dunes and Fen | 321 |
| IE0000764 | Hook Head | 16,940 |
| IE0000781 | Slaney River Valley | 6020 |
| IE0001021 | Carrowmore Point to Spanish Point and Islands | 4238 |
| IE0001040 | Barley Cove to Ballyrisode Point | 795 |
| IE0001058 | Great Island Channel | 1443 |
| IE0001061 | Kilkeran Lake and Castlefreke Dunes | 98 |
| IE0001090 | Ballyness Bay | 1236 |
| IE0001141 | Gweedore Bay and Islands | 6016 |
| IE0001190 | Sheephaven | 1842 |
| IE0001195 | Termon Strand | 87 |
| IE0001228 | Aughrusbeg Machair and Lake | 422 |
| IE0001230 | Courtmacsherry Estuary | 735 |
| IE0001257 | Dog's Bay | 141 |
| IE0001275 | Inisheer Island | 552 |
| IE0001309 | Omey Island Machair | 229 |
| IE0001459 | Clogher Head | 24 |
| IE0001482 | Clew Bay Complex | 11,987 |
| IE0001497 | Doogort Machair/Lough Doo | 184 |
| IE0001501 | Erris Head | 815 |
| IE0001513 | Keel Machair/Menaun Cliffs | 1616 |
| IE0001529 | Lough Cahasy, Lough Baun and Roonah Lough | 301 |
| IE0001680 | Streedagh Point Dunes | 630 |
| IE0001741 | Kilmuckridge-Tinnaberna Sandhills | 86 |
| IE0001742 | Kilpatrick Sandhills | 40 |
| IE0001766 | Magherabeg Dunes | 75 |
| IE0001932 | Mweelrea/Sheeffry/Erriff Complex | 20,983 |
| IE0001957 | Boyne Coast and Estuary | 630 |
| IE0001975 | Ballyhoorisky Point to Fanad Head | 1293 |
| IE0002005 | Bellacragher Saltmarsh | 17 |
| IE0002012 | North Inishowen Coast | 7069 |
| IE0002034 | Connemara Bog Complex | 49,226 |
| IE0002070 | Tralee Bay and Magharees Peninsula, West to Cloghane | 11,632 |
| IE0002074 | Slyne Head Peninsula | 4028 |
| IE0002111 | Kilkieran Bay and Islands | 21,314 |
| IE0002123 | Ardmore Head | 30 |
| IE0002129 | Murvey Machair | 80 |
| IE0002137 | Lower River Suir | 7100 |
| IE0002158 | Kenmare River | 43,290 |

**Table 3.15. Continued**

| Site code | SAC site name protecting all or part of a coastal, marine or estuarine ecosystem | Area (ha) |
|---|---|---|
| IE0002159 | Mulroy Bay | 3209 |
| IE0002161 | Long Bank | 3372 |
| IE0002162 | River Barrow and River Nore | 12,373 |
| IE0002165 | Lower River Shannon | 68,330 |
| IE0002170 | Blackwater River (Cork/Waterford) | 10,150 |
| IE0002172 | Blasket Islands | 22,712 |
| IE0002187 | Drongawn Lough | 31 |
| IE0002189 | Farranamanagh Lough | 28 |
| IE0002193 | Ireland's Eye | 42 |
| IE0002243 | Clare Island Cliffs | 355 |
| IE0002249 | The Murrough Wetlands | 606 |
| IE0002250 | Carrowmore Dunes | 443 |
| IE0002259 | Tory Island Coast | 3046 |
| IE0002261 | Magharee Islands | 2270 |
| IE0002262 | Valencia Harbour/Portmagee Channel | 2693 |
| IE0002263 | Kerry Head Shoal | 5797 |
| IE0002264 | Kilkee Reefs | 2916 |
| IE0002265 | Kingstown Bay | 80 |
| IE0002268 | Achill Head | 7165 |
| IE0002269 | Carnsore Point | 8736 |
| IE0002274 | Wicklow Reef | 1533 |
| IE0002280 | Dunbeacon Shingle | 42 |
| IE0002281 | Reen Point Shingle | 7 |
| IE0002283 | Rutland Island and Sound | 3418 |
| IE0002287 | Lough Swilly | 9262 |
| IE0002306 | Carlingford Shore | 526 |
| IE0002327 | Belgica Mound Province | 41,162 |
| IE0002328 | Hovland Mound Province | 108,956 |
| IE0002329 | South-West Porcupine Bank | 33,121 |
| IE0002330 | North-West Porcupine Bank | 71,941 |
| | Total | 844,383 |

### 3.4.1 Data source

Five ecosystems were examined with respect to carbon sequestration.

The carbon absorbed per unit area (in this case per hectare) for each ecosystem is based on existing studies from elsewhere. Further details are given in the methodology section (section 3.4.2). To value this ecosystem service, the value of the carbon dioxide removed is based on the Irish carbon tax of €20 per tonne of $CO_2$ equivalent (Department of Finance, 2011). The valuation of this carbon sequestration service uses the avoided damage method, as the carbon absorbed avoids the social cost associated with the additional build-up of carbon in the atmosphere (the social cost of climate change).

### 3.4.2 Methodology

The methodology varied in relation to the type of ecosystem assessed. Further details on the method used for each is presented below.

*Coastal ecosystems*

The two coastal semi-terrestrial ecosystems examined in this report are saltmarsh and sand dunes. For the saltmarsh and sand dunes, the areas are based on

CORINE data (Lydon and Smith, 2014). Note that the minimum area associated with the CORINE data is 25 ha and, owing to the linear nature of many coastal ecosystems, this most probably underestimates the area of saltmarsh and sand dunes.

The carbon absorbed per unit area (in this case per hectare) for each coastal ecosystem is based on studies reported by the UK NEA (Beaumont *et al.*, 2010). The estimate for sand dunes of 0.58 (±0.26) tonnes carbon (C) per hectare per year is based on a report by Jones *et al.* (2008), which was converted to $CO_2$ equivalent using a factor of 3.66 to give an estimate of 2.1 tonnes $CO_2$ $ha^{-1}$ $year^{-1}$.

Sand dune areas were based on the CORINE estimate for "Beaches, dunes and sand plains" for 2012, which was 12,013 ha. This may be an overestimate of the area of dunes, but it is also noted that the minimum area associated with the CORINE data is 25 ha and, owing to the linear nature of many coastal ecosystems, the data source may be an underestimation of the area of sand dunes in some places. The area was multiplied by the value of 2.1 t $CO_2$ $ha^{-1}$ $year^{-1}$ by 12,013 ha to generate an estimate of 26.4 kt $CO_2$.

A similar approach was used for the saltmarsh, which covered an extent of 5179 ha based on CORINE data (Lydon and Smith, 2014). The estimate used for carbon absorption was 1.42 t C $ha^{-1}$ $year^{-1}$, the midpoint of carbon absorbed by saltmarsh reported by Cannell *et al.* (1999) (0.64–2.19 t C $ha^{-1}$ $year^{-1}$), which was converted to $CO_2$ by multiplying by 3.66 to give a value of 5.2 t $CO_2$ $ha^{-1}$ $year^{-1}$. Multiplying this value by the saltmarsh area of 5179 ha gives an estimate of 26.9 kt $CO_2$.

### *Estuaries*

To estimate the carbon flux from Irish estuaries, the mean carbon flux from 14 estuarine environments in the north-east Atlantic region was taken from Chen and Borges (2009) as shown in Table 3.16. The values reported in Table 3.16 are in mol C $m^{-2}$ per year[7] and these were converted to t C $ha^{-1}$ by multiplying by 0.1201. In turn, this was converted to tonnes $CO_2$ $ha^{-1}$ $year^{-1}$ by multiplying by 3.66. Note that a negative sign indicates that the estuarine environments are emitting carbon to the atmosphere.

**Table 3.16. Carbon flux in 14 estuarine environments in the north-east Atlantic region (figures from Chen and Borges, 2009)**

| Location | Carbon flux (in mol C $m^{-2}$ $year^{-1}$) | Carbon flux (t $CO_2$ $ha^{-1}$ $year^{-1}$) | Reference |
|---|---|---|---|
| Aveirolagoon (PT) | –12.4 | –5.5 | Borges and Frankignoulle (unpublished) |
| Douro (PT) | –76 | –33.4 | Frankignoulle *et al.* (1998) |
| Elbe (DE) | –53 | –23.3 | Frankignoulle *et al.* (1998) |
| Ems (DE) | –67.3 | –29.6 | Frankignoulle *et al.* (1998) |
| Gironde (FR) | –30.8 | –13.5 | Frankignoulle *et al.* (1998) |
| Guadalquivir (ES) | –31.1 | –13.7 | de la Paz *et al.* (2007) |
| Loire (FR) | –64.4 | –28.3 | Abril *et al.* (2003) |
| Randers Fjord (DK) | –2.2 | –1.0 | Gazeau *et al.* (2005) |
| Rhine (NL) | –39.7 | –17.5 | Frankignoulle *et al.* (1998) |
| Sado (PT) | –31.3 | –13.8 | Frankignoulle *et al.* (1998) |
| Saja-Besaya (ES) | –52.2 | –22.9 | Ortega *et al.* (2005) |
| Scheldt (BE/NL) | –63 | –27.7 | Frankignoulle *et al.* (1998) |
| Tamar (UK) | –74.8 | –32.9 | Frankignoulle *et al.* (1998) |
| Thames (UK) | –73.6 | –32.4 | Frankignoulle *et al.* (1998) |
| Mean | –47.9 | –21.1 | |

7 The mole (unit symbol mol) is defined as the amount of a chemical substance that contains as many elementary entities, e.g. atoms, molecules, ions, electrons or photons, as there are atoms in 12 grams of carbon-12 (12C), the isotope of carbon with relative atomic mass 12.

The area of estuaries is based on that reported for transitional waters minus coastal lagoons for the WFD and gave an estimate of 80,680 ha. This was multiplied by the mean carbon flux of 14 north-east Atlantic estuarine environments reported by Chen and Borges (2009) of –21.1 t $CO_2$ $ha^{-1}$ $year^{-1}$ to give an estimate of 1702 kt $CO_2$ per year being emitted from Irish estuaries.

#### *Coastal waters*

To estimate the carbon flux from Irish estuaries, the mean carbon flux from three shallow and coastal marine environments in the north-east Atlantic region taken from Chen and Borges (2009), as shown in Table 3.17, was used. The values reported in Table 3.17 are in mol C $m^{-2}$ $year^{-1}$ and these were once again converted to t C $ha^{-1}$ $year^{-1}$ by multiplying by 0.1201. In turn, this was converted to t $CO_2$ $ha^{-1}$ $year^{-1}$ by multiplying by 3.66.

The area of coastal waters (including bays) is based on coastal waters reported for the WFD, which gives an area of 1,314,374 ha. This was multiplied by the mean of the values from Table 3.17 (0.4 t $CO_2$ $ha^{-1}$ $year^{-1}$) to give an estimate of carbon absorption by Irish coastal waters of 525.7 kt $CO_2$ per year.

#### *Offshore waters*

For the offshore waters, the carbon flux value was based on the average for 2015 generated from two grid cells of the National Ocean and Atmospheric Association (NOAA) model of oceanic carbon flux (NOAA, 2016; available online: http://cwcgom.aoml.noaa.gov/cgom/OceanViewer/). The reason that only these cells are used is that they cover the majority of the Irish EEZ. The grid cell *Irish Coast South* covers the area between 10° and 15° longitude west and between 50° and 54° latitude north. The grid cell *Irish Coast North* covers the area between 10° and 15° longitude west and between 54° and 58° latitude north. The monthly measurements of carbon flux for these two cells are shown in Figure 3.2.

These monthly estimates are generated from model data based on satellite measurements of sea surface temperature (SST) and wind speeds that can be used to estimate atmosphere to ocean carbon flux based on empirical relationships between carbon flux, SST and wind speed. The model is explored in more detail by Park *et al.* (2010).

The mean of the grid cells from Figure 3.2 is estimated to be 2.42 mol C $m^{-2}$ $year^{-1}$ and this was converted to t C $ha^{-1}$ $year^{-1}$ by multiplying by 0.1201. In turn, this was converted to t $CO_2$ $ha^{-1}$ $year^{-1}$ by multiplying by 3.66 to give a figure of 1.06 t $CO_2$ $ha^{-1}$ $year^{-1}$.

The area of offshore waters used in the calculation is based on the Irish EEZ (Sea Around Us, 2016) (409,929 $km^2$) and the WFD coastal waters and bays have been subtracted from this value to produce a figure of 39,678,526 ha. Multiplying this figure by 1.06 t $CO_2$ $ha^{-1}$ $year^{-1}$ gives an estimate of 42,059 kt $CO_2$ $year^{-1}$.

### *3.4.3 Results*

Table 3.18 summarises the results from the methodology section and Table 3.19 shows the estimates of the total amount of carbon dioxide generated per ecosystem and the aggregated total within the Irish EEZ.

**Table 3.17. Annual estimate of carbon flux is based on the mean of three shallow and coastal marine environments in the north-east Atlantic region (figures from Chen and Borges, 2009)**

| Location | Carbon flux (in mol C $m^{-2}$ $year^{-1}$) | Carbon flux (t $CO_2$ $ha^{-1}$ $year^{-1}$) | Reference |
|---|---|---|---|
| Bristol Bay | 0.2 | 0.1 | Borges *et al.* (2005) |
| English Channel | 0.15 | 0.1 | Borges and Frankignoulle (2003); Thomas *et al.* (2010) |
| Galican Coast | 2.2 | 1.0 | Borges *et al.* (2005) |
| **Mean** | **0.85** | **0.4** | |

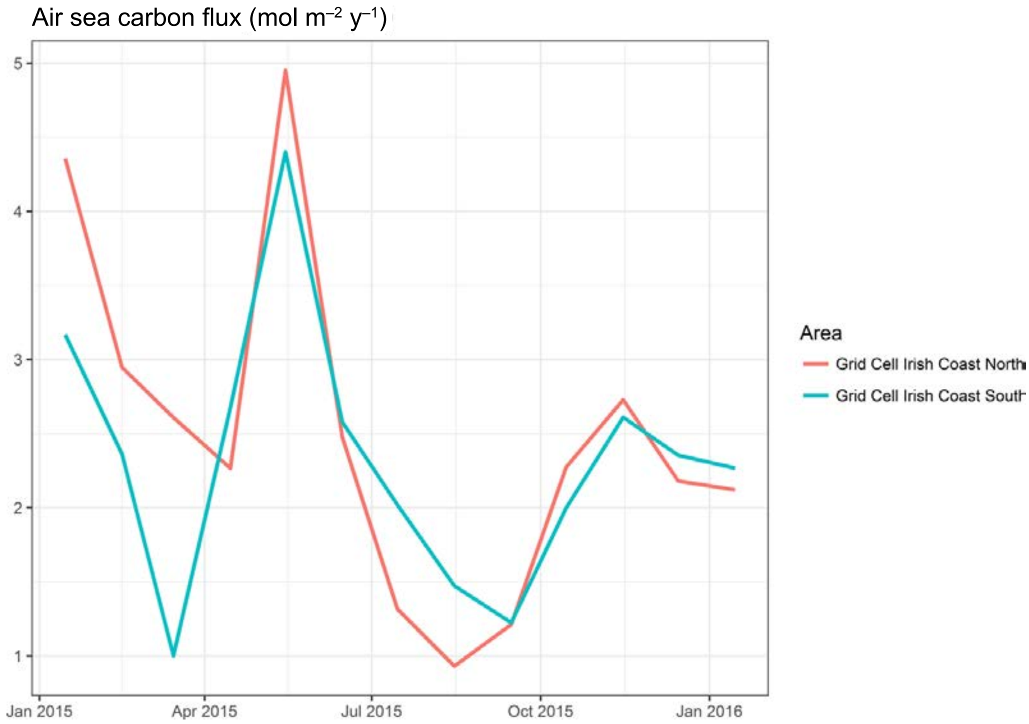


**Figure 3.2. Air–sea carbon flux for grid cells off the Irish western coast taken from NOAA model (from data in Park *et al.*, 2010).**

**Table 3.18. Irish coastal and marine ecosystem areas and estimated annual carbon absorption amounts**

| Ecosystem | Irish area (ha) | Carbon absorption (t $CO_2$ ha$^{-1}$) | References |
|---|---|---|---|
| Saltmarsh | 5179 | 5.2 (2.4 to 8.0)[a] | Cantell *et al.* (1999) |
| Sand dunes | 12,013 | 2.1 (0.25 to 4)[a] | Jones *et al.* (2008) |
| Estuaries | 80,680 | –21.1 (–33.4 to –1.0)[b] | Chen and Borges (2009) |
| Coastal waters and bays | 1,314,374 | 0.4 (0.0 to 1.0)[b] | Chen and Borges (2009) |
| Offshore waters | 39,678,526 | 1.06 | NOAA (2016) |

**[a]Confidence interval.**
**[b]Range.**

**Table 3.19. Estimated total amount of carbon absorbed by Irish coastal and marine ecosystems and its value**

| Ecosystem type | Estimated total carbon absorption (kt $CO_2$) per annum | Estimated carbon absorption value (millions of euros) per annum |
|---|---|---|
| Saltmarsh | 26.9 | 0.5 |
| Sand dunes | 26.4 | 0.5 |
| Estuaries | –1702 | –34.0 |
| Coastal waters and bays | 525.7 | 10.5 |
| Offshore waters | 42,059 | 841.2 |
| Estimated totals | 40,936 | 818.7 |

**Although the saltmarsh is the best carbon sequestrating ecosystem on a per hectare basis (and releases relatively little methane compared with freshwater marsh), offshore waters are the largest contributors to the climate regulating service owing to their large size. In addition, the high negative values associated with estuaries are due to carbon-rich material in the rivers being converted into $CO_2$ by the highly productive ecosystems. As these values are based on $CO_2$ per ha figures in some of the larger European rivers entering the north-east Atlantic region, they may be overestimating the amount of $CO_2$ released from estuarine environments in Ireland.**

# 4 Ireland's Cultural Marine Ecosystem Services

## 4.1 Recreational Services

Coastal and marine recreation is another important service provided by coastal and marine ecosystems. The value that recreationalists attach to the marine environment for direct use can be substantial, although it may not be reflected by market prices. Taking these values into account is an important consideration in terms of the management, conservation and planning options for marine and coastal ecosystems.

### *4.1.1 Data source*

Secondary sources of information were used to estimate the quantity (in terms of visitation rates) and value of marine and coastal recreation. The estimated number of trips for all coastal and marine recreational pursuits came from a nationwide household survey carried out by RedC Survey Company on behalf of SEMRU in 2012. A total of 812 people, aged 18 and over, were surveyed. Participants were sampled based on gender, age and working status, giving a representative sample comparable to the Irish population. Respondents were asked a number of questions related to visits to the Irish coastline during the previous year.

The estimates of the value of angling from shore and angling from a boat on the sea came from a recent study by Hynes *et al*. (2017). The estimates used for the value of sea kayaking came from Hynes (2006).

The estimates of the value of swimming, windsurfing, diving, sailing, snorkelling, birdwatching, walking along coast/sea/beach, other boating, surfing, kite surfing, whale/dolphin watching, family seaside visits, sunbathing, picnics, gathering seaweed, shellfish, etc., came from an extensive literature review that generated a database of 112 previous marine and coastal valuation studies for use in the development of a meta-analysis.

### *4.1.2 Methodology*

As mentioned previously, an alternative to the use of primary valuation methods is value transfer. Value transfer is a process of valuing a service benefit of a policy site by using values estimated for similar service benefits at another study site and applying these values to the policy site.

A unit value transfer method was used to estimate the total value for sea angling and sea kayaking. This involved a direct transfer of a value estimate from an existing study or studies to the policy site, possibly adjusting for inflation, and, if transferring internationally, also adjusting for exchange rates and purchasing power parity. In the cases of sea angling and sea kayaking, the individual per trip values estimated from the previous studies of these pursuits in Ireland were multiplied by the total estimated number of trips taken in the population. This generated a total value estimate for these pursuits per annum.

A functional value transfer method was used to estimate the total value for swimming, windsurfing, diving, sailing, snorkelling, birdwatching, walking along coast/sea/beach, other boating, surfing, kite surfing, whale/dolphin watching, family seaside visits, sunbathing, picnics, gathering seaweed, shellfish, etc. The chosen functional transfer method was what is referred to as a meta-analysis. Meta-analysis involves the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings and making a prediction for out-of-sample estimates. The meta-analysis developed here examined the study characteristics of 112 previous coastal and marine recreation valuation studies and the ability of those characteristics to explain the variation in value estimates using a log-linear regression model. By systematically analysing the variation in estimated values from the different studies, we identified the extent to which methods, design, ecosystem type, recreation pursuit and other site characteristics affect reported coastal and marine recreation values.

The estimated regression model for the meta-analysis was specified as follows:

$$\ln(y_i) = \propto + b_v X_{vi} + b_s X_{si} + b_c X_{ci} + u_i \qquad \text{(Equation 4.1)}$$

where $\ln(y_i)$ is the natural logarithm of the value estimates from the previous studies measured in 2015 value euros per year; the subscript *i* is an index for the value observations; ∝ is a constant term; $b_V$, $b_S$ and $b_C$ are vectors containing the coefficients of the explanatory variables $X_V$ (valuation study characteristics), $X_S$ (site characteristics) and $X_C$ (country-level characteristics); and $u$ is the error term.[8] The resulting model was then used to estimate a per trip value for each of the activities listed above.

#### 4.1.3 Results

Based on the 2012 survey results, the total number of trips taken by the population (aged 18+) for the range of marine recreation activities were estimated and are listed in the first two columns of Table 4.1. Using the value estimates from the literature and calculations from the coastal and marine recreation value meta-analysis, the aggregate recreational value obtained by Irish society from Ireland's marine resources was calculated.[9] Our coastal and marine environment provides us with an estimated €1.7 billion in recreation service value.

### 4.2 Aesthetic Services

The value of this ecosystem service lies in the beauty of the landscape generated by the ecosystem for those viewing it. Examples of the added value of a beautiful view is found in hotel rooms with a sea view, which often command a premium or the additional price paid for a house because of the scenic view it commands of an estuary or the sea. The hedonic pricing method can be employed to estimate the additional value of residential property located beside or near the coast relative to those properties inland.

**Table 4.1. Marine recreation activities**

| Activity | Mean number of trips per person per year | Estimated total number of trips per annum | Estimated total value (€) per year |
|---|---|---|---|
| Fishing from shore | 0.424 | 1,450,985 | 351,138,395 |
| Fishing from sea | 0.400 | 1,370,844 | 331,744,176 |
| Swimming | 3.142 | 10,760,068 | 113,411,119 |
| Windsurfing | 0.126 | 430,234 | 4,534,667 |
| Diving | 0.011 | 37,962 | 701,533 |
| Sea kayaking | 0.054 | 185,591 | 15,404,053 |
| Sailing | 0.096 | 329,002 | 3,467,686 |
| Snorkelling | 0.075 | 257,297 | 4,754,843 |
| Birdwatching | 0.761 | 2,606,713 | 27,474,752 |
| Walking along coast/sea/beach | 19.517 | 66,846,559 | 704,562,735 |
| Other boating | 0.151 | 518,812 | 5,468,275 |
| Surfing | 0.307 | 1,050,277 | 11,069,921 |
| Kite surfing | 0.007 | 25,308 | 266,745 |
| Whale/dolphin watching | 0.075 | 257,297 | 9,005,385 |
| Family seaside visits, sunbathing, picnics, gathering seaweed, shellfish, etc. | 3.159 | 10,819,120 | 114,033,529 |
| Total | | 96,946,069 | 1,697,037,814 |

**Estimated trips refer only to those undertaken by Irish residents so will underestimate the total number of trips taken for marine recreation pursuits in the country.**

8 $X_V$ variables included were dummies for contingent valuation, choice experiment, zonal travel cost, contingent behaviour, study was pre 2002, report or non-peer reviewed publication, WTP to avoid degradation, WTP for improvement. $X_s$ variables included were dummies for studies from Europe, Australia, Latin America, Africa, studies relate to sea angling, diving, water quality impact, pollution and debris impact, Marine Protected Area, household level survey, tourists only, residents only, estuarine, beach, mangrove, reef, lagoon. $X_C$ variables included the amount of national marine waters under protection, GDP per capita, country level indicators for humane orientation, performance orientation and societal attitudes to economic growth and waterway pollution. For further details of the meta-analysis, see Hynes *et al*. (2017b).

9 See Appendix 2 for full listing of the literature estimate sources.

### 4.2.1 Data source

A proxy for the aesthetic ecosystem service was based on estimating the proportion of house values attributable to being located near the coast. Therefore, the data sources reflect the proxy for this ecosystem service. For house prices, Daft.ie prices (Daft, 2012) were used, which detail house price by urban and rural markets and by number of bedrooms in a house for the year 2012 (see Table 4.2), and in order to assign the value attributable to being located near the coast, percentages were taken from the paper by Lyons (2012) shown in Table 4.3. To aggregate the values, housing density per bedroom type by small area (SA) was used from the Census 2011 data (CSO, 2015). To convert the stock value of the housing to a flow

**Table 4.2. House price value by number of bedrooms (thousands of euros)**

| | 1 bedroom | 2 bedrooms | 3 bedrooms | 4 bedrooms | 5 bedrooms |
|---|---|---|---|---|---|
| *Urban areas* | | | | | |
| Dublin City centre | 123 | 182 | 203 | 273 | 350 |
| Dublin North City | 105 | 152 | 215 | 317 | 465 |
| Dublin South City | 116 | 193 | 229 | 424 | 578 |
| Cork City | 80 | 130 | 180 | 268 | 383 |
| Galway City | 78 | 133 | 164 | 220 | 309 |
| Limerick City | 83 | 105 | 148 | 220 | 281 |
| Waterford City | 52 | 66 | 115 | 198 | 271 |
| *Rural areas* | | | | | |
| Dublin North County | 116 | 159 | 207 | 336 | 509 |
| Dublin South County | 162 | 228 | 320 | 548 | 694 |
| Dublin West County | 93 | 123 | 167 | 260 | 434 |
| Meath | 62 | 114 | 147 | 238 | 328 |
| Kildare | 59 | 115 | 169 | 259 | 361 |
| Wicklow | 100 | 163 | 194 | 312 | 409 |
| Longford | * | 88 | 93 | 141 | 226 |
| Offaly | 67 | 86 | 124 | 191 | 275 |
| Westmeath | 62 | 104 | 119 | 169 | 240 |
| Laois | 55 | 72 | 105 | 166 | 308 |
| Louth | 55 | 91 | 128 | 209 | 251 |
| Carlow | * | 85 | 125 | 203 | 302 |
| Kilkenny | 74 | 94 | 140 | 201 | 338 |
| Wexford | 83 | 80 | 123 | 194 | 248 |
| Co. Waterford | 45 | 75 | 157 | 239 | 257 |
| Kerry | 80 | 131 | 154 | 213 | 252 |
| Co. Cork | 87 | 120 | 151 | 248 | 290 |
| Clare | 81 | 94 | 124 | 186 | 261 |
| Co. Limerick | 70 | 92 | 142 | 239 | 243 |
| Tipperary | 59 | 107 | 130 | 205 | 252 |
| Co. Galway | 54 | 99 | 135 | 180 | 228 |
| Mayo | 61 | 87 | 119 | 169 | 237 |
| Roscommon | 35 | 65 | 99 | 146 | 197 |
| Sligo | 46 | 68 | 125 | 197 | 271 |
| Leitrim | 53 | 80 | 114 | 141 | 165 |
| Donegal | 67 | 79 | 118 | 187 | 229 |
| Cavan | 59 | 69 | 94 | 166 | 185 |
| Monaghan | * | 58 | 113 | 172 | 185 |

***Information not available.**

value, the stock was modelled as a perpetuity and a discount rate based on the average retail interest rate for loans for house purchases for 2012 (Central Bank of Ireland, 2016) For further details see the section on methodology (section 4.3.2).

### *4.2.2 Methodology*

Lyons (2012) estimated a log-linear hedonic pricing model for Irish house sales between 2006 and 2010, which included dummies for sales at various distances from the coast. Lyons (2012) had two distance dummies related to the coast, those "at the coast", which were houses 0–250 m from the coast and those "near the coast", within 250 m to 1600 m. Lyons (2012) showed a significant negative relationship between distance to the coast, with houses at and near the coast showing higher relative prices compared with those further inland, except for rural houses in the 250–1600-m zone, which had a lower price relative to the base case of inland houses, although the difference was quite small (–1.2%). There was no explanation given for this result. The method suggested by Kennedy (1981) was used to convert the dummy coefficients into percentage differences in price. The price differential for houses "at the coast" and "near to the coast" for both urban and rural areas is shown in Table 4.3.

Using QGIS software with the 2011 census data at the SA level (sub-electoral division), the numbers of houses within 0–250 m and 250–1600 m of the coast by the number of bedrooms was estimated by overlaying a buffer area related to these (see Figure 4.1 for an example) and multiplying these by the density of the houses in each SA, which gave the numbers of houses within those distances. Price data for 2012 were taken from the Daft report (Daft, 2012) on house prices for counties and cities around Ireland (see Table 4.1). This allowed a capital stock value for house values within each zone to be estimated, as well as the additional aesthetic value of having a house at or near the coast. The relative price difference for being near the coast was then applied to estimate a stock value for this proxy of the aesthetic ecosystem service.

**Table 4.3. Percentage increase in house prices at and near to the coast**

| Distance to coast | Location of house | Percentage increase in house price |
|---|---|---|
| 0–250 m | Urban | 14.2 |
| | Rural | 4.9 |
| 250–1600 m | Urban | 7.4 |
| | Rural | –1.2 |

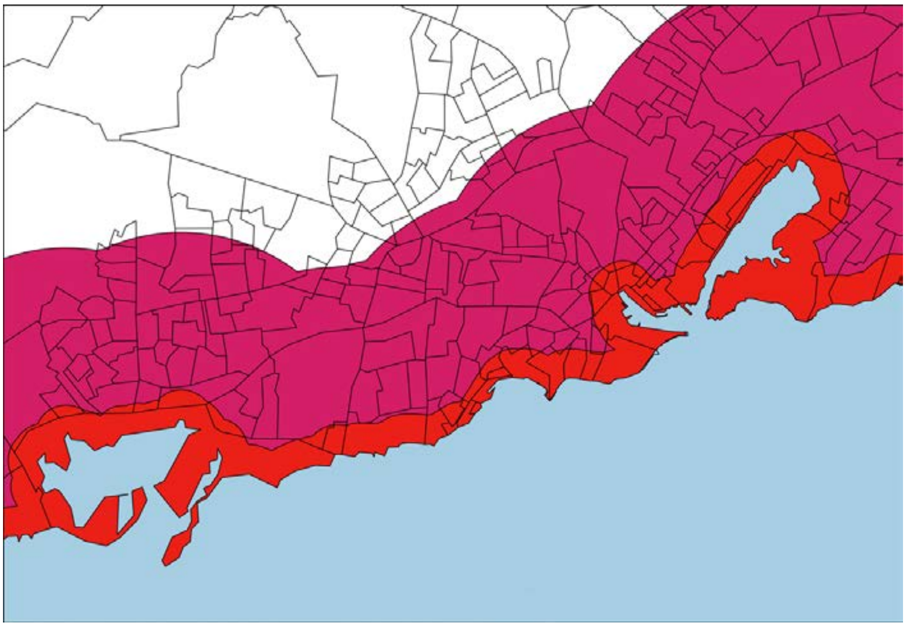

**Figure 4.1. Coastal buffers: an overlay of 0–250 m buffer (red) and 250–1600 m buffer (purple) is shown for census SAs in Galway City.**

This stock value was then converted to a flow value to be comparable to other values estimated in this report. The "stock value" was modelled as the present value of a perpetuity, with the flow of aesthetic ecosystem service then modelled as a flow of annual payments using the equation shown below.

$$\mathrm{PV} \times r = A \qquad \text{(Equation 4.2)}$$

Where PV is present value in perpetuity, $r$ is the rate of interest or discount rate and $A$ is the annual payment, i.e. the flow value.

A discount rate of 2.95% was selected based on the average retail interest rate for loans for house purchases for 2012.

### *4.2.3 Results*

The values by county are shown in Table 4.4 and both the total estimated stock values and flow values are shown in Table 4.5.[10] This represents a proxy of the value of the aesthetic view but does not include the total economic value of aesthetics, as it measures only the value of living near the coast and does not take into account the economic value of an aesthetic view from visitors to the coast (although one could argue that at least some of this value is likely to be accounted for in marine recreational services, particularly for domestic visitors).

**Table 4.4. Estimated aesthetic value by county (thousands of euros)**

| Region | 0–250 m | 250–1600 m | 0–1600 m |
|---|---|---|---|
| Clare County | 22,403 | –14,844 | 7559 |
| Cork County | 113,848 | –68,493 | 45,355 |
| Donegal County | 47,660 | –34,023 | 13,637 |
| Dublin City | 425,060 | 1,412,407 | 1,837,467 |
| Dún Laoghaire–Rathdown | 88,988 | –125,873 | –36,885 |
| Fingal | 138,249 | –97,319 | 40,930 |
| Galway City | 80,411 | 260,575 | 340,985 |
| Galway County | 26,010 | –13,000 | 13,010 |
| Kerry County | 31,936 | –20,486 | 11,450 |
| Leitrim County | 192 | –198 | –6 |
| Limerick County | 9027 | –2254 | 6773 |
| Louth County | 42,242 | –39,486 | 2755 |
| Mayo County | 23,880 | –14,389 | 9491 |
| Meath County | 9959 | –10,704 | –745 |
| Sligo County | 19,842 | –15,671 | 4170 |
| Waterford County | 29,543 | –19,005 | 10,538 |
| Wexford County | 21,454 | –18,289 | 3165 |
| Wicklow County | 35,436 | –52,168 | –16,732 |
| Total | 1,166,140 | 1,126,779 | 2,292,920 |

**Table 4.5. Estimated increased annual value of houses at or near the coast (proxy for aesthetic ecosystem service) (euros)**

| | Value "at the coast" | Value "near the coast" | Total aesthetic value |
|---|---|---|---|
| | 0–250 m | 250–1600 m | 0–1600 m |
| Stock value | 1166.14 million | 1,126,77 million | 2,292.92 million |
| Flow value | 34,401,130 | 33,239,981 | 67,641,140 |

10 Flows of ecosystem services are provided over a defined time interval by a stock of natural resources. Stocks are analogous to the stock value of a capital asset (e.g. savings, house value, shares of a company) and the flow is analogous to the interest that the stock provides (interest, rent and dividend). Stock values can be thought of as the net present value sum of all future flow values that could be derived from an ecosystem.

# 5 Conclusions

This technical report demonstrates the data sources and methods that can be used to estimate the value of a number of coastal and marine ecosystem service benefit values. In particular, the study estimated the value of waste assimilation services, coastal defence services, carbon sequestration services, recreational services, the contribution that proximity to the coast can make to the value of residential property, offshore and inshore capture fisheries, aquaculture and seaweed harvesting. A major issue facing coastal and marine managers and planners is how to ensure that the marine environment's capacity to continue providing ecosystem benefits is not diminished in the face of widespread pressures. As recognised by the integrated marine plan for Ireland, "Harnessing Our Ocean Wealth", the maritime sector can play an important role in growing Ireland's economy but the innovation required to maximise opportunities from the marine environment is likely to put further pressure on coastal and marine ecosystems and the services they deliver. As pointed out in the *Economics of Ecosystems and Biodiversity* report (Kumar, 2010), ignoring the value of these ecosystem services and persisting with conventional approaches to wealth creation and development is a risky strategy if it means losing the benefits that coastal and marine ecosystems provide.

Placing a monetary value on a good or service may imply that full information is available, but for non-market goods this is not always the case. The levels of certainty associated with the quantities of the ecosystem services and their economic values are given in Table 5.1 and are dependent on the assumptions and caveats associated with each ecosystem service.

The certainty scores are based on a 3-point scale (low, medium, high) and are therefore a subjective

**Table 5.1. Certainty associated with generated values**

| Ecosystem service | CICES classification | Quantity estimate certainty | Value estimate certainty |
|---|---|---|---|
| *Provisioning ecosystem service* | | | |
| Offshore capture fisheries | Wild animals | High | High |
| Inshore capture fisheries | Wild animals | Medium | Medium |
| Aquaculture | Animals/aquaculture | High | High |
| Algae/seaweed harvesting | Wild plants and algae/plants and algae from aquaculture | Medium | Medium |
| Water for non-drinking purposes | Surface water for non-drinking purposes | High | – |
| *Regulation and maintenance ecosystem services* | | | |
| Waste services | Mediation of waste, toxics and other nuisances | High | Medium |
| Coastal defence | Mediation of flows | Medium | Low |
| Lifecycle and habitat services | Lifecycle maintenance, habitat and gene pool protection | High | – |
| Climate regulation | Atmospheric composition and climate regulation | Low | Low |
| *Cultural services* | | | |
| Recreational services | Physical and experiential interactions | Medium | Medium |
| Aesthetic services | Aesthetic | Medium | Medium |
| Non-use values | Existence and bequest values | High | Medium |

**"–", no information available.**

measure dependent on the authors' best judgement. Those areas where there is lower certainty show where there is a need for more research or investigation, in either the information related to quantity of the ecosystem service provided or the valuation methodology used.

The low certainty associated with a number of the estimates produced indicates that knowledge gaps still exist for many ecosystem services, both in measuring the quantity of the ecosystem service in physical terms and in the lack of information and understanding needed to apply an economic value to certain ecosystem services.

This initial assessment of Ireland's coastal and marine ecosystem services and their value is an important first step in incorporating ecosystem services into policy and decision making related to Ireland's marine and coastal environment. An avenue for future research is the mapping of the marine and coastal ecosystems and linking them to estimates of the associated ecosystem service value flows. Such research would assist decision makers with responsibility for marine spatial planning and the implementation of the EU Maritime Spatial Planning Directive (2014/89/EU) as they attempt to manage coastal and marine developments in a manner that maximises the delivery of value to society while minimising forgone market opportunities.

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# Abbreviations

| | |
|---|---|
| **AER** | Annual Environmental Report |
| **BIM** | Bord Iascaigh Mhara |
| **BOD** | Biochemical oxygen demand |
| **BSA** | Biologically sensitive area |
| **CCGT** | Combined cycle gas turbine |
| **CICES** | Common International Classification of Ecosystem Services |
| **CORINE** | Coordination of Information on the Environment (databases) |
| **EC** | European Commission |
| **EEZ** | Exclusive Economic Zone |
| **EIS** | Environmental impact statement |
| **EU** | European Union |
| **FAO** | United Nations Food and Agriculture Organization |
| **GDP** | Gross domestic product |
| **GES** | Good environmental status |
| **GNI** | Gross national income |
| **HOOW** | Harnessing Our Ocean Wealth (marine plan) |
| **ICES** | International Council for the Exploration of the Sea |
| **MEA** | Millennium Ecosystem Assessment |
| **MSFD** | Marine Strategy Framework Directive |
| **NOAA** | National Ocean and Atmospheric Association |
| **OLS** | Ordinary least squares |
| **PE** | Population equivalent |
| **SA** | Small area |
| **SAC** | Special Area of Conservation |
| **SEEA** | System of Environmental–Economic Accounting |
| **SPA** | Special Protection Area |
| **STECF** | Scientific, Technical and Economic Committee for Fisheries |
| **TEEB** | The Economics of Biodiversity and Ecosystems (report) |
| **UK NEA** | UK National Ecosystem Assessment |
| **UN** | United Nations |
| **WFD** | Water Framework Directive |
| **WTA** | Willingness to accept |
| **WTP** | Willingness to pay |
| **WWTP** | Wastewater treatment plant |

# Appendix 1 Details of the Pollutants Discharged from Coastal and Estuarine Licensed Urban Wastewater Treatment Plants

**Table A1.1. Details of the pollutants discharged from coastal and estuarine licensed urban wastewater treatment plants[a]**

| RegCD | Name | BOD/cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0034 | Ringsend | 3,880,506 | 3,205,575 | 613,235 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c5e5.pdf | Liffey Estuary Lower | Transitional | |
| D0013 | Limerick | 152,681 | 185,770 | 40,155 | 2014 AER | http://www.epa.ie/licences/lic_eDMS/090151b280526114.pdf | Limerick Dock | Transitional | |
| D0033 | Cork City | 496,875 | 816,784 | 88,514 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c452.pdf | Lough Mahon | Transitional | |
| D0050 | Galway | 45,125 | 309,991 | 19,893 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c458.pdf | Inner Galway Bay North | Coastal | |
| D0057 | Ringaskiddy | 1,505,351 | 294,664 | 61,095 | 2014 AER | http://www.epa.ie/licences/lic_eDMS/090151b280528adc.pdf | Cork Harbour | Coastal | |
| D0038 | Shanganagh | 74,876 | 407,023 | 41,028 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c5e8.pdf | Southwestern Irish Sea – Killiney Bay (HA 10) | Coastal | |
| D0022 | Waterford city | 77,385 | 177,730 | 22,813 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30ad.pdf | Lower Suir Estuary (Little Island – Cheekpoint) | Transitional | |
| D0024 | Swords | 20,101 | 43,904 | 3172 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30af.pdf | Broadmeadow Water | Transitional | |
| D0041 | Drogheda | 24,536 | 87,456 | 5018 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059d4ae.pdf | Boyne Estuary | Transitional | |
| D0053 | Dundalk | 15,249 | 96,393 | 9690 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059bebb.pdf | Castletown Estuary | Transitional | |
| D0010 | Greystones | 14,317 | 41,062 | 10,532 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30a9.pdf | Southwestern Irish Sea – Killiney Bay (HA 10) | Coastal | |
| D0030 | Wexford town | 13,667 | 36,204 | 1088 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30b1.pdf | Wexford Harbour | Coastal | |
| D0023 | Balbriggan | 8467 | 26,022 | 9728 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b31c6.pdf | Northwestern Irish Sea (HA 08) | Coastal | |
| D0009 | Letterkenny | 10,842 | 12,927 | 1580 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5a0.pdf | Swilly Estuary | Transitional | |
| D0051 | Clonakilty and Environs | 15,150 | 2637 | 2707 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c459.pdf | Clonakilty Harbour | Transitional | |
| D0014 | Sligo | 41,347 | 39,196 | 4344 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c368.pdf | Garavoge Estuary | Transitional | |
| D0017 | Dungarvan | 8250 | 26,966 | 5838 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c44d.pdf | Dungarvan Harbour | Coastal | |

**Table A1.1. Continued**

| RegCD | Name | BOD/ cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0114 | Portrane/Donabate | 6765 | 24,403 | 6254 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30cb.pdf | Northwestern Irish Sea (HA 08) | Coastal | |
| D0006 | Arklow and Environs | *372,234* | *62,039* | *12,408* | Application form | http://www.epa.ie/licences/lic_eDMS/090151b2804c29e7.pdf | Avoca Estuary | Transitional | Estimates based on PE taken from application form |
| D0021 | Malahide | 11,507 | 21,887 | 5119 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30ab.pdf | Malahide Bay | Coastal | |
| D0055 | Westport | 3684 | 9837 | 1981 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059d4af.pdf | Westport Bay | Transitional | |
| D0012 | Wicklow | 8388 | 21,797 | 5657 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30aa.pdf | Southwestern Irish Sea – Killiney Bay (HA10) | Coastal | |
| D0045 | Shannon Town | 196,602 | 77,936 | 16,761 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c456.pdf | Upper Shannon Estuary | Transitional | |
| D0139 | Youghal | *313,170* | *52,195* | *10,439* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b2805389d3.pdf | Lower Blackwater M Estuary/Youghal Harbour | Transitional | Estimates based on PE taken from EPA inspector's report |
| D0040 | Tralee | 20,670 | 40,801 | 5528 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30c4.pdf | Lee K Estuary | Transitional | |
| D0056 | Midleton | 4572 | 11,684 | *675* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c45b.pdf | North Channel Great Island | Transitional | |
| D0044 | Carrigtwohill and Environs | 27,794 | 17,352 | 2011 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c455.pdf | Lough Mahon (Harper's Island) | Transitional | |
| D0016 | Ballina | 3955 | 42,700 | 4711 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c369.pdf | Moy Estuary | Transitional | |
| D0036 | New Ross | 9140 | 15,506 | 844 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30c3.pdf | New Ross Port | Transitional | |
| D0125 | Buncrana | 101,639 | *32,650* | *6530* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5a6.pdf | Lough Swilly | Coastal | |
| D0015 | Tramore | 6801 | 30,491 | 1408 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c44c.pdf | Tramore Back Strand | Coastal | |
| D0046 | Courtown-Gorey | 4828 | 18,510 | 2332 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c457.pdf | Southwestern Irish Sea (HAs 11; 12) | Coastal | |
| D0148 | Carrick-on-Suir | 1978 | 4160 | 174 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c476.pdf | Upper Suir Estuary | Transitional | |
| D0029 | Enniscorthy | 8740 | 20,080 | 2521 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30b0.pdf | Upper Slaney Estuary | Transitional | |

**Table A1.1. Continued**

| RegCD | Name | BOD/cBOD ($kg\,year^{-1}$) | TN ($kg\,year^{-1}$) | TP ($kg\,year^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0179 | Listowel WWTP | 3191 | 10,869 | *1040* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30e7.pdf | Upper Feale Estuary | Transitional | |
| D0185 | Dingle | 2953 | *7901* | *986* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c618.pdf | Dingle Harbour | Coastal | |
| D0119 | Rush | *137,817* | *22,969* | *4594* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b28039f8e8.pdf | Northwestern Irish Sea (HA 08) | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0011 | Killybegs | 246,078 | 37,451 | 11,274 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5a1.pdf | Killybegs Harbour | Coastal | |
| D0132 | Kinsale | 3662 | 5823 | 1101 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805a0171.pdf | Lower Bandon Estuary | Transitional | |
| D0078 | Kilkee | *109,062* | *18,177* | *3635* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c2ed.pdf | Shannon Plume (HAs 27; 28) | Coastal | Estimates based on PE taken from 2015 AER |
| D0075 | Kilrush | *101,616* | *16,936* | *3387* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c371.pdf | Mouth of the Shannon (HAs 23; 27) | Coastal | Estimates based on PE taken from 2015 AER |
| D0135 | Donegal Town | 2225 | 10,013 | 278 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059ec18.pdf | Donegal Bay (Erne) | Coastal | |
| D0113 | Carndonagh/Malin | 1715 | 6464 | 791 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059e015.pdf | Trawbreaga Bay | Coastal | |
| D0331 | Milltown | 1070 | *5185* | *579* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b3115.pdf | Castlemaine Harbour | Transitional | |
| D0170 | Dunmore East | *95,221* | *15,870* | *3174* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c613.pdf | Waterford Harbour | Coastal | Estimates based on PE taken from 2015 AER |
| D0188 | Blackrock | 14,198 | 16,773 | 2574 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c47f.pdf | Inner Dundalk Bay | Transitional | |
| D0172 | Rosscarbery Owenahincha | *62,102* | *13,308* | *2662* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b28057af23.pdf | Rosscarbery Bay | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0182 | Killorglin | 2960 | *5122* | *721* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805a0172.pdf | Castlemaine Harbour | Transitional | |
| D0184 | Kenmare | 716 | *4377* | *474* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c617.pdf | Inner Kenmare River | Transitional | |

**Table A1.1. Continued**

| RegCD | Name | BOD/cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0072 | Achill Island Central WWTP | 927 | 6887 | 375 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c464.pdf | Western Atlantic Seaboard (HAs 32; 33; 34) | Coastal | |
| D0130 | Bundoran | 64,415 | 10,429 | 1728 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805a2c4d.pdf | Bundoran Bay | Coastal | |
| D0087 | Kilcoole | 594 | 2783 | 202 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30c8.pdf | Kilcoole Marsh | Transitional | |
| D0168 | Bantry | 2678 | *6576* | *144* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c611.pdf | Inner Bantry Bay | Transitional | |
| D0107 | Strandhill | 17,715 | 8917 | 1452 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c379.pdf | Sligo Bay | Coastal | |
| D0166 | Skibbereen | 2942 | 2541 | 601 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c47c.pdf | Ilen Estuary | Transitional | |
| D0198 | Clifden | 20,243 | 11,980 | 1064 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5a8.pdf | Clifden Bay | Transitional | |
| D0102 | Enniscrone | 1071 | 1993 | 401 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c378.pdf | Killala Bay | Coastal | |
| D0212 | Moville | *60,072* | *10,012* | *2002* | Application form | http://www.epa.ie/licences/lic_eDMS/090151b2802798ea.pdf | Lough Foyle | Coastal | Estimates based on PE taken from application form |
| D0183 | Ballybunion | 950 | 2054 | 502 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30e8.pdf | Cashen | Transitional | |
| D0162 | Ardmore | *57,378* | *9563* | *1913* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b28035fcab.pdf | Eastern Celtic Sea (HAs 13; 17) | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0199 | Clareabbey | 2596 | 2431 | 525 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c61c.pdf | Fergus Estuary | Transitional | |
| D0268 | Carlingford Sewerage Scheme | 2725 | 3426 | 559 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c498.pdf | Carlingford Lough | Coastal | |
| D0173 | Rosslare Strand and Environs | 1437 | 7496 | 1396 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30e3.pdf | Southwestern Irish Sea (HAs 11; 12) | Coastal | |
| D0211 | Dunfanaghy-Portnablagh | 6796 | *6504* | *1301* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f0dd.pdf | Sheephaven Bay | Coastal | |
| D0423 | Whitegate-Aghada | *42,771* | *7128* | *1426* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b28055dce8.pdf | Cork Harbour | Coastal | Estimates based on PE taken from EPA inspector's report |

**Table A1.1. Continued**

| RegCD | Name | BOD/ cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0345 | Rathmullan | 41,656 | *6169* | *1234* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5ad.pdf | Swilly Estuary | Transitional | |
| D0176 | Lismore | 808 | 3871 | 410 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c614.pdf | Upper Blackwater M Estuary | Transitional | |
| D0352 | Lifford | 28,233 | *5972* | *1194* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5ae.pdf | Foyle and Faughan Estuaries | Transitional | |
| D0272 | Cappoquin | 31,026 | 5392 | | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c62a.pdf | Upper Blackwater M Estuary | Transitional | |
| D0128 | Ballyshannon | 1528 | 5129 | 709 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059ec16.pdf | Erne Estuary | Transitional | |
| D0350 | Downings | 45,020 | 5509 | 832 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805a2c4e.pdf | Sheephaven Bay | Coastal | |
| D0276 | Kinvara | 30,683 | 7945 | 1233 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c382.pdf | Kinvarra Bay | Transitional | |
| D0274 | Portlaw | 6559 | 4852 | 864 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c62c.pdf | Middle Suir Estuary | Transitional | |
| D0074 | Belmullet | *36,989* | *6165* | *1233* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b28046f39c.pdf | Belmullet Bay | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0208 | Dungloe | 8391 | 2289 | 290 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5a9.pdf | Dungloe Bay | Coastal | |
| D0343 | Falcarragh | 10,172 | *6015* | *1203* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059d4b0.pdf | Ballyness Bay | Coastal | |
| D0341 | Ramelton | 30,222 | 19,345 | 6460 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f0de.pdf | Swilly Estuary | Transitional | |
| D0232 | Kilmore Quay Village and Environs | *35,215* | *5869* | *1174* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b2804b9038.pdf | Eastern Celtic Sea (HAs 13; 17) | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0067 | Killala | *32,850* | *5475* | *1095* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c460.pdf | Killala Bay | Coastal | Estimates based on PE taken from 2015 AER |
| D0327 | Ballyvaughan WWTP | *32,850* | *5475* | *1095* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4a9.pdf | Ballyvaghan Bay | Coastal | Estimates based on PE taken from 2015 AER |
| D0224 | Newport | *22,535* | *4829* | *966* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b280579098.pdf | Newport Bay | Transitional | Estimates based on PE taken from EPA inspector's report |

**Table A1.1. Continued**

| RegCD | Name | BOD/cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0512 | Ardara | 642 | 2368 | 249 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5b0.pdf | Owenea Estuary | Coastal | |
| D0297 | Castletownbere | *28,470* | *4745* | *949* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c635.pdf | Berehaven | Coastal | Estimates based on PE taken from 2015 AER |
| D0080 | Lahinch | 3675 | 2850 | 718 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c5f4.pdf | Inagh Estuary | Transitional | |
| D0418 | Ballyduff | 32,570 | *4075* | *815* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b313a.pdf | Cashen | Transitional | |
| D0081 | Ennistymon | 5410 | 2167 | 411 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c5f5.pdf | Inagh Estuary | Transitional | |
| D0461 | Castlegregory | 13,533 | *3962* | *792* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c662.pdf | Outer Tralee Bay | Coastal | |
| D0186 | Ballyheigue | 1264 | *3140* | *45* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30e9.pdf | Outer Tralee Bay | Coastal | |
| D0245 | Duncannon | *25,667* | *4278* | *856* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b2804ffac7.pdf | Barrow Suir Nore Estuary | Transitional | Estimates based on PE taken from EPA inspector's report |
| D0312 | Adare | 863 | 1138 | 36 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c640.pdf | Maigue Estuary | Transitional | |
| D0181 | Cahersiveen | 691 | *1423* | *190* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c616.pdf | Ferta | Transitional | |
| D0095 | Ballysadare | 675 | 3248 | 134 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c377.pdf | Ballysadare Estuary | Transitional | |
| D0145 | Mooncoin | 717 | 1192 | 154 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c608.pdf | Middle Suir Estuary | Transitional | |
| D0295 | Schull | 619 | *1305* | 532 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4a2.pdf | Roaring Water Bay | Coastal | |
| D0322 | Clarecastle | *21,900* | *3650* | *730* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b2805122b9.pdf | Fergus Estuary | Transitional | Estimates based on PE taken from EPA inspector's report |
| D0140 | North Cobh | 527 | 1080 | 227 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c606.pdf | Lough Mahon | Transitional | |
| D0285 | Sneem | 544 | *1059* | *117* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c62d.pdf | Sneem Harbour | Transitional | |
| D0265 | Clogherhead | 2377 | 5391 | 766 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c623.pdf | Louth Coast (HA 06) | Coastal | |

**Table A1.1. Continued**

| RegCD | Name | BOD/cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0538 | St Johnston | *20,236* | *3373* | *675* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b2805567f3.pdf | Foyle and Faughan Estuaries | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0241 | Fethard-on-Sea and Environs | 4569 | *2996* | *599* | 2014 Inspectors report | http://www.epa.ie/licences/lic_eDMS/090151b28050ce3c.pdf | Eastern Celtic Sea (HAs 13; 17) | Coastal | |
| D0266 | Tullyallen Sewerage Scheme | 376 | 1700 | 159 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c497.pdf | Boyne Estuary | Transitional | |
| D0522 | Mountcharles | 4928 | *2432* | *617* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059ec1d.pdf | Donegal Bay (Erne) | Coastal | |
| D0165 | Rosslare Harbour | 1049 | 3438 | 865 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b30e1.pdf | Southwestern Irish Sea (HAs 11; 12) | Coastal | |
| D0284 | Fenit | 10,336 | 3501 | 417 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b3113.pdf | Outer Tralee Bay | Coastal | |
| D0358 | Baile Na nGall | 772 | 343 | 208 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4b2.pdf | Dungarvan Harbour | Coastal | |
| D0535 | Fahan | 3686 | *2480* | *496* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f0e8.pdf | Swilly Estuary | Transitional | |
| D0471 | Glengarriff | *11,498* | *2464* | *493* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b314d.pdf | Glengarriff Harbour | Transitional | Estimates based on PE taken from 2015 AER |
| D0516 | Ballycotton | 36,034 | *2657* | *531* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c670.pdf | Ballycotton Bay | Coastal | |
| D0523 | Carrigart | 13,050 | 2172 | 444 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f5b2.pdf | Mulroy Bay Broadwater | Coastal | |
| D0469 | Union Hall | *9857* | *2112* | *422* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b3143.pdf | Glandore Harbour | Transitional | Estimates based on PE taken from 2015 AER |
| D0430 | Liscannor | 13,928 | *2321* | *464* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4c1.pdf | Liscannor Bay | Coastal | |
| D0353 | Stradbally | 2957 | *1971* | *394* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c653.pdf | Eastern Celtic Sea (HAs 13; 17) | Coastal | |
| D0269 | Castlebellingham | 4291 | 3018 | 285 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c625.pdf | Outer Dundalk Bay | Coastal | |
| D0519 | Manorcunningham | 1024 | *932* | *169* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059f0e4.pdf | Swilly Estuary | Transitional | |

**Table A1.1. Continued**

| RegCD | Name | BOD/ cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0218 | Mallaranny | 78 | 543 | 120 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c48a.pdf | Clew Bay | Coastal | |
| D0283 | Tarbert | 3518 | *1679* | *336* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b3112.pdf | Lower Shannon Estuary | Transitional | |
| D0467 | Ballydehob | 7879 | *1643* | *329* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c663.pdf | Roaring Water Bay | Coastal | |
| D0429 | Innishannon | 29,833 | 9973 | 951 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4c0.pdf | Upper Bandon Estuary | Transitional | |
| D0296 | Baltimore | 272 | 237 | 140 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c634.pdf | Ilen Estuary | Transitional | |
| D0286 | Glenbeigh | 879 | *790* | *144* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c62e.pdf | Cromane | Transitional | |
| D0315 | Askeaton | 9070 | 1875 | 327 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c643.pdf | Deel Estuary | Transitional | |
| D0239 | Mullaghmore | 2979 | 1094 | 177 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c37f.pdf | Donegal Bay (Erne) | Coastal | |
| D0381 | Grange | 3581 | 1874 | 182 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c388.pdf | Donegal Bay Southern | Coastal | |
| D0502 | Foynes | 9690 | 4821 | 455 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c66a.pdf | Foynes Harbour | Transitional | |
| D0324 | Doonbeg | 462 | 554 | 49 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4a8.pdf | Doonbeg Bay | Coastal | |
| D0528 | Fiddown | 7255 | 3090 | 315 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c674.pdf | Middle Suir Estuary | Transitional | Based on effluent samples in AER report |
| D0287 | Waterville | 441 | *542* | *86* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b3114.pdf | Ballinskelligs Bay | Coastal | |
| D0373 | Easky | 296 | *477* | *69* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c387.pdf | Easky Estuary | Transitional | |
| D0539 | Rossnowlagh | 255 | *442* | *62* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059ec1f.pdf | Donegal Bay (Erne) | Coastal | |
| D0504 | Glin | 6455 | 1939 | 216 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4de.pdf | Lower Shannon Estuary | Transitional | |
| D0394 | Cliffony | 47 | 323 | 12 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c38d.pdf | Donegal Bay Southern | Coastal | |
| D0541 | Belgooly | 1132 | *622* | *148* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c676.pdf | Oysterhaven | Transitional | |

**Table A1.1. Continued**

| RegCD | Name | BOD/ cBOD (kg year$^{-1}$) | TN (kg year$^{-1}$) | TP (kg year$^{-1}$) | Source | Source link | Primary discharge water body | WFD water body type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| D0511 | Achill Sound | 53 | 438 | 269 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4e0.pdf | Blacksod Bay SW/Achill Sound | Coastal | |
| D0468 | Castletownshend | *4117* | *686* | *137* | Inspector's report | http://www.epa.ie/licences/lic_eDMS/090151b28040c091.pdf | Rosscarbery Bay | Coastal | Estimates based on PE taken from EPA inspector's report |
| D0421 | Knightstown | 890 | *506* | *101* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b313c.pdf | Valencia Harbour | Coastal | |
| D0459 | Ballylongford | 160 | *180* | *30* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b2805b313f.pdf | Lower Shannon Estuary | Transitional | |
| D0409 | Campile | 7659 | 2103 | 342 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c656.pdf | Barrow Suir Nore Estuary | Transitional | |
| D0388 | Carraroe | 1664 | *277* | *55* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059ec1b.pdf | Casla Bay | Coastal | |
| D0396 | Spiddal | 1369 | *230* | *46* | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059ec1c.pdf | Aran Islands, Galway Bay, Connemara (HAs 29; 31) | Coastal | |
| D0367 | Doogort | 49 | 271 | 44 | 2015 AER | http://www.epa.ie/licences/lic_eDMS/090151b28059c4b6.pdf | Blacksod Bay | Coastal | |
| D0054 | Cobh | | | | | | Cork Harbour | Coastal | Included in Ringaskiddy estimates |
| D0129 | Passage-Monkstown | | | | | | Cork Harbour | Coastal | Included in Ringaskiddy estimates |
| D0436 | Ringaskiddy Village | | | | | | Cork Harbour | Coastal | Included in Ringaskiddy estimates |
| D0005 | Bray | | | | | | | | Sent to Shanganagh WWTP |
| D0122 | Lusk | | | | | | | | Sent to Portrane-Donabate WWTP |

**[a]Data in italics are the total nitrogen and total phosphorous emissions estimated for 15 WWTPs that were missing data for secondary treatment based on an OLS regression analysis using the information from other wastewater plants treating to secondary treatment level and without the intercept term.**

# Appendix 2 Guidelines for Undertaking an Ecosystem Services Assessment

## Introduction

Decision support frameworks such as cost–benefit analysis, multi-criteria analysis or impact assessment (e.g. environmental or regulatory) can offer an open, objective and transparent methodology of choosing between alternatives. However, any methodology that fails to include all the aspects and consequences of a decision may lead to poor choices. Including an ecosystem services assessment as part of a decision support framework, such as environmental impact assessment (EIA), regulatory impact assessment (RIA) or plan of any kind, could ensure that a plan's or project's indirect effects on society through its impact on nature are considered during the decision making process.

The methodology used in this guidance document was adapted from Hooper *et al*. (2016) and will focus on marine, coastal and estuarine ecosystem services, although the fundamentals of this guidance document (shown in Figure A2.1) could be adjusted and applied to an ecosystem service assessment in any environment. The need for ecosystem service assessment focused on the marine, coastal and estuarine environment is driven by a number of policies including the Integrated Maritime Policy for the European Union (EC, 2007) and at national level in Ireland by the national marine strategy, Harvesting our Ocean Wealth (GoI, 2012). In addition, recent EU directives including the Maritime Spatial Planning Directive (MSPD) (EC, 2014) and Marine Strategy Framework Directive (MSFD) (EC, 2008) require assessments of ecosystem services.

There has been much debate, which continues, on how to define ecosystem services. This guidance document uses the MEA (MEA, 2005) definition that ecosystem services are "the benefits that ecosystems provide to people". This means that, for the rest of the document, ecosystem services are synonymous with benefits. It is left to the practitioner to choose the classification system (step 3) but it should be noted that different ecosystem services classification systems have different boundary conditions for defining the relevant ecosystem services.

This guidance document is not intended as a rule of law, but practitioners should aim to follow the basic steps of the guidance document using available data. Practitioners should also identify and acknowledge knowledge gaps when incorporating an ecosystem services assessment into their decision support framework. A summary of the steps outlined is shown in the flow chart in Figure A2.1.

## Step 1: Outline the Background and Reason for Undertaking an Ecosystem Services Assessment

The first stage of an ecosystem services assessment is for the practitioners to outline the reason for undertaking it. They should specify whether the ecosystem services assessment is measuring the flow of ecosystem services over a specific period (e.g. one year) or examining significant change expected to the site due to impact from a project, policy or plan. The reason for the ecosystem services assessment will affect the level of information and methods used in other steps of the assessment. For example, identifying the flow of ecosystem services from a site will depend on the boundaries set for a site, although such boundaries may change because a project is being undertaken. Other steps that may be affected by the nature of the assessment would be the indicators and the valuation methods used (if valuation is being undertaken).

## Step 2: Undertake a Site Characterisation

The next stage of an ecosystem services assessment is to define the boundaries of the site as much as possible and undertake a site characterisation to give context to the assessment. In order to define a boundary for the local area ecosystem services, there are a number of approaches available.

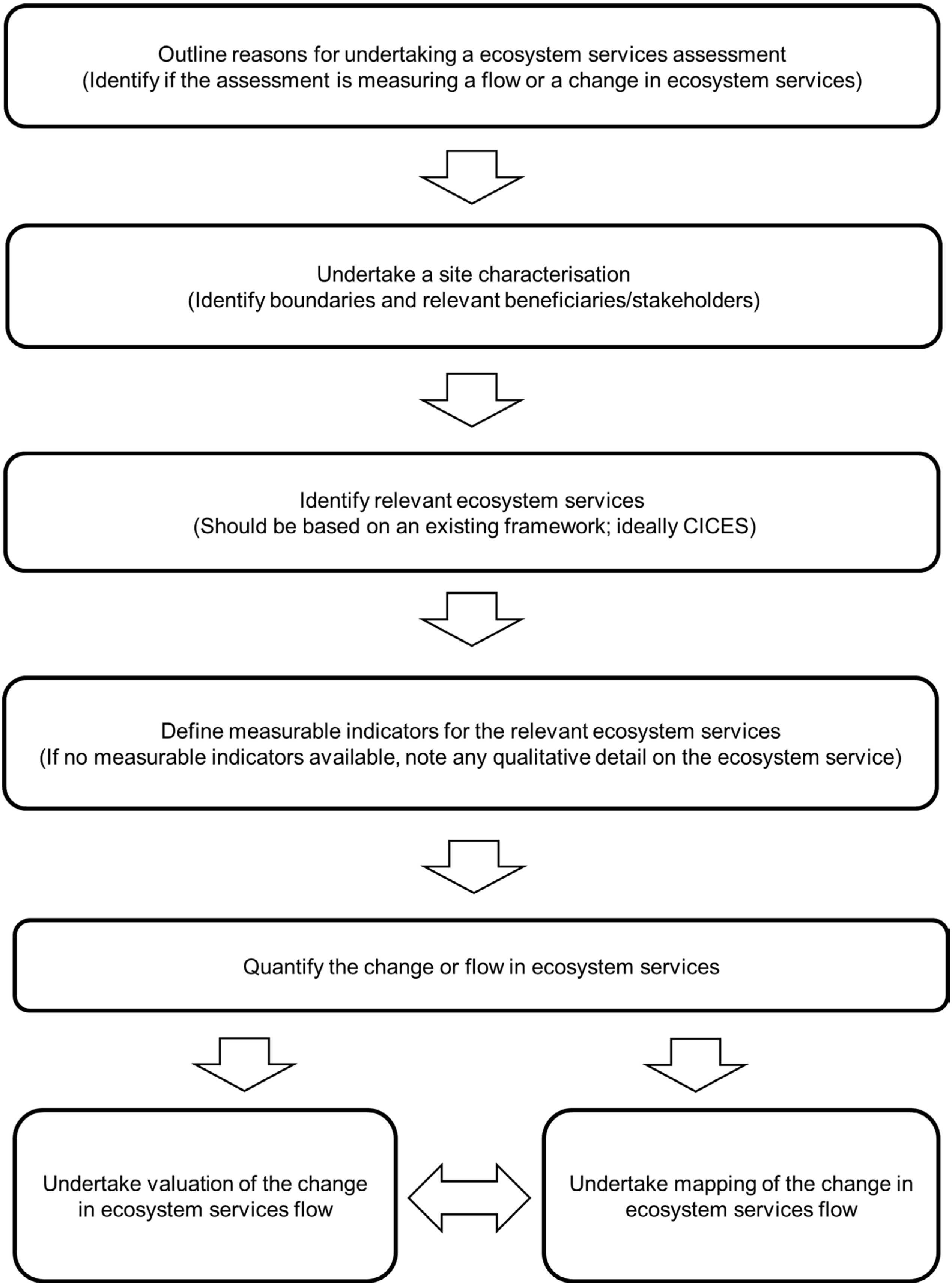


**Figure A2.1. Flowchart of the steps for undertaking an ecosystem services assessment (adapted from Hooper *et al*., 2016).**

Troy and Wilson (2006) suggest that the boundary for an ecosystem service assessment will depend on the type of ecosystem service being assessed, but note that watersheds offer good compromises as natural boundaries for provisioning and for regulation and maintenance ecosystem services. Political divisions may be more appropriate for certain cultural ecosystems (Hynes *et al*., 2013), or economic jurisdictions as determined by distance decay (Bateman *et al*., 2006) may be appropriate for ecosystem services such as recreation or non-use values (Hanley *et al*., 2003; Bateman *et al*., 2006).

However, most of the research on boundary conditions for assessment has been focused on terrestrial and some coastal ecosystem services, but, as noted by Börger *et al*. (2014), for marine sites such approaches may not be appropriate because of the lack of data and the highly variable and mobile nature of some species and ecosystems both spatially and temporally. Practitioners of ecosystem services assessment in the marine environment should be flexible in defining the boundaries of a site based on best information available.

A site characteristic should give an overview of the site in terms of the main ecosystem services, ecosystems, habitats or species that are particularly important or of concern. In addition, some details should be given on the local population and if there is significant inflow of other persons (tourists, workers) into the site. The reason for this focus on population is that certain ecosystem services, particularly cultural and some regulating ecosystem services are dependent on the local population. Care should be taken in aggregating values for some ecosystem services if economic valuation is intended, as political boundaries may not exactly align with economic jurisdictions (for further detail, see Bateman *et al*., 2006).

## Step 3: Identify Relevant Ecosystem Services

Depending on the reason for an ecosystem services assessment (step 1), it may be that only a number of ecosystem services are impacted and need to be assessed or it may be that the practitioner needs to examine all the ecosystem services within a site. In many cases, each new study develops its own concepts and classifications or develops a variation on a previously used ecosystem service classification system, with Liquetes *et al*. (2013) finding that 68% of studies did not follow a particular classification.

It is recommended that practitioners use a classification framework for ecosystem services assessment. The benefits of using a classification framework are that it offers a systematic checklist of ecosystem services, helps to avoid double counting and can help to identify knowledge gaps. However, taking this "standardised" approach can lead practitioners to ignore the fluid and overlapping nature of ecosystem services and may not take into account the linkages and systems nature of ecosystems and the services they generate. Practitioners should take particular account of this in assessing knock-on effects or cumulative impacts if the assessment is examining the change in ecosystem services due to a project, policy or plan.

It is generally accepted that ecosystem services can be broken down into three main groupings.

- Provisioning services – these ecosystem services are tangible goods and there is often a direct connection between the ecosystem and the provision of these ecosystem services.
- Regulation and maintenance services – these ecosystem services regulate the world around us and are often consumed indirectly in the background.
- Cultural services – cultural ecosystem services refer to the psychical, psychological and spiritual benefits that humans obtain from contact with nature.

While some earlier classification systems (e.g. MEA, 2005) included a fourth grouping, supporting services, it is now considered that those "supporting services" describe natural processes and functions within the ecosystem rather than services that could generate benefits to society. There are a number of internationally recognised ecosystem service classification systems available that further divide the first three ecosystem services groupings. These include;

- the Millennium Ecosystem Assessment (MEA, 2005);
- the *Economics of Biodiversity and Ecosystems* (TEEB) report (Kumar, 2010);
- the UK National Ecosystem Assessment (UK NEA) (Watson *et al*., 2011);

**Table A2.1. Potential indicators for marine and coastal ecosystem services**

| Ecosystem service | CICES classification | Potential indicator |
|---|---|---|
| *Provisioning ecosystem service* | | |
| Offshore capture fisheries | Wild animals | Fish landings |
| Inshore capture fisheries | Wild animals | Fish landings |
| Aquaculture | Animals/aquaculture | Aquaculture production |
| Algae/seaweed harvesting | Wild plants and algae | Seaweed production |
| Water for non-drinking purposes | Surface water for non-drinking purposes | Water consumption (e.g. for cooling or other uses) |
| *Regulating and maintenance ecosystem services* | | |
| Waste services | Mediation of waste, toxics and other nuisances | Mass or volume of pollutants discharged in to the marine environment |
| Coastal defence | Mediation of flows | Extent of saltmarshes or other habitats providing coastal defence |
| Lifecycle and habitat services | Lifecycle maintenance, habitat and gene pool protection | Biodiversity indicators or protected sites indicators |
| Pest and disease control | Pest and disease control | Number of disease outbreaks or numbers/ extent of invasives |
| Climate regulation | Atmospheric composition and climate regulation | Mass or volume of carbon and other greenhouse gas uptake for sequestration or storage |
| *Cultural services* | | |
| Recreational services | Physical and experiential interactions | Number of visits to marine ecosystems (e.g. beaches, seas, cliffs) |
| Scientific and educational services | Scientific and educational | Number of students in marine-related courses/number of papers related to research at a certain site |
| Marine heritage, culture and entertainment | Heritage, cultural and entertainment | Number of marine-related protected structures, marine museum visits, number of activities or festivals related to the marine |
| Aesthetic services | Aesthetic | Increase value in house prices, increased prices in hotel rooms |

- the Final Ecosystem Goods and Services Classification System (FEGS-CS) (Landers and Nahlik, 2013);
- the Common International Classification of Ecosystem Services (CICES) (Haines Young and Potschin, 2010.

The last of these classification systems, CICES (Haines Young and Potschin, 2013), is the ecosystem services classification system that is endorsed by the authors of this guidance document. Initially developed in an accounting context by the SEEA, led by the UN Statistical Division (UNSD), its hierarchical and flexible structure is built on the three main ecosystem service types (provisioning, regulation and maintenance, and cultural), which make it an ideal system for assessment of ecosystem services (Maes *et al*., 2013). Since the original report (Haines Young and Potschin, 2010), this system has been updated and revised and the most up-to-date version of the classification system is CICES 4.3. To determine whether or not the ecosystem service is relevant, the analyst also needs to consider:

- whether the project/activity has an impact on the service or is dependent upon it;
- how significant the impact is;
- who the beneficiaries are, where they are located and how many of them there are;
- what substitutes for the impacted ecosystem service are readily available to beneficiaries.

Once these questions are answered and the relevant ecosystem services are identified, the next step then involves considering the benefit flows from the services.

## Step 4: Define Measurable Indicators for the Relevant Ecosystem Services

Based on the ecosystem services identified in the previous step, indicators for the level of ecosystem services generated should be defined and be linked to the benefits generated for society. Hooper *et al.* (2016) note that any proposed indicator should be assessed against a number of benchmarks: measurability (data are available that can be measured), sensitivity (the ability to detect change over time), specificity (it can respond to the specific change or impact being measured), scalability (able to be used at various spatial scales) and transferability (the ability to use the indicator in other sites or compare across sites). These requirements mirror the requirements suggested for environmental indicators (Niemeijer and de Groot, 2008). Ideally these indicators should also be linked to ecosystem functioning (i.e. how the functions/processes within the ecosystem provide benefits) or to the benefits that are generated for society. There is an additional advantage to using an ecosystem services classification system, as these systems contain a set of suitable indicators. The classification system suggested by this report (CICES) has been noted by some as having one of the most comprehensive indicator sets (Müller *et al.*, 2016).

If no measurable indicators are available, practitioners should highlight this fact and note any qualitative detail of the ecosystem service. This is likely to be the case for regulating services where there is often insufficient knowledge or it may not be practicable or even possible to obtain sufficient understanding of the delivery of the ecosystem service within the site. In addition, with regard to cultural services, practitioners may find it very difficult to identify suitable indicators and it may be impossible for certain ecosystem services that have a sacred and/or religious element. That certain ecosystem services may not be measurable may mean that stakeholders and beneficiaries should be consulted and their views should be taken into account. In such cases, an alternative to identifying indicators is to spatially define relevant areas of importance for such ecosystem services for the relevant stakeholders and beneficiaries and incorporate this information into the decision making process.

Below is a suggested list of suitable indicators for ecosystem services associated with marine, coastal and estuarine ecosystem services that are adapted from this study and Charles *et al.* (2016). It is not intended to be a complete list and it is hoped that, with further research, this list can be expanded in the future.

## Step 5: Quantify the Change or Flow in Ecosystem Services

When the aim is to quantify the flow in ecosystem services over a particular time period (e.g. over one year), the practitioner should look at the chosen indicators and assess whether they are suitable to estimate the flow of each relevant ecosystem service of interest. Where there is no suitable indicator for measuring flow of ecosystem services or where the period does not match the chosen period, the practitioner should use their judgement, expert knowledge and best available evidence to give some estimate of the flow of that ecosystem service or else describe in qualitative terms the flow of the ecosystem service and areas within the site that underpin that service.

When the aim of the ecosystem service assessment is to measure the change in the flow of ecosystem services due to an impact from a project, policy or plan, the practitioner must first undertake a baseline assessment of the flow of ecosystem services under a business-as-usual scenario (i.e. the current flow of ecosystem services). The significant changes to the flow of ecosystem services should then be outlined (whether they will increase or decrease or whether there will be a redistribution of the flow of ecosystem services either spatially or temporally). These changes may be modelled for a number of different scenarios and the practitioner should then also identify possible mitigation measures if needed.

## Step 6: Further Steps

The output from this process into the decision making process can be terminated at step 5, but many assessments have extended the ecosystem services assessment by using the information generated in the previous steps to produce maps of ecosystem services, undertaking a valuation exercise related to the change in flow of ecosystem services or both. Some information is given below on these possible further steps by practitioners.

### *Step 6.1: Undertake mapping of the change in ecosystem services flow*

Mapping ecosystem services and/or their economic values may allow spatially explicit prioritisation and problem identification of threats to ecosystem services. They are also useful for communication between different stakeholders (Wood, 2010), can display a range of information at various spatial and temporal scales (Burkhard *et al*., 2013) and will allow up- or down-scaling of values from national level to local level and vice versa (Maes *et al*., 2013). This may help to integrate these values into policymaking decisions, for example to identify areas that are ecosystem services "hotspots" and may need to be protected (García-Nieto *et al*., 2013). In addition, for some ecosystem services where a suitable indicator cannot be found, spatially defining areas of importance for these ecosystem services may be an alternative method of integrating these ecosystem services into the decision making process.

An example of this is Willis *et al*. (2014) who mapped the general public's values regarding a bay in the UK by asking respondents to indicate (on a map) three key areas that were significant or valuable to them (using green spots) and a further three that respondents felt were under threat or challenged (using red spots). This information was then used to generate "hotspot" maps of the areas of significance to the general public and to identify areas that were under threat. An extension of this would be to undertake a survey of the general public and stakeholders within a site to map cultural values (which may be difficult to assess using other methods) by using different coloured spots/stickers (green – "nature"; red – "recreation" and blue – "cultural heritage") to identify locations of cultural ecosystem services that are important to those groups.

However, it should be noted that mapping of ecosystem services may generate some issues. Certain ecosystem services may be more easily mapped than others leading to under-appreciation of the latter's value (economic or otherwise). It may also be difficult to convey knowledge gaps and uncertainties associated with certain ecosystem services on maps and some (e.g. Hauck *et al*., 2013) have noted that maps can convey an "air of authority" leading to improper use in decision making.

### *Step 6.2: Undertake valuation of the change in ecosystem services flow*

Providing an economic quantification of the value of the costs and benefits derived from marine ecosystem services can improve the delivery of responsible environmental management decisions by making formerly implicit weightings explicit and improving the transparency of the weighting of the costs and benefits of a project.

In an ideal world, a practitioner should be able to estimate the economic value of the costs and benefits associated with each ecosystem service. In the real world, there may be a lot of uncertainty associated with both the indicators of ecosystem services and their values. Valuation of certain ecosystem services may be more difficult for some relative to others and, for certain ecosystem services, it may be impossible (e.g. ecosystem services with a sacred and/or religious element). Therefore, it is recommended that economic valuation should not be the sole criterion used for any decision that has a significant impact on marine or coastal ecosystem services.

The practitioner will have to decide if the ecosystem services assessment is needed to undertake a primary valuation exercise for each ecosystem service or if market data and secondary valuation techniques, such as value transfer, are suitable. In the case of desk studies, value transfer is often applied. Value transfer involves taking valuation estimates from primary valuation studies and applying them to an alternative site where one is valuing the same environmental good or service as in the primary study (Norton *et al*., 2012). The lower cost of and relatively shorter time required for such transfer exercises can outweigh the disadvantages of uncertainties or errors associated with the transfer of values from one site to another. Care should be taken to apply a suitable methodology for the ecosystem service. Table A2.2 gives an outline of the various methodologies available for use with marine and coastal ecosystem services.

More and more, policymakers are including nature and the benefits it generates into decision making. An ecosystem services assessment can be a useful tool in helping to improve decision making. It can demonstrate how decisions will affect elements of nature that generate ecosystem services for society.

**Table A2.2. Main methodologies for estimating marine ecosystem service values (adapted from UNEP-WCMC, 2011)**

| Type and methods | Notes | Ecosystem service valued |
|---|---|---|
| Revealed preference methods | Methods based on values for ecosystem services that are "revealed" by behaviour in associated markets. | |
| Market prices | Market prices are rarely equal to values. Prices do not generally reveal the "consumer surplus" (the value to the consumer over and above the price paid). They can also be distorted by taxes and subsidies. | Capture fisheries, aquaculture, algae/seaweed harvesting |
| Production functions | Production functions are statistical models that relate how changes in some ecosystem functions affect production of a marketed good or service. | |
| Avoided costs/replacement costs | Avoided or replacement costs are a measure of the value of a service based on the cost to replace the ecosystem function or service. | Waste services, climate regulation, coastal defence |
| Non-market revealed preference techniques | Methods based on values for ecosystem services that are revealed by behaviour in associated markets. | |
| Travel cost | The travel cost method is used to estimate the value of sites that people travel to (i.e. for recreation) based on the theory that the time taken and travel costs represents the price of access to the site. | Recreational services |
| Hedonic pricing | Hedonic pricing is a statistical modelling technique that estimates the implicit price paid for environmental characteristics of the area or for a pleasing sea view through the variation in the property prices in different areas. | Aesthetic services |
| Stated preference methods | Methods based on surveys in which respondents give valuation responses in hypothetical situations. | |
| Contingent valuation | Contingent valuation is a holistic method of valuing a single change to an environmental good or service where the change is described and the respondent is asked about their WTP/WTA. | Non-use values |
| Choice experiments | Choice experiments estimate values from the choices respondents make between options with different specified attributes of an environmental good. | Non-use values |
| *Other methods* | | |
| Value transfer | A secondary valuation methodology that uses existing value evidence to be applied to new cases without the need for primary valuation studies. | All ecosystem services |
| Point, function and meta-analysis transfer methods | Point value transfer transfers a single value or mean value, which may or may not be adjusted. Function transfer is a function that has be estimated using a primary valuation method. Meta-analysis pools similar primary studies to generate a statistically robust function for use in value transfer. | |

This guide gives an outline of the steps in undertaking an ecosystem services assessment and the issues and challenges that practitioners may be faced with when undertaking such an assessment.

# Appendix 3 Studies Used in Meta-analysis


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**AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL**
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

## Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

**Rialú:** *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

**Eolas:** *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

**Tacaíocht:** *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

## Ár bhFreagrachtaí

### Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

### Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

### Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

### Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

### Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

### Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

### Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

### Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

### Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

### Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

### Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

# EPA Research Report 239

## Valuing Ireland's Coastal, Marine and Estuarine Ecosystem Services

Authors: Daniel Norton, Stephen Hynes and John Boyd

### Identify Pressures

Marine ecosystem services are provided by the processes, functions and structure of the marine environment that directly or indirectly contribute to societal welfare, health and economic activities. Marine ecosystems' ability to continue to deliver services is impacted by human activities taking place in in the coastal zone and on our marine waters. The research highlighted the potential welfare loss to society if the flow of marine ecosystem services is not maintained.

### Inform Policy

Marine ecosystem service valuation is important for the implementation of an integrated ecosystem approach to marine resource management. Those with responsibility for the implementation of policies such as the EU Marine Strategy Framework Directive, the EU Maritime Spatial Planning Directive, the EU 2020 Biodiversity Strategy and the Harnessing Our Ocean Wealth Strategy should also benefit from the information generated in this report. The research presented here is an important first step in incorporating ecosystem service values into policy and decision making related to Ireland's marine and coastal environment

### Develop Solutions

Factoring marine ecosystem service values into national income account frameworks may help to ensure a more sustainable economy for Ireland by making sure that growth in the economy does not exceed the ability of the marine environment to continue to deliver important ecosystem services. The research generated estimates for the quantity and value of provisioning, regulation and maintenance, and cultural marine ecosystem services that should be useful in this regard.

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