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Research Article

Applying Marine and Coastal Ecosystem Accounting in an estuary managed by a Not-for-Profit Organisation: Evidence from Australia

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Abstract

This paper explores the application of the System of Environmental-Economic Accounting - Ecosystem Accounting (SEEA-EA) framework in the Derwent Estuary in Tasmania, Australia, which is managed by a not-for-profit organisation. Following the principles of the SEEA-EA, we constructed a set of ecosystem accounts, inclusive of ecosystem extent (covering the key ecosystems present in the Derwent Estuary), ecosystem condition (seagrass and rocky reef) and associated ecosystem services flows (global climate regulation, fish nursery and recreational fishing) in physical and monetary terms. The ecosystem accounts highlight the importance of ecosystems such as seagrass in providing economic benefits and social well-being at the local level. We also identified significant data gaps for marine and coastal environments, which may limit the ability to implement a full set of ecosystem accounts. However, our case study establishes initial steps for the development of marine and coastal ecosystem accounting (EA) in the

Derwent Estuary, offers recommendations for organisations and government agencies and provides guidance for potential future research.

Keywords

marine and coastal ecosystems, Ecosystem Accounting, not-for-profit organisations, Environmental-Economic Accounting

Introduction

Covering more than two-thirds of the Earth's surface, marine and coastal ecosystems have long been important to human beings for food, shelter, employment and recreation (Cummins et al. 2023). In fact, marine and coastal resources provide livelihoods for hundreds of millions of people and contribute to the global economy around US$1.5 trillion in 2010 and US$3 trillion in 2030 (Rayner et al. 2019). However, marine and coastal ecosystems worldwide are rapidly declining, due to the combined effects of climate change and other anthropogenic drivers such as pollution, ovefishing and coastal development (Talukder et al. 2022).

To better manage these ecosystems, it is crucial to account for their condition and value to improve the decision-making in marine management (Cummins et al. 2023). Several accounting frameworks have been developed to monitor and record ecosystems. Amongst these, the SEEA-EA framework has been mostly applied since it is the only accounting framework that contains both biophysical and economic accounts consistent with the System of National Accounts (SNA) (Comte et al. 2022). As such, through this framework, environmental and economic data on ecosystems are organised and systematically presented to provide information for decision-making at various levels, including government agencies, industries and not-for-profit organisations (NFPOs) (Edens et al. 2022). For instance, national-level accounts support the economic arguments needed to allocate funds to nature-based solutions (King et al. 2024). At organisational level, ecosystem accounts enable businesses, landowner and site manager understand the risks from deterioration of natural capital to improve environmental monitoring and management (Gorman et al. 2024).

Since its introduction, most research on the SEEA-EA framework has primarily focused on terrestrial ecosystems, such as forests and woodlands, with limited attention paid to marine and coastal environments (Comte et al. 2022). In addition, most studies seek to produce ecosystem accounts using the SEEA-EA (for example, Mengo et al. 2022, Cardona et al. 2023). Even though the implementation of the SEEA-EA is adaptable to different levels and purposes (United Nations 2024), relatively little is known about how ecosystem accounts can be developed across specific sectors, including public, private and not-for-profit sectors. There have been calls in the literature for a broader application of EA, emphasising the need to connect EA more closely with its users (Vardon et al. 2019, Comte et al. 2022). Hence, the present study seeks to fill these gaps by providing empirical evidence on the application of the SEEA-EA to an estuary managed by the Derwent Estuary Program (DEP) - a conservation not-for-profit organisation (NFPO) in Tasmania, Australia. Conservation NFPOs, which operate at local, national and international levels, are dedicated to protecting and conserving ecologically important ecosystems and vulnerable species. In regard to the case organisation, it was established in 1999 as a regional partnership between state and local government, industries, scientists and the community to support the restoration and protection of the Derwent Estuary (DEP 2022). Its mission is to provide information to support decision-making about the Estuary and to serve as the voice of the Derwent Estuary. The organisation's key role is to coordinate and support ecological monitoring activities, engage with key stakeholders and report on the health of the Derwent Estuary to partners and the public (DEP 2022). As such, this study aims to examine the process of developing EA in the not-for-profit sector and to suggest opportunities for future research.

Australia's marine and coastal habitats are the focus of this study for two reasons. First, Australia is an island continent ranked as the third-largest marine jurisdiction on the Planet (OPSAG 2013). Marine-based industries (e.g. tourism, fishing, ports, shipping and boat-building) are major contributors to the Australian Gross Domestic Product (GDP) by generating more than $118 billion each year and supporting 462,000 jobs (AIMS 2023). Yet, many Australian coastal ecosystems have been extensively degraded (Laubenstein et al. 2023). Second, as a global leader in sustainable ocean management, Australia has committed to sustainably managing 100 percent of its ocean area by 2025 and fostering a thriving ocean economy by 2050 (Australian Government 2022). By 2025, the Australian Government will have invested $10.8 million to improve ocean and marine park management in Australia, more than $500 million to support ocean adaptation and resilience; and successfully developed the Sustainable Ocean Plan (Australian Government 2025). Regarding ocean accounting, the Australian government has prioritised implementing an internationally recognised ocean accounting framework, developing ocean ecosystem accounts and tracking national performance, based on these accounts (Australian Government 2025). Therefore, this study not only supports decision-making to address the declining health of marine and coastal habitats in Australia, but also aligns the Australian Government's commitments to sustainable ocean management.

The remainder of this paper is structured as follows: first, an overview of the SEEA-EA framework is presented. This is followed by a literature review of marine and coastal EA. Next, the research methodology is outlined, then the EA tables and their descriptions are illustrated. The paper concludes with a discussion of the research findings and their implications, followed by the conclusion.

The SEEA-EA framework

The SEEA-EA is a coherent framework for integrating information on ecosystem assets and their service flows with information on economic and other human activities of the associated beneficiaries such as households, businesses and governments (United

Nations 2024). The SEEA-EA framework comprises five inter-related types of ecosystem accounts, as illustrated in Fig. 1: (1) ecosystem extent accounts, which record the total area of all ecosystem types within an EA area and the changes in each ecosystem type; (2) ecosystem condition accounts, which record the condition of ecosystem types, based on selected characteristics at specific points in time; (3) ecosystem services accounts (physical terms), which record the flows of final ecosystem services supplied by ecosystem assets and used by economic units during an accounting period and also allow for the recording of intermediate services flows between ecosystem assets; (4) ecosystem service accounts (monetary terms), which record the monetary value of ecosystem service flows. The monetary valuation of ecosystem services commonly involves estimating unit prices for each service and multiplying them by the corresponding physical quantity recorded in the ecosystem services flow account; (5) monetary ecosystem asset accounts, which record the net present value of all ecosystem services provided by an ecosystem asset (United Nations 2024). Fig. 1 provides a diagrammatic representation of the ways in which all five accounts are interconnected, illustrating how a change in an ecosystem's extent or condition can impact the flow of services and, consequently, the total value of that ecosystem's assets.

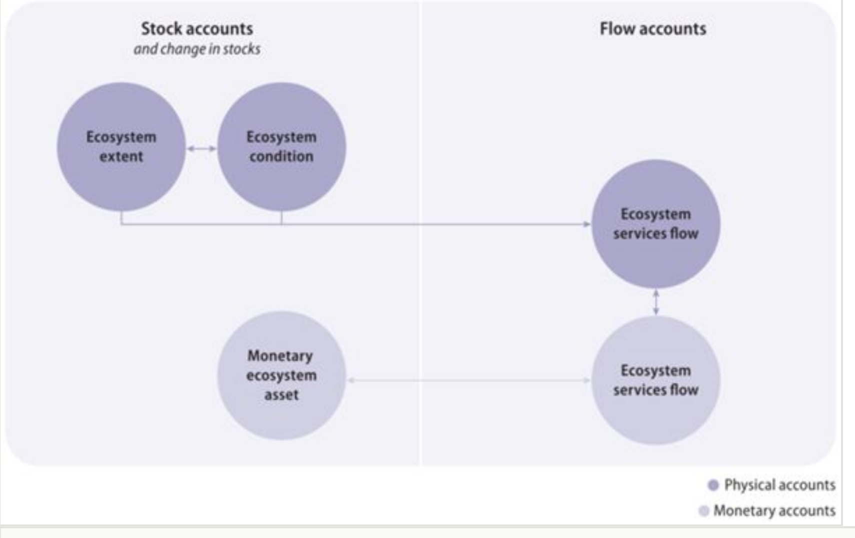

Figure 1.

Relationship between ecosystem accounts (United Nations 2024).

The next section will summarise the current application of the SEEA-EA framework in the marine and coastal ecosystem context.

Literature review

Transparent and systematic information on the current state of ecosystems is needed to better manage them (Comte et al. 2022, Loureiro et al. 2023). As a result, EA research has gained significant attention from government agencies and the scientific community. As stressed by many scholars (Vardon et al. 2016, Ogilvy et al. 2022, Chen et al. 2023), a common practice in EA literature is to produce accounts based on currently available data on the ecosystems of interest. In the realm of marine and coastal ecosystems, many of EA initiatives are driven by government agencies or supported by international partnerships. The Global Ocean Accounts Partnership (GOAP), a multi-stakeholder initiative, supports a variety of pilot projects worldwide, demonstrating the application of ocean accounting frameworks across diverse contexts (GOAP 2025). For instance, Indonesia has implemented ocean accounts in the Gili Matra Marine Protected Area, focusing on ecosystem extent, ecosystem services and ocean governance. The Government of the Maldives is developing ecosystem accounts using the SEEA-EA framework in Laamu Atoll, an ecologically and economically important area in Maldives. Complementing these government-led efforts, numerous scientific studies have also applied the SEEA-EA (formerly the SEEA- Experimental EA), with most focusing on EA at the local or regional scale. For instance, Cardona et al. (2023) examined an estuarine wetland in Colombia, while Dvarskas (2019) studied Long Island coastal bays in the United States and Farrell et al. (2021) focused on the Dargle catchment in Ireland. A few studies have addressed ecosystem accounting at the national level, such as those examining coastal active sand dunes in New Zealand (Ryan et al. 2023), marine ecosystems in Finland (Virtanen et al. 2024) and marine and coastal habitats in Grenada – a tri-island country in the eastern Caribbean (Mengo et al. 2022).

In Australia, several marine and coastal EA studies have been identified through a review of the academic literature articles and the 'grey literature' (i.e. government and industry reports). At regional and local scales, examples include studies on Geographe Marine Park in Western Australia (IDEEA Group 2020); Port Philip Bay in Victoria (Eigenraam et al. 2016); Tomago wetland (Glamore et al. 2024) and Lake Illawarra (Gacutan et al. 2022) in New South Wales; and Mitchell River (Smart et al. 2022) and the Great Barrier Reef (ABS 2014, ABS 2017) in Queensland. At the national level, in 2022, the Australian Bureau of Statistics published three national ocean ecosystem accounts for mangroves, seagrasses and saltmarshes, which included their extent and condition as well as the monetary value of their ecosystem services (Australian Government 2022).

Overall, most studies agree that the SEEA-EA framework is effective for monitoring ecosystem quantity and quality. However, many of these studies have been unable to present a full set of ecosystem accounts due to data limitations. For instance, some studies lack condition data (Eigenraam et al. 2016, Gacutan et al. 2022), while others face a lack of time series data for ecosystem extent accounts (Mengo et al. 2022) or insufficient data on ecosystem services (Farrell et al. 2021, Ryan et al. 2023). Since EA comprises a set of interconnected accounts, missing information results in incomplete representation of ecosystems and under-utilisation of the accounting framework.

An emerging research stream is exploring the potential application of EA in different institutional settings. This trend in literature is also supported by Comte et al. (2022) who reviewed 378 scientific articles published between 1990 and 2021 on ecosystem accounting. In particular, Comte et al. (2022) emphasise the need to link ecosystem accounting to a broader range of stakeholders, including NFPOs, government agencies and industries. Additionally, Vardon et al. (2019) argue that a lack of thorough understanding of EA amongst decision-makers has hindered its limited implementation. These authors call for more research to bridge this knowledge gap through practical examples or case studies. Research that connects EA with its users not only helps them understand the value of the framework, but also encourages them to adopt it. Most studies in this area focus on policy-makers by exploring how ecosystem accounts can provide information for policy decisions in the areas of land planning (Chen et al. 2023), biodiversity conservation (Coates et al. 2020) and finance and macroeconomic policies (Vardon et al. 2023). For marine environments, EA could support more informed decision-making by highlighting trade-offs between resource use and ecosystem health. This is particularly valuable for Marine Spatial Planning (MSP) and Marine Protected Areas (MPAs) that guide human activities in marine ecosystems and aim to balance development needs with conservation goals (Cavalletti et al. 2020, Gacutan et al. 2022b, GOAP 2022). For instance, environmental data on ecosystem extent and condition can help track the progress of conservation efforts and support marine planning objectives (GOAP 2022). In parallel, the economic valuation of marine-related services — such as recreational fishing and tourism — can guide decisions that promote sustainable economic development within MSP (GOAP 2022). EA can also serve as a valuable management tool for MPA managers by capturing the full range of values generated by MPAs and highlighting the environment's contribution to human activities (Cavalletti et al. 2020).

A few studies have examined private sector application. For example, Ingram et al. (2022) identified opportunities for businesses to use the SEEA-EA framework and Ogilvy et al. (2022) tested EA within two wool-producing businesses in Australia. The role of EA in the not-for-profit sector remains under-studied. The current study addresses this research gap by examining the application of the SEEA-EA by a conservation NFPO in Australia. The SEEA-EA implementation has often been led by the official statistics community aiming to complement traditional output estimates, based on the SNA production boundary with measurements of ecosystem services (United Nations 2024). However, many other agencies still play a role in implementing the SEEA-EA. For instance, NFPOs play a critical role in biodiversity conservation and management (Cuckston 2018) and their adoption of the SEEA-EA could further support their efforts to address biodiversity decline. Our case organisation (DEP) has a mission to conduct scientific research to monitor the ecosystems. Therefore, by implementing the SEEA-EA, the organisation can better understand the relationship between the environment and the economy, helping them to make more informed decisions about natural resource management. By exploring how the SEEA-EA framework can be applied in NFPOs, this study contributes to the growing literature on EA in different institutional contexts.

Methodology

Ecosystem Accounting Area

The Derwent Estuary, situated in southern Tasmania, Australia, is a waterway of great natural beauty and diversity. The Estuary covers an area of 198 km^2 extending from New Norfolk to the mouth which lies between Tinderbox and the Iron Pot light (DEP 2020). As of the 2022 census, the councils bordering the Estuary were home to approximately 43% of Tasmania's population — 221,000 people. The Derwent Estuary has played a vital role in Tasmania's cultural, economic and natural heritage (DEP 2022). It is a key source of the region's drinking water and hydroelectric power. Additionally, it supports recreation, boating, fishing, marine transport and industrial production. It also sustains diverse ecosystems and species.

The Derwent Estuary is typically divided into three functional zones – upper, middle and lower – which are distinguished by their physical, chemical and biological conditions (DEP 2015; Fig. 2). These zones provide a useful framework for assessing ecosystem services and environmental changes across the Estuary's varied landscapes.

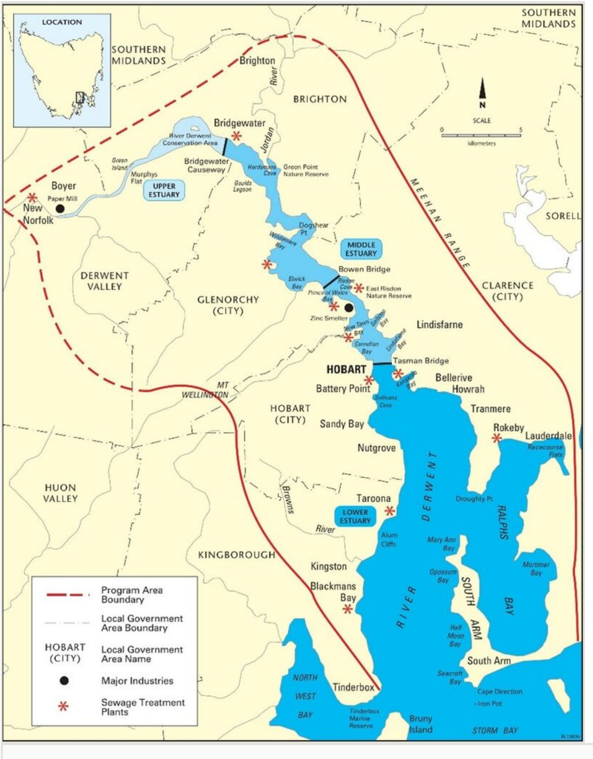

Figure 2.

Map of the Derwent Estuary with Local Government Area (LGA) boundaries and labelled functional zones (upper, mid- and lower Estuary).*[1]

Data compilation strategy

The SEEA-EA framework (see Fig. 1) was used to guide the compilation of accounting tables. Environmental and socio-economic data on ecosystem extent, condition and services were gathered from the DEP, government reports and the scientific literature. Table 1 outlines the type and source of data used for each ecosystem account.

Table 1.

Data and information used in this study.

SEEA-EA accounts	Indicator	Measurement unit	Years available	Data source
Ecosystem extent accounts	Area	Hectare (ha)	2007	Lucieer et al. (2007)
Seagrass condition account	Percentage of seagrass, bare sediment and algae coverage	Score (0-1)	2016-2019	Seagrass monitoring project of DEP
Rocky reef condition account	Fish species diversity and abundance; Invertebrate species diversity and abundance; Algal species diversity	Index (0-1)	2010	Barrett et al. (2012)
Global climate regulation service account	Carbon storage Carbon sequestration	Tonnes CO2, $ Tonnes CO2, $	2019	Serrano et al. (2019)
Recreational fishing service account	Annual consumer expenditure of recreational fishers	Number of fishers, $	2013-2018	Lyle et al. (2014), Lyle et al. (2019)
Fish nursery service account	Fish enhancement	kilogram (kg), $	2019	Jänes et al. (2020)

Ecosystem extent accounts

The Derwent Estuary supports a diverse range of ecosystems across both tidal and subtidal environments. The extent of each ecosystem for the Derwent Estuary is publicly available in the *Derwent Estuary Habitat Atlas* (DEP 2009), which was developed using data primarily from Lucieer et al. (2007). The Atlas provides one-off observations of habitat extent.

Ecosystem condition accounts

Monitoring estuarine ecosystems is costly and usually infrequent, often with long intervals between monitoring exercises (Testa et al. 2017). As a result, the information available for systematic reporting on the changing condition of ecosystems over time can be limited. The DEP has monitored the condition for seagrass, rocky reefs and saltmarsh ecosystems (DEP 2020). Although the available saltmarsh data include biotic indicators, such as plant and bird species diversity, the data are highly variable between individual saltmarshes and it is not linked to human pressures or to key abiotic, functional and landscape characteristics for a comprehensive condition assessment. Consequently, saltmarsh condition data were not deemed useful for deriving condition metrics and was excluded. The condition indicators used are outlined in Table 2.They correspond to the SEEA Ecosystem Condition Typology (ECT) Group B Biotic characteristics, Class B2 structural state for seagrass and class B1 compositional state for rocky reefs (United Nations 2024).

Table 2.

Condition indicators of seagrass and rocky reef adapted to the ecosystem condition typology class (SEEA ECT).

		Rocky reef		**Seagrass**	
SEEA Ecosystem Condition Typology Class		**Variable descriptor**	**Measurement unit**	**Variable descripter**	**Measurement unit**
Group B: Biotic ecosystem characteristics	B1- Compositional state	Fish species abundance	Score (0-1)	*No variable selected*	
		Fish species diversity	Score (0-1)	*No variable selected*	
		Invertebrate & cryptic abundance	Score (0-1)	*No variable selected*	
		Invertebrate & cryptic fish species diversity	Score (0-1)	*No variable selected*	
		Algal species diversity	Score (0-1)	*No variable selected*	
	B2- Structural state	*No variable selected*		Seagrass cover	Score (0-1) Number
		No variable selected		Bare sediment cover	Score (0-1)
		No variable selected		Algae cover	Score (0-1)

- *Seagrass*

Seagrasses in the upper and middle estuary (480 ha) have been monitored since 2015 due to their high ecological value (DEP 2022). Seagrass meadows are monitored at four sites (Murphys Flat, Dromedary Marsh, Granton Banks and Jordan River), multiple times a year to account for seasonal variability. However, condition assessments are not undertaken for the smaller patches of seagrass in the mid- to lower estuary. At each site, condition is assessed using photo-quadrat images, which are analysed to determine the percentage cover of seagrass, algae and bare sediment. Seagrass condition is measured as the percentage cover of seagrass, while the percentage cover of sediment and algae are also included as indicators of environmental stressors. It is important to note that, in this case study, the term ‘seagrass’ is a general term referring to aquatic macrophytes and seagrass meadows. *[2]

For this study, seagrass condition indicators for each year were calculated by averaging the percentage cover values across the four monitoring sites. These values were converted into decimal form (ranging from 0 to 1) for consistency with the SEEA-EA framework (United Nations 2024).

- *Rocky reef*

Condition data for rocky reefs in the Derwent Estuary are available in two studies, Barrett et al. (2012) and White and Brasier (2021), both representing the entire Estuary. However, these studies differ in research purpose and methodology, resulting in different condition indicators of rocky reefs. To maintain consistency, this case study used only the study of Barrett et al. (2012) to generate the rocky reef condition account at one data point.

Specifically, Barrett et al. (2012) conducted a quantitative assessment of rocky reef biodiversity in the Derwent Estuary, providing a baseline for its condition. The survey covered 27 sites using a standard belt transect methodology developed by the Reef Life Survey to monitor reefs across Australia to document biological diversity and abundance. In this case study, rocky reef condition is assessed, based on the diversity and abundance of fish, invertebrate and algal species.

As suggested by United Nations (2024), rocky reef condition indicators were normalised to an index ranging from 0 to 1 by applying a linear transformation, as shown in the following formula:

$$I = (V - VL) / (VH - VL),$$

where I is the value of the indicator, V is the value of the variable, VH is the value of the condition variable relating to the highest point of the indicator scale and VL is the value of the variable relating to the lowest point of the indicator scale. This approach enables the comparison of indicators on a common scale, with a value of 1 representing the best achievable condition.

Following normalisation, values from 27 monitoring sites were aggregated by averaging them within two zones: the Middle Estuary and the Lower Estuary. The overall index for the accounting period represents the average of these two zones.

Ecosystem services physical and monetary accounts

Table 3 provides a quick overview of various ecosystem services typically provided by key estuarine ecosystems globally. The classification in the first and second column is adapted from United Nations (2024). The information relating to ecosystems and their associated services is adapted from the literature (Barbier et al. 2011, Xu et al. 2020, Eger et al. 2023).

In this study, we focused on ecosystem services for which sufficient information was available for the Derwent Estuary. These include regulating and maintenance services (global climate regulation and fish nursery) and cultural services (recreational fishing) (See Table 1). The fish nursery and global climate regulation services are provided from the seagrass, whereas recreational fishing service is a service provided by the Derwent Estuary as a whole ecosystem. Table 4 describes relevant components of the ecosystem services included in this study, adapted from United Nations (2024).

Table 3.

Key estuarine ecosystems and their associated services.

Ecosystem services		**Key estuarine ecosystems**						
		Coral / Rocky reefs	Seagrasses	Salt marshes	Mangroves	Sand beaches & dunes	Kelp forest	Wetlands
Provisioning services	*Raw materials & food*	✓	✓	✓	✓	✓	✓	✓
Regulating & maintenance services	*Global climate regulation*		✓	✓	✓	✓	✓	✓
	Fish nursery		✓	✓	✓		✓	✓
	Coastal protection	✓	✓	✓		✓		✓
	Erosion control		✓	✓	✓			
	Nutrient cycling	✓				✓		
	Water purification			✓	✓	✓		✓
Cultural services	*Tourism, recreation, education and research*	✓	✓	✓	✓	✓		✓

To enhance the reliability and appropriateness of the ecosystem services physical and monetary accounts, we used data from studies conducted either in Tasmania or in areas biophysically and socioeconomically similar to Tasmania. Specifically, the estimates for the global climate regulation service pertain to Tasmania, while those for recreational fishing are specific to the Derwent Estuary. Due to the absence of Tasmanian estimates for fish nursery service, this study adopted estimates for Australia from Jänes et al. (2020) . This approach, known as the ‘benefit transfer method’, applies estimates of ecosystem service quantity or value from one site to another, similar site (Plummer 2009). The method is widely used in economic valuation of environmental benefits where no local data are available and time or budget constraints prevent its collection. While its application in EA has been limited, it is a growing area of research (Grammatikopoulou et al. 2023). In this study, use the unit value transfer approach recommended by the SEEA-EA for cases where primary data are available from the country for which the accounts apply (United Nations 2024). Below, we provide detailed descriptions of each ecosystem service included in this study.

Table 4.

Logic chains for the Derwent Estuary's ecosystem services included in this study.

	Ecosystem Service	Ecosystems	Factors determining supply		Factors determining use	Physical metrics	Benefits	Beneficiaries
			Ecological	Societal				
Regulating and maintenance services	Global climate regulation services	Derwent estuarine ecosystems	Ecosystem extent and condition	Ecosystem management; GHG emissions	Vulnerability to climate change (exposure, sensitivity and adaptive capacity)	Tonnes of carbon sequestered & stored	Reduced concentrations of GHG in the atmosphere leading to less climate change and fewer adverse effects	Collectively consumed by individuals, households and businesses globally
	Nursery population and habitat maintenance services	Derwent estuarine ecosystems	Ecosystem extent and condition, including species diversity and abundance	Ecosystem management	Demand for recreational fishing	Size of biomass stocks	Continuing supply of fish stock and maintainance of ecosystem health	Recreational fishers and ultimately all of society
Cultural services	Recreational fishing	Derwent estuarine ecosystems	Ecosystem extent and condition, presence of fish stocks	Ecosystem management including facilities to support access to estuary	Proximity of access sites, demand for recreational fishing	Number of recreational fishers	Physical and mental health, enjoyment	Recreational fishers (households), tourism and outdoor leisure service sectors

Cultural services- Recreational fishing

Cultural services refer to '*the experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contributes to a range of cultural benefits*' (United Nations 2024, p. 145). We estimated the monetary value of cultural services associated with recreational fishing in this case study. Fishing can involve a combination of catching, processing, selling of fish, shellfish or other aquatic species and is classified as either commercial or recreational (Pawson et al. 2008). Since commercial fishing is limited in the Derwent Estuary, this study focused solely on the economic value of recreational fishing.

Recreational fishing is defined as '*the leisure-related uses of coastal fish resources*' (Terashima et al. 2020, p. 925). Nature-based recreation activities are complex ecosystem services that provide multiple benefits, which are often difficult to separate (Pelletier et al. 2021). This is further supported by Lyle et al. (2019), who found that, for most recreational anglers in Tasmania, the non-catch benefits of fishing — such as relaxation, social interactions and engagement with nature — are more important than actually catching or consuming fish. Notably, 94% of fishing trips were reported as satisfying, regardless of whether any fish were caught (Lyle et al. 2019). This highlights the cultural and social significance of recreational fishing in Tasmania (Lyle et al. 2019). To value recreational fishing, this study relied on data from Lyle et al. (2014) and Lyle et al. (2019), two Tasmanian surveys that collected information on annual consumer expenditures by recreational fishers in the year 2013 and 2018. These studies reported that the average annual expenditure per recreational fisher was $1,008 in 2013 and $1,787 in 2018, with a total of 9,557 recreational fishers in 2013 and 6,961 in 2018 in the Derwent Estuary.

Regulating and maintenance services

Regulating and maintenance services are services '*resulting from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles and thereby maintain environmental conditions beneficial to individuals and society*' (United Nations 2024, p. 145). In this case study, we evaluated the fish nursery and global climate regulation services.

· <u>Fish nursery service</u>

Fish nursery service refers to the service that provides habitat for fish reproduction, survival and growth (Jänes et al. 2020). This service is regarded as an intermediate ecosystem service as it supports the final ecosystem services including commercial fishing and recreational fishing.

Coastal ecosystems such as seagrass have been widely recognised for providing fish nursery services (Jänes et al. 2020). Thus, we estimated the monetary value of fish nursery services, based on the extent of seagrass. Since no local data on fish nursery services in Tasmania are available, this study applied the benefit transfer method from Jänes et al. (2020), which assessed nursery services across four Australian States (New South Wales, Victoria, Queensland and South Australia). We used the unit value transfer method, where an estimate of the monetary value of an ecosystem service per hectare is used to estimate the value of the same ecosystem service in another location (United Nations 2024; para 9.81). We estimate this approach to be appropriate due to the geographic proximity of the sites, which results in very similar ecosystem characteristics, market conditions and socio-economic factors. The findings of Jänes et al. (2020) indicate that: One hectare of seagrass supports 55,589 additional individual fish (equal to 4,064 kg of biomass enhancement), valued at $21,276 per hectare annually.

· <u>Global climate regulation</u>

Global climate regulation services are '*the ecosystem contributions to reducing concentrations of GHG in the atmosphere through the removal (sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems*' (United Nations 2024, p. 146). In this case study, we estimated the value the global climate regulation sevices provided by seagrass in the Derwent Estuary.

To calculate the physical quantity of carbon sequestered and stored, we used the rate published by Serrano et al. (2019), who reviewed carbon storage and sequestration data for coastal ecosystems across Australian climate regions. Tasmania is classified as a temperate climate region, so we used the tempearte regions data from Serrano et al. 2019 as shown in Table 5.

Table 5.

Carbon stock and carbon sequestration rates for temperate seagrass from Serrano et al. (2019).

Carbon stock and carbon sequestration rates	**Seagrass**
Carbon Stock - Above ground biomass (Mg C ha^{-1})	0.27
Carbon Stock- Soil (Mg C ha^{-1} in 1 m-thick)	113
Total carbon stock (Mg C ha^{-1})	113.27
Carbon sequestration rates (Mg C ha^{-1} yr^{-1})	0.5

To estimate the monetary value of carbon sequestration and storage, we applied the Australian Carbon Credit Unit (ACCU) valuation method. The ACCU is issued by the Clean Energy Regulator, an Australian Government agency responsible for carbon abatement initiatives. One ACCU represents one tonne of carbon dioxide (CO_2) stored or avoided and it can be traded on the national carbon market. This valuation is aligned with the exchange value principle proposed in the SEEA-EA framework. We applied the ACCU spot price of $33.75 per tonne of carbon, as observed at the time of analysis in December 2023 (Clean Energy Regulator 2023).

Results

This section presents the ecosystem accounts in both accounting tables and narrative explanation.

Ecosystem extent accounts

The ecosystem extent accounts describe the major ecosystems found in the Derwent Estuary. Table 6 summarises the extent for each ecosystem account type for the year 2007.

Table 6.

Estuarine ecosystem asset accounts for the year 2007.

Ecosystem type	**Extent (hectares)**
Sand and silt	17060
Sand flat and beach	1140
Seagrass	680

Ecosystem type	Extent (hectares)
Rocky reef	300
Saltmarsh	220
Wetland	130
Unvegetated mud flat	100
Rocky shorelines	90
Cobble reef	30
Kelp forest	30
Total	**19780**

Amongst these ecosystems, sand and silt are the most abundant, covering approximately 17,060 hectares of the Estuary accounting area. The next most abundant ecosystem is sand flat and beach (1,140 hectares, primarily in the lower Estuary), followed by seagrass (680 hectares), rocky reef (300 hectares, scattered throughout the Estuary) and saltmarsh (220 hectares, also scattered across the Estuary). Other ecosystem types - including wetland, cobble reef, kelp forest, mudflats and rocky shorelines - occupy the remaining 380 hectares of the Estuary. Figs 3, 4, 5 illustrates the spatial distribution of these ecosystems across the upper, middle and lower zones of the Estuary, respectively.

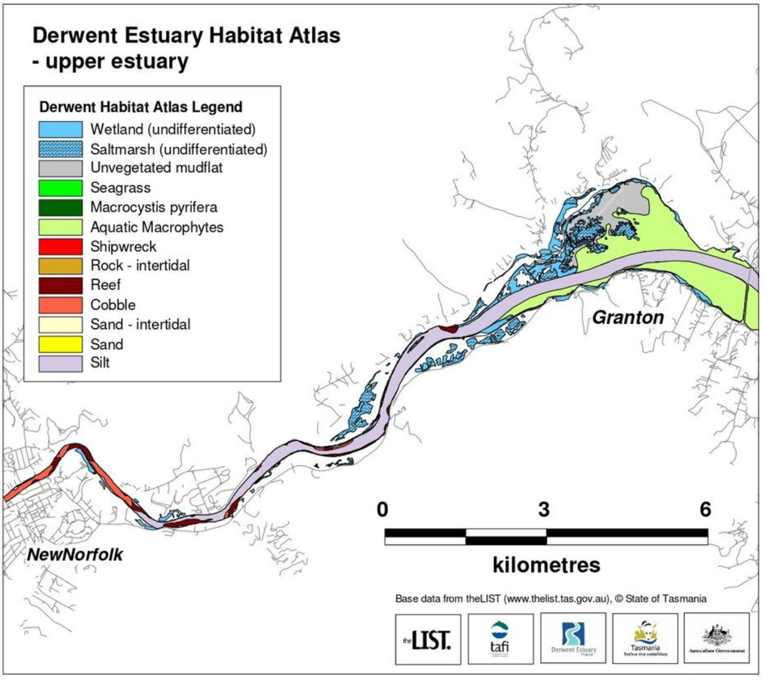

Figure 3.

Distribution of ecosystem types in the Upper Derwent Estuary (Source: DEP 2015).

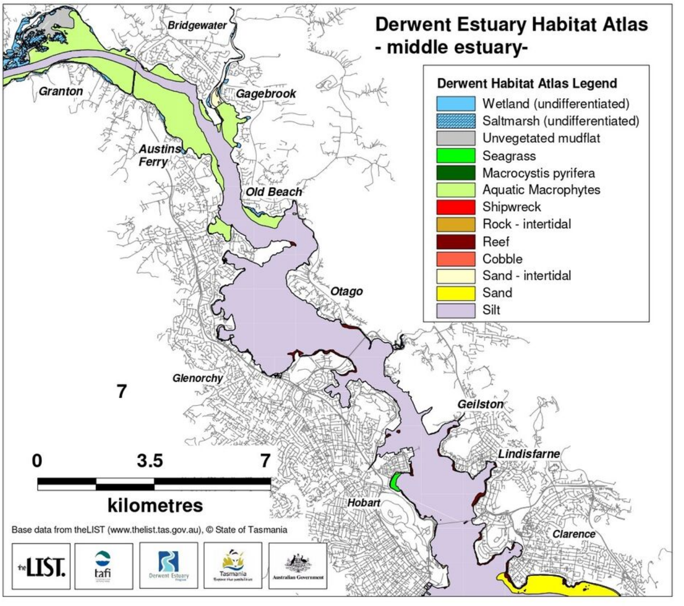

Figure 4.

Distribution of ecosystem types in the Middle Derwent Estuary (Source: DEP 2015).

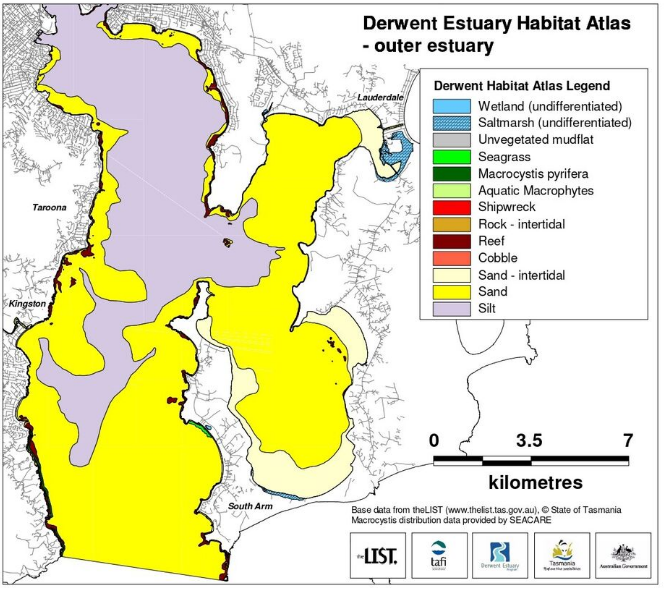

Figure 5.

Distribution of ecosystem types in the Lower Derwent Estuary (Source: DEP 2015).

Ecosystem condition accounts: seagrass and rocky reef

Seagrass condition

Table 7 presents the seagrass condition account in the Derwent Estuary from 2016 to 2019, with a detailed explanation of calculation provided in Suppl. material 1. Although data were collected annually, only the opening (2016) and closing (2019) years are shown, in alignment with SEEA-EA presentation guidelines. Seagrass condition is measured by seagrass percentage cover (seagrass cover). A good condition is represented by high seagrass cover and low algae and sediment cover. Poor condition is represented by high cover of algae and/or sediment cover and low seagrass cover. An increase in bare sediment cover signals dieback events and poor condition, while a decrease suggests seagrass recovery.

Table 7.

Ecosystem condition account for seagrass ecosystems in the Derwent Estuary from 2016 to 2019.

SEEA ECT Class	Variables		Seagrass		
	Descriptor	Measurement unit	Opening value	Closing value	Change
Structural state	Seagrass cover	Score (0-1)	0.11	0.67	0.56
	Bare sediment cover	Score (0-1)	0.35	0.2	-0.15
	Algae cover	Score (0-1)	0.53	0.14	-0.39

In 2016 (opening condition), seagrass condition was very poor, characterised by low seagrass cover (0.1), moderate bare sediment cover (0.35) and high algae cover (0.53). By 2019 (closing condition), seagrass condition had significantly improved, with high seagrass cover (0.67) and reduced algae cover (0.1). The poor condition observed in 2016 was likely driven by anthropogenic pressures, including high nutrient loading and low river discharge (DEP 2020). River discharge refers to the volume of water flowing through the river, while nutrient loading represents the amount of nutrients and pollutants entering the system. The increased seagrass coverage in 2019 highlights its capacity to recover from stressors such as algal smothering and dieback, as well as the high variability of seagrass conditions from year to year in the Derwent Estuary.

One of the major challenges in producing ecosystem service accounts is the lack of time-series data on ecosystem extent. Time-series data on ecosystem extent is crucial for measuring the changes in ecosystem services (United Nations 2024). As suggested by Houdet et al. (2020), ecosystem condition indicators can serve as proxies to reflect changes in ecosystem extent and, subsequently, ecosystem services. To address the absence of time series data for seagrass extent, we applied a novel approach that adjusted seagrass extent based on the bare sediment condition indicator. Amongst the available condition indicators, percentage cover of bare sediment seemed the most reliable indicator of reduced seagrass coverage, as it better reflects changes in seagrass density and, consequently, ecosystem service capacity. Seagrass extent for the opening and closing balance was adjusted using the following equation: original extent*(1-bare sediment presence). The original extent refers to the recorded seagrass area of 680 hectares. Table 8 shows the adjusted seagrass extent data, which increased from 442 hectares in 2016 to 544 hectares in 2019.

Table 8.

Adjusted ecosystem extent account of seagrass ecosystems from 2016 to 2019.

Ecosystem type	**Opening value (hectares)**	**Closing value (hectares)**
Seagrass	442	544

Rocky reef condition

Suppl. material 2 presents the calculation of the rocky reef ecosystem condition in the Derwent Estuary for the year 2010. Table 9 summarises the rocky reef condition account in 2010. Due to the lack of appropriate physical and monetary valuation methods, rocky reef condition metrics were not integrated into the ecosystem accounts, but are included here for demonstration purposes.

Table 9.

Condition account for rocky reef in the Derwent Estuary for the year 2010.

SEEA ECT Class	Variables		Rocky reef		
	Descriptor	Measurement unit	Middle Estuary	Lower Estuary	Total Accounting Area
Compositional state	Fish species abundance	Score (0-1)	0.38	0.17	0.28
	Fish species diversity	Score (0-1)	0.1	0.58	0.34
	Invertebrate & cryptic abundance	Score (0-1)	0.25	0.51	0.38
	Invertebrate & cryptic fish species diversity	Score (0-1)	0.16	0.54	0.35
	Algal species diversity	Score (0-1)	0.08	0.54	0.31

Condition indices were applied to two of the Derwent Estuary's functional zones (middle and lower) as intra-zonal differences are of particular interest to the DEP. In 2010, species diversity — including fish, invertebrates, cryptic fish and algae — as well as invertebrate and cryptic fish abundance, were highest in the lower Estuary. The only exception was fish abundance, which peaked in the middle Estuary. Overall, rocky reef condition appeared better in the lower Estuary compared to the middle Estuary.

Ecosystem services accounts

This section presents the accounts of three ecosystem services: global climate regulation, recreational fishing and fish nursery. Suppl. material 3 explains the calculation of ecosystem services accounts in both physical and monetary terms.

Global climate regulation account

Table 10 shows the accounts for the global climate regulation provided by seagrass in both physical and monetary terms.

Table 10.

Global climate regulation service physical and monetary accounts provided by seagrass from 2016-2019.

	Accounting entry	Units	Carbon sequestration	Carbon retention
Physical term	Opening stock	tonnes	811	183,740
	Addition to stock		187	42,401
	Reduction to stock			
	Net change in stock		187	42,401
	Closing stock		998	226,141
Monetary terms	Opening stock	A$	27,374	6,201,218
	Addition to stock		6,317	1,431,050
	Reduction to stock			
	Net change in stock		6,317	1,431,050
	Closing stock		33,691	7,632,269

During 2016-2019, there is an increase in seagrass extent due to its change in condition, which led to an increase in its capacity to provide climate change mitigation. In particular, seagrass stored approximately 183,740 tonnes of CO_2 in soil and biomass, which is equivalent to $6,201,218 in monetary terms in 2016, whereas in the year 2019, these figures were 226,141 tonnes of CO_2 and $7,632,269 in dollar value. With carbon sequestration, in 2016, seagrass sequestered approximately 811 tonnes of CO_2 which contributed to an annual value of A$27,374, whereas, for the year 2019, it was 998 tonnes of CO_2 and A$33,691 in monetary value, respectively.

Recreational fishing account

Table 11 shows the accounts for the recreational fishing service provided by seagrass in the Derwent Estuary in both physical and monetary terms from 2013 to 2018. On average, during this period, approximately 9,557 and 6,961 recreational fishers participated annually in the Derwent Estuary, respectively, with total annual consumer expenditure estimated at A$9,633,456 and A$12,439,307.

Table 11.

Recreational fishing service physical and monetary accounts in the Derwent Estuary from 2013 to 2018.

	Accounting entry	Units	Recreational fishing
Physical term	Opening stock	Number of fishers	9,557
	Addition to stock		
	Reduction to stock		-2,596
	Net change in stock		-2,596
	Closing stock		6,961
Monetary terms	Opening stock	Fishers' annual consumer expenditure (A$)	9,633,456
	Addition to stock		2,805,851
	Reduction to stock		
	Net change in stock		2,805,851
	Closing stock		12,439,307

Fish nursery account

Table 12 shows the physical and monetary accounts for the fish nursery service provided by seagrass.

Table 12.

Fish nursery service physical and monetary accounts provided by seagrass from 2016 to 2019.

	Accounting entry	Units	Fish nursery
Physical term	Opening stock	Fish biomass enhancement (kg)	1,796,288
	Addition to stock		414,528
	Reduction to stock		
	Net change in stock		414,528
	Closing stock		2,210,816
Monetary terms	Opening stock	Value of fish biomass enhancement (A$)	9,403,992
	Addition to stock		2,170,152
	Reduction to stock		
	Net change in stock		2,170,152
	Closing stock		11,574,144

During 2016-2019, there was an increase in seagrass extent due to its change in condition, which led to an increase in fish biomass enhancement provided by seagrass. Seagrass in the Estuary provided approximately 1,796 tonnes of fish biomass with a value of A$9,403,992 in 2016 and 2,211 tonnes of fish biomass with a value of A$11,574,144 in 2019.

Discussion and recommendation

Insights from the application of the SEEA-EA framework

This study demonstrates the feasibility of applying the SEEA-EA framework to marine and coastal ecosystems, even under data-limited conditions. By compiling ecosystem extent, condition and service accounts for the Derwent Estuary, this work offers practical insights into how available monitoring data can be repurposed for ecosystem accounting. For instance, by linking seagrass condition indicators with service flows (climate regulation and fish nursery), the accounts revealed how increases in condition could affect both physical service delivery and its estimated economic value.

Another key strength of this study is its demonstration of how NFPOs can use EA to better align their ecological monitoring activities with decision-making and reporting needs. The case organisation has an established seagrass monitoring programme, but until now, the information has not been systematically linked to broader ecological-economic performance. By introducing economic dimensions through ecosystem services, SEEA-EA offers a complementary approach to their current reporting tools (e.g. the State of Derwent report, annual report and Derwent Report Card), enhancing understanding of the services provided by the Derwent Estuary. In doing so, the SEEA-EA becomes more than just a reporting tool — it supports the NFPO's goals of improving the health of the Derwent ecosystems, evaluating the effectiveness of their monitoring programmes and communicating with stakeholders. Framing seagrass data in economic terms through EA can enhance the NFPO's ability to engage with funding bodies, regulators and the broader community. For instance, it may strengthen grant applications and improve accountability to stakeholders. Given the limited research on the specific benefits of EA for NFPOs, our understanding in this area remains underdeveloped.

At a broader level, these ecosystem accounts can support government efforts to monitor ecosystem conditions and understand the environmental-economic relationship of ecosystems. They can provide information for policy-making by highlighting trade-offs between environmental, social and economic outcomes, guiding investment decisions and identifying funding mechanisms for the Derwent Estuary (Mengo et al. 2022). While not all ecosystems were included, the seagrass accounts effectively demonstrate links between ecosystem condition and service provision. EA also reveal trends in ecosystem health and capacity, potentially prompting further research or investment (Dvarskas 2019). For instance, decision-makers could use these accounts to justify limits on river discharge and nutrient loads within the Derwent Estuary.

Challenges in accounting for marine and coastal ecosystems

With regard to ecosystem extent accounts, the extent data were derived from the Derwent Estuary Habitat Atlas, which represents a single data point for ecosystem extent in 2007 (DEP 2009). No further updates have been made, leading to limited extent data for marine and coastal ecosystems. This limitation arises for several reasons. The extent of marine and coastal ecosystems is highly variable both temporally and spatially (Navarro et al. 2024). Additionally, marine ecosystem mapping is resource-intensive, requiring specialised equipment, ships and engineering expertise to work in deep environments (Fraschetti et al. 2024). As a result, comprehensive field-based mapping of these ecosystems is both economically impractical and technically challenging (Grilli et al. 2021). However, with the advancements in remote sensing technology, this data limitation is likely to improve in the future.

Challenges also arose in constructing **ecosystem condition accounts**. Firstly, not all available **condition data** are suitable or sufficient for EA. Amongst the **three ecosystems** in the Derwent Estuary (seagrass, rocky reef and saltmarsh) with available condition data, only **seagrass and rocky reef data** could be used. Additionally, the available condition data are fragmented in terms of geographical coverage, methodology and research objectives. For instance, seagrass condition assessments were limited to the upper and middle Estuary, restricting spatial comparisons. In contrast, rocky reef condition data came from a baseline survey, allowing spatial comparisons across functional zones (middle and lower Estuary), but not temporal comparisons. Consequently, these data limitations hinder a comprehensive assessment of the Estuary's overall condition. However, despite these challenges, this study demonstrates the potential of applying the SEEA-EA framework in data-constrained contexts. These challenges also highlight the importance of site-specific ecological surveys to improve the quality and coverage of future condition accounts.

Secondly, the lack of standardised condition indicators for ecosystems complicates the process of selecting appropriate indicators, as noted in literature (Barbier 2017, Dvarskas 2019). The choice of condition indicators was restricted to available data rather than a standardised set of indicators across ecosystems. Lastly, compiling ecosystem condition accounts requires technical expertise. Understanding ecosystems and ecological processes is essential for defining and analysing relevant indicators (Grilli et al. 2021). In this case study, researchers collaborated with an ecological scientist to develop condition indicators suitable for accounting tables.

For the ecosystem service accounts, the Derwent Estuary hosts diverse marine ecosystems that provide various ecosystem services. However, this experimental study focused on seagrass only and its associated services (global climate regulation, fish nursery and recreational fishing) due to limited data availability. When drafting the ecosystem service flow accounts (both physical and monetary), the United Nations (2024) recommends identifying the specific contribution of each ecosystem to the provision of each service. While this was feasible for global climate regulation and fish nursery services, the recreational fishing data were not sufficiently detailed to attribute benefits to individual ecosystems.

According to the United Nations (2024), condition accounts help assess an ecosystem's capacity to provide services to society and the economy. However, Barbier (2017) argues that linking ecosystem condition changes to specific ecosystem services is challenging, requiring expert knowledge to understand how ecosystem functions influence service provision. Additionally, there is a dearth of literature on marine and coastal EA, particularly regarding the relationship between ecosystem conditions and ecosystem services. This study contributes to filling this gap by incorporating seagrass condition indicators into the assessment. Specifically, condition data were used to adjust the effective extent of seagrass meadows, which, in turn, provided information for the calculation of ecosystem services (climate regulation and fish nursery) in both physical and monetary terms.

We also found limited reliable references for valuing certain marine and coastal ecosystems. The case organisation emphasised the importance of valuing rocky reef ecosystems, yet verifiable references were scarce. For instance, Bennett et al. (2015) valued rocky reefs, using the 'benefit transfer method', citing studies by De Groot et al. (2012) and Costanza et al. (2014). However, in line with Cummins et al. (2023), our review of these studies found no clear explanation of how their valuations were derived. Therefore, we did not use those references to value rocky reefs in the Derwent Estuary. This data gap highlights the need for further research on ecosystem services provided by key ecosystems, such as rocky reefs. Additionally, collaboration between researchers and organisations is necessary to ensure research aligns with end-users needs.

Finally, in this study, we acknowledged a high level of uncertainty in the accounting table estimates. As noted by Navarro et al. (2024), the uncertainty arises from the inherently high spatial and temporal variability of marine and coastal ecosystems and limited data availability. Additionally, the compilation process introduces cumulative uncertainty: the uncertainty in ecosystem extent estimates affects ecosystem service physical accounts (e.g. carbon sequestration and fish nursery estimates, which depend on extent data). In turn, uncertainties of physical accounts impact monetary valuation of both ecosystem services and ecosystem monetary accounts. Lastly, the benefit transfer method offers a cost-effective and easy-to-use option for valuation, but it comes with higher uncertainty. Direct valuation methods provide more accurate and reliable estimates, but they are more resource intensive. In summary, recognising these uncertainties and balancing these trade-offs are essential in developing marine and coastal ecosystem accounts, as failing to do so may lead to misinformed decisions regarding natural resource management (Navarro et al. 2024).

Recommendation

In line with the existing literature (Dvarskas 2019, Mengo et al. 2022, Cardona et al. 2023), this pilot study revealed significant data limitations in implementing EA. These gaps also highlighted the challenges in mapping coastal and marine ecosystems and quantifying ecosystem services due to the dynamic and interconnected nature of ecosystems (Grilli et al. 2021). To address these gaps, several practices should be considered, as follows:

First, it is crucial to conduct more locally based ecological research to improve data availability (Dvarskas 2019, Grilli et al. 2021). In the case of the Derwent Estuary, more frequent and comprehensive data collection on the extent and condition of ecosystems is needed to generate time-series data. For ecosystem extent data, the adoption of advancements, such as remote sensing technology, has opened up opportunities for frequent habitat mapping (Grilli et al. 2021). Based on the challenges discussed above about ecosystem condition data, we propose the following:

1. National experts can provide definitions of standard condition indicators for all marine and coastal ecosystems, offering a consistent framework for measuring and comparing the condition of ecosystems across different locations and times.
2. To better link ecosystem condition with ecosystem services, these standardised condition indicators should be directly relevant to specific ecosystem services, such as carbon sequestration, water quality, fish nurseries etc.
3. More locally relevant studies adopting standardised condition indicators are needed to assess changes in ecosystem condition over time. As such, ecosystem accounts should be updated consistently and regularly (e.g. five or ten years) to provide information for decision-making and policy development.

Second, since different types of data are held by different entities (Vardon et al. 2018), collaboration with relevant stakeholders can improve data access. The compilation process of ecosystem accounts requires the collection of scattered data from various governmental, non-governmental and research entities (Vardon et al. 2018). As mentioned earlier, the data used to compile ecosystem accounts in this case study came from the NFPO, its collaborative partners and academic literature. Therefore, constructing ecosystem accounts needs data exchange between different entities. Additionally, a thorough understanding of ecological models and processes, as well as interdisciplinary perspectives, were found to be crucial in developing ecosystem accounts within the area of interest (Dvarskas 2019, Grilli et al. 2021). Hence, this study calls for more interdisciplinary collaboration amongst ecologists, economists and accountants to promote research and the application of EA.

Third, while more local ecological data are required, where this is not immediately available, we recommend increasing the use of the benefit transfer method in EA applications for two reasons. On the one hand, benefit transfer skills are less demanding than primary data collection skills, which make this method helpful for constructing monetary valuation of ecosystem accounts and providing consistent periodic updates of monetary accounts (Grammatikopoulou et al. 2023). On the other hand, the establishment of new data sources and online platforms facilitates the application of this method (Vardon et al. 2018, Vardon et al. 2023). For example, in 2008, the European Commission launched the online platform ‘Shared Environmental Information System’ to facilitate the use of environmental data across Europe. Another example is ‘The Economics of Ecosystem and Biodiversity’, a global database of monetary valuations of ecosystem services from empirical studies. These practices are expected to improve data availability at a low cost, thereby ensuring the regular production of ecosystem accounts. However, since the SEEA-EA framework adopts the exchange value principle (United Nations 2024), it is important to clarify whether the original study estimates exchange or welfare values in its valuation when applying the benefit transfer method (Grammatikopoulou et al. 2023). Over-reliance on benefit transfer methods, however, could reduce the motivation to collect local data. The SEEA-EA is inherently spatial, requiring detailed local data to accurately reflect ecosystem conditions and services. Benefit transfer, by relying on data from different locations, may not capture the unique characteristics of local ecosystems. While it may be useful for accelerating the use of SEEA-EA in policy applications, it is important to consider the risks of widespread use.

When EA is implemented and repeated at regular intervals, it may drive investment in improving data quality and quantity (Vardon et al. 2018), as the repeated production of accounts will lead to regular data exchange between data providers and account producers. Data providers can see how their data are used to construct ecosystem accounts, while account producers can detect, examine and correct any data anomalies (Vardon et al. 2018). Over time, data accuracy, accessibility and interpretability will improve, leading to greater trust and use by decision-makers (Vardon et al. 2018). These improvements in the availability of trustworthy, reliable environmental information will allow policy-makers to fully consider the environment in development planning and economic management (Vardon et al. 2023). Therefore, the repeated production of ecosystem accounts helps build trust amongst data providers, account producers and account users.

Conclusions

This study explored the feasibility of compiling marine and coastal ecosystem accounts using the SEEA-EA framework in the context of a NFPO. The pilot exercise demonstrates the process of EA and outlines the data required to construct ecosystem accounts from the NFPO's perspective. These ecosystem accounts can be treated as a supplement to the NFPO's current reporting system, providing an extra mechanism to support their internal decision-making and communicate with their stakeholders. Additionally, the compilation process reveals significant data gaps that hinder the full application of EA. However, the study highlights that initial attempts at EA are a necessary first step in undertaking a more rigorous accounting process: an organisation cannot and should not expect to begin by accounting for everything.

This study provides important insights and recommendations for future application of the SEEA-EA. There are many opportunities for future research, given the limited resources of the NFPO, including generating data required to populate ecosystem accounts and exploring how the NFPO would use these accounts. Future research may also explore the relevance of ecosystem accounts by considering the perspective of external stakeholders. Such engagement helps decision-makers better understand, use and trust EA, thereby enhancing the accuracy and relevance of EA. Ultimately, these efforts would contribute to the sustainable management of marine and coastal ecosystems.

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Conflicts of interest

The authors have declared that no competing interests exist.

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Supplementary materials

Suppl. material 1: Seagrass condition account doi

Authors: Duong Le Thuy Ha; Marie-Chantale Pelletier; Akira Weller-Wong
Data type: spreadsheet
Download file (65.83 kb)

Suppl. material 2: Rocky reef condition account doi

Authors: Duong Le Thuy Ha; Marie-Chantale Pelletier; Akira Weller-Wong
Data type: spreadsheet
Download file (20.81 kb)

Suppl. material 3: Ecosystem services accounts doi

Authors: Duong Le Thuy Ha; Marie-Chantale Pelletier; Akira Weller-Wong
Data type: spreadsheet
Download file (22.93 kb)

Endnotes

*1 Source: DEP website: https://www.derwentestuary.org.au/

*2

Aquatic macrophyte beds dominate the middle and upper stretches of the Derwent Estuary. These beds are typically a mixture of the aquatic macrophyte *Ruppia megacarpa* and the seagrass *Heterozostera tasmanica*, with *Rupppia* being the dominant component (Lucieer et al. 2007). However, in the Derwent Estuary literature, the term *seagrass* and *aquatic macrophyte* have been used interchangeably (Lucieer et al. 2007, Mount 2011). Additionally, habitat mapping has not differentiated between seagrass *Ruppia* and *Heterozstera*, which is an issue in the extensive meadows in the mid- and upper Estuary. For this study, the authors opted to evaluate the ecosystem based on seagrass species (*Zostera/ Heterozostera*), given the availability of ecosystem service data and their extent throughout the Estuary. However, this approach introduces a potential source of error, highlighting the need for habitat data that differentiate at the genus level. From this point forward, the term *aquatic macrophytes* and *seagrass meadows* (see map) are referred to exclusively as *seagrass*.