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Quantifying fisheries enhancement from coastal vegetated ecosystems.

Holger Jänes*[,1], Peter I. Macreadie1, Philine S.E. Zu Ermgassen[2], Jonathan R. Gair[3], Sarah Treby[1], Simon, Reeves[4], Emily Nicholson[1], Daniel Ierodiaconou[1], Paul Carnell[1]

[1]School of Life and Environmental Sciences, Centre for Integrative Ecology, Deakin University, Victoria 3125, Australia. Burwood campus

[2] Changing Oceans Group, School of Geosciences, University of Edinburgh, James Hutton Rd, King's Buildings, Edinburgh EH9 3FE, United Kingdom.

[3]School of Mathematics, University of Edinburgh, James Clerk Maxwell Building, Peter Guthrie Tait Road, Edinburgh EH9 3FE, United Kingdom.

[4] The Nature Conservancy, Adelaide Office, 451 Pulteney Street, Adelaide SA 5000, Australia.

Abstract

Coastal ecosystems are estimated to support 95% of the world's commercially-important fish, owing largely to their provision of nursery habitat for juveniles; however, systematic databases with such data are scarce. By systematically reviewing the literature across Australia, we quantified fisheries enhancement from three key coastal vegetated habitats: seagrass meadows, mangrove forests, and tidal marshes. From juvenile densities, we modelled adult fish biomass enhancement resulting from these structured habitats and linked fish of economic importance with market values. We found that seagrass displayed higher per hectare abundance, biomass and economic enhancement compared to mangroves and tidal marshes. On average, one hectare of seagrass supported 55,000 more fish annually compared to unvegetated seabed, resulting in an additional biomass of 4,000 kg and a value increase of AUD 21,200 annually. Mangroves supported 19,000 more fish, equivalent to 265 kg^{-1} ha^{-1} y^{-1}, and tidal marshes provided a modest 1,700 more fish, equivalent to 64 kg^{-1} ha^{-1} y^{-1}. The most abundant fish across all ecosystems were small, non-commercial species (e.g. gobies and glassfish), but the highest biomass and economic value originated from larger, longer-lived fish that are regularly targeted by fisheries (e.g. breams and mullets). By quantifying enhancement value across Australia, our findings provide further evidence for, the benefit these critical habitats provide in supporting coastal fisheries and human well-being.

Key words: Ecosystem services; monetary valuation; systematic quantitative literature review; fisheries production;

1. Introduction

Ecosystem services are broadly defined as direct or indirect benefits that people derive from ecosystems (Jones, 2010). Ecosystem services are generated by various ecosystems functions and interactions amongst them, for example; habitat provision, carbon storage and nutrient cycling and clean air (Barbier et al., 2011; Ghaley et al., 2014). Such benefits are often challenging to quantify, especially as many of the services are not marketable. Economists therefore often value ecosystem services based on the society's willingness to pay for the benefits provided by ecosystems while quantifying and accounting for the impacts of ecosystem services on human welfare (Risén et al., 2017). Willingness-to-pay analysis can, however, produce widely varying results depending on the socio-economic background of people; it is measured in terms of each individual's own assessment of his or her well-being.

We adopt a slightly broader view from Freeman (2003) stating that the value of resource–environmental systems resides in the contributions that the ecosystem functions and services make to human well-being. Thus, to appropriately value ecosystem services, it is important to quantify the components of ecosystems that underlie the provision of services and directly link them to consumable human benefit (Brauman et al., 2007; Cole and Moksnes, 2016).

One important set of ecosystem services contributing to global socio-economic well-being is derived from wild-capture fisheries, that provide significant input to the global economy through seafood production (93.4 million tonnes in 2014) (FAO, 2016). However, a well-functioning fishery sector often depends on the presence of coastal ecosystems, such as seagrass meadows, mangrove forests and tidal marshes, as they act as nursery areas, which support fish production through the provision of important habitat (Ley and Rolls, 2018; Ronnbaack, 1999; Taylor et al., 2016). A nursery area can be described as an ecosystem that supports fish growth and survival, and contributes a disproportionately higher number of individuals to adult populations relative to nearby ecosystems (Beck *et al.*, 2001). Seagrasses, mangroves, and tidal marshes around the world are known to provide such function to fish (Bloomfield and Gillanders, 2005; Griffiths, 2001; Hyndes et al., 2003). Habitat provision makes these coastal ecosystems a keystone feature for global fish production (Becker and Taylor, 2017; Cole and Moksnes, 2016; Muller and Strydom, 2017; Smith et al., 2008).

To value the importance of coastal ecosystems for fish production, it is important to quantify and directly link ecosystems with fisheries data (Taylor et al., 2018). The ecological values of ecosystem services from fisheries often relate to fish abundance and biomass (Maire et al., 2018; Zwolinske et al., 2014), whereas marketable benefits can be effectively expressed through monetary units (Rahman et al., 2018; Schild et al., 2018). Despite the remarkable potential of juvenile fish abundance estimates from nursery areas to directly link coastal ecosystems and fish production, there are few recent studies that explore the potential to use these in conjunction with ecological modelling and economic analysis. For example, the value of seagrasses across southern Australia has been estimated at AUD 31,650 ha^{-1} y^{-1} using enhancement estimates related to nursery habitat availability (Blandon and Zu Ermgassen, 2014b). An island scale (Gran Canaria, Eastern Atlantic) value of seagrasses was estimated at EUR 606 239 y^{-1} based on fish abundance data (Tuya et al., 2014).

In this study, we integrated decades of juvenile fish density data with biomass modelling and economic analysis to infer the coastal ecosystem values of seagrasses, mangroves and tidal marshes to fisheries in Australia We **(a)** Systematically gathered and quantified juvenile fish abundances from seagrass, mangrove and tidal marsh ecosystems across Australia; **(b)** Modelled adult fish biomass from juvenile abundances for species that were positively enhanced by coastal ecosystems – i.e. difference in fish abundances on seagrass vs unvegetated seabed; **(c)** Combined fish biomass estimates with catch and value data of commercially targeted species; and **(d)** Estimated fish-specific dollar values for seagrass, mangrove and tidal marsh ecosystems across Australia and within each state.

2. Material and methods

2.1 Data collection

A literature review was conducted (04.2017–08.2017) in ISI Web of Science (WoS), with the aim of identifying enhancement in fish production from coastal vegetated ecosystems (seagrass, mangrove and tidal marsh) in Australia. Data collection followed the systematic quantitative literature review approach (see Pickering and Byrne 2014 for details). The following search terms were used in WoS: 'fish' AND 'Australia' AND 'seagrass' OR 'mangrove' OR 'saltmarsh' (i.e. tidal marshes), which yielded in total of 736 publications for subsequent scanning. To be included in the analysis, publications had to **(a)** present original data on juvenile fish abundances from seagrass or mangrove or tidal marsh ecosystems, together with abundances from an unvegetated control in Australia; and **(b)** provide details of the total area of seabed sampled, such that fish numbers could be standardized per unit area and studies could be compared. These criteria reduced the number of publications suitable for analysis to 14, but were essential for a robust analysis (see Table 1 in supplementary material for a detailed description of the publication selection process). Fish enhancement by the structured habitats was estimated relative to the unvegetated control.

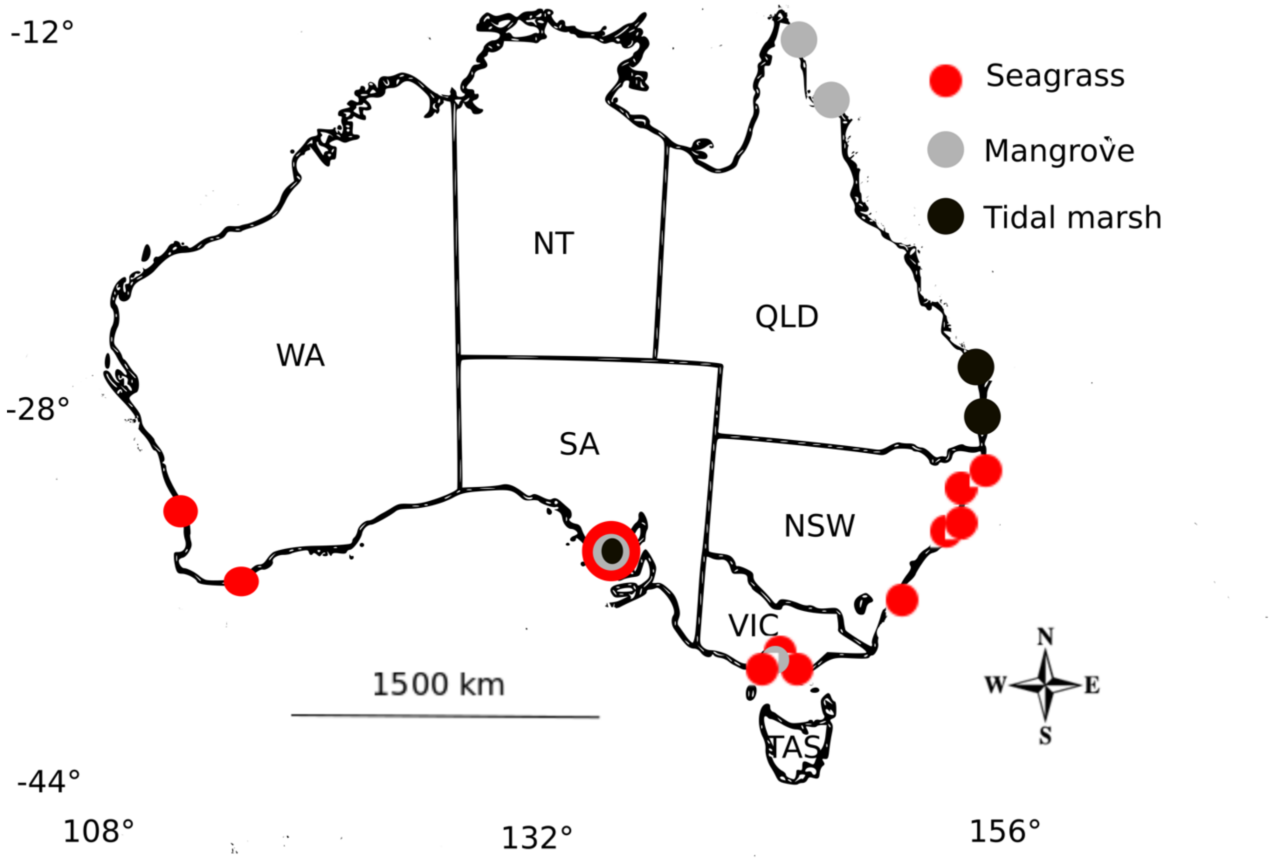

Figure 1. Locations from individual studies and ecosystems incorporated in the meta-analysis. WA – Western Australia; NT – Northern Territory; SA – South Australia; QLD – Queensland; NSW – New South Wales; VIC – Victoria; TAS – Tasmania (see Table 2. In supplementary materials).

2.2 Species selection

For a fish species to be included in the analysis, the juvenile densities must **(a)** be positively enhanced by either seagrass, mangrove, or tidal marsh ecosystems, relative to an unstructured control; and **(b)** be represented by two or more individual sampling events for better account for variability. Enhancement is defined as the difference between juvenile fish abundances on coastal ecosystems compared to an unvegetated reference/control area in the study location (most commonly unvegetated sand bottom). An individual sampling event was defined as one taken in different sampling sessions e.g. months, seasons or parts of the estuary within one season.

2.3 Fish abundance enhancement estimates

Data was standardized to represent the mean number of individuals per fish species (ha^{-1} y^{-1}) enhanced by each of the three ecosystems. For most studies, fish densities were calculated using the total abundance for each species divided by the sampling frequency and area. When data was presented as mean number of individuals per haul, then the total abundance of fish was estimated by multiplying the mean number per haul with sampling frequency and area. The enhancement (E) of the fish stock of species (s) by coastal ecosystems (e) was then calculated for each species in each study using the following equation:

$$E_{s,e} = (P_{s,e} - P_{s,u})$$

Equation 1: Where *P* is the abundance of juveniles (estimated to be 0.5 years old) of species *s,* in ecosystem *e* (reported as fish per ha^{-1}),and $P_{s,u}$ is the abundance of species *s,* in unvegetated ecosystems *u*.

Juvenile fish enhancement estimates included in the analysis varied in terms of the number of independent sampling events representing the mean, thus, representing varying levels of confidence regarding juvenile fish enhancements. To account for the number of independent sampling events representing juvenile fish enhancement, values were weighted by the number of independent samples representing the mean. Independent sampling events were defined as those either collected by different studies, or in different bays or estuaries over several months, or from varying seasons within one study. After accounting for the number of individual sampling events, we calculated the enhancement for each fish species across all studies (Blandon and zu Ermgassen, 2014):

$$E_{m,s,e} = \frac{\sum(E_{s,e,l} \times N_{s,e,l})}{\sum(N_{s,e,l})}$$

Equation 2: Where $E_{m,s,e}$ is the mean *m* enhancement (*E*) of species *s,* in ecosystem *e*; $E_{s,e,l}$ is the enhancement (*E*) of the fish stock of species *s* by coastal ecosystems *e* in location *l*; and $N_{s,e,l}$ is the number of individual sampling events for species *s* in ecosystem *e* in location *l*.

Fish were determined to be enhanced by coastal ecosystems when they were present in two or more individual sampling events with an overall greater positive mean abundance on coastal ecosystems compared to unvegetated ecosystems.

The efficiency of netting when sampling fish is highly variable, thus, the accuracy of fish abundances derived from coastal ecosystems might be variable. Sampling efficiency of seine nets (the majority of our abundance data were originally collected with seine nets) could range from 20–83% depending on inter- (Jenkins et al., 1997) or intraspecific variation (Rozas and Minello, 1997). Due to the large variability of species-specific catch efficiencies, we did not apply a correction factor for our data, however, we suggest that our synthesised abundance enhancements, biomass calculations and economic valuations likely undervalue coastal ecosystems in relation to fish production and should thus be viewed as conservative.

2.4 Fish biomass enhancement estimates

Total average annual biomass production of each fish species supported by coastal ecosystems (kg ha^{-1} y^{-1}) was determined by following the methodology developed by Peterson, Grabowski and Powers, 2003 and revised by (see detailed description in Zu Ermgassen, 2016). This methodology estimates the average enhancement in annual fish biomass production from coastal ecosystems. We consider species-specific natural mortalities; however, we do not include fishing mortality. The following equation calculates the proportion of individuals in age class 0.5 surviving to age class *i*.

$$y = e^{-Mi}$$

Equation 3: Where y is the proportion of fish population surviving to age class i and M is the species-specific natural mortality, thus, for each age class the biomass enhancement (kg ha^{-1}) was calculated by:

$$B_i = B_{0.5} \times e^{(-M \times (i-0.5))}$$

Equation 4: Where B_i is the biomass enhancement for age class i, and $B_{0.5}$ is equal to the previously calculated $E_{m,s,e}$ (see section 2.3). For each age class, the length of an average fish was calculated using Lorenzen (2000) growth equation and the average weight was estimated using length-weight relationships. The total average annual biomass enhancement (kg ha^{-1}) of species was calculated by summing the incremental increase in weight for an average fish in each year class by the number/density (ha^{-1}) of fish (B_i) in each age class.

All species-specific growth parameters used to calculate theoretical stock biomass enhancement were obtained from www.fishbase.org (Froese and Pauly, 2018) and are listed in supplementary material table_1. Where species-specific values for required modelling parameters were not available, suitable proxy species were used. Suitable proxy species were in the same Genus or Family for which required parameters were available.

2.6 Economic valuation

Initially, biomass enhancement of economically relevant fish was combined with commercial catch data from the latest available fisheries reports: New South Wales (Stewart *et al.*, 2015), Victoria (Department of Primary Industries, 2012); and South Australia (PIRSA, 2015). From these reports, the most recent 3-year annual catch statistics (catch in tonnes and AUD value) of economically important species were extracted. Economic values were then calculated by multiplying the price per kilogram of each fish species by the average annual biomass enhancement from coastal ecosystems (kg ha^{-1} y^{-1}) (see supplementary material table_3 for full data file). This provides an estimated value for the coastal ecosystem based on the additional biomass of fish theoretically available to the fishery, per unit area of coastal ecosystem. Economic valuation here is based on the theoretical biomass enhancement by the system and not what is caught. All calculated market values were CPI (consumer price index) corrected and adjusted to 2019 standards. CPI considers the inflation rate of goods and services over time and allows adjustment of historic value data to the current economic climate.

In addition to economic value, we summarised the underlying fish abundance and biomass data and calculated fish-specific enhancement values individually for each state. This is because fisheries are managed separately in each state, and state boundaries can provide meaningful ecological classification measures for coastal ecosystems as they range over distinct geographic distances.

Statistical analyses for fish abundance and economic value were carried out with tidyverse package in R (Wickham et al., 2017) whereas fish biomass was modelled in C++. All R and C++ code used to carry out the analysis is available on request.

3. Results

3.1 Fish abundance and biomass enhancements

Coastal ecosystems acted as nursery grounds for juvenile fish across Australia. Fish-specific abundance and biomass enhancement was best characterized for seagrasses, which positively enhanced the abundance of 117 fish species, followed by mangroves (23) and tidal marshes (8) (Figure 2a). Four species out of the 148 that were positively enhanced by coastal ecosystems had to be excluded from biomass modelling due to the lack of available species-specific growth parameters (see highlighted rows in table_2, supplementary material). Seagrasses positively enhanced fish abundance and biomass in five out of six states and two territories in Australia, whereas mangrove enhancement was present in only two states, and tidal marsh in just one state (Figure 2a, b).

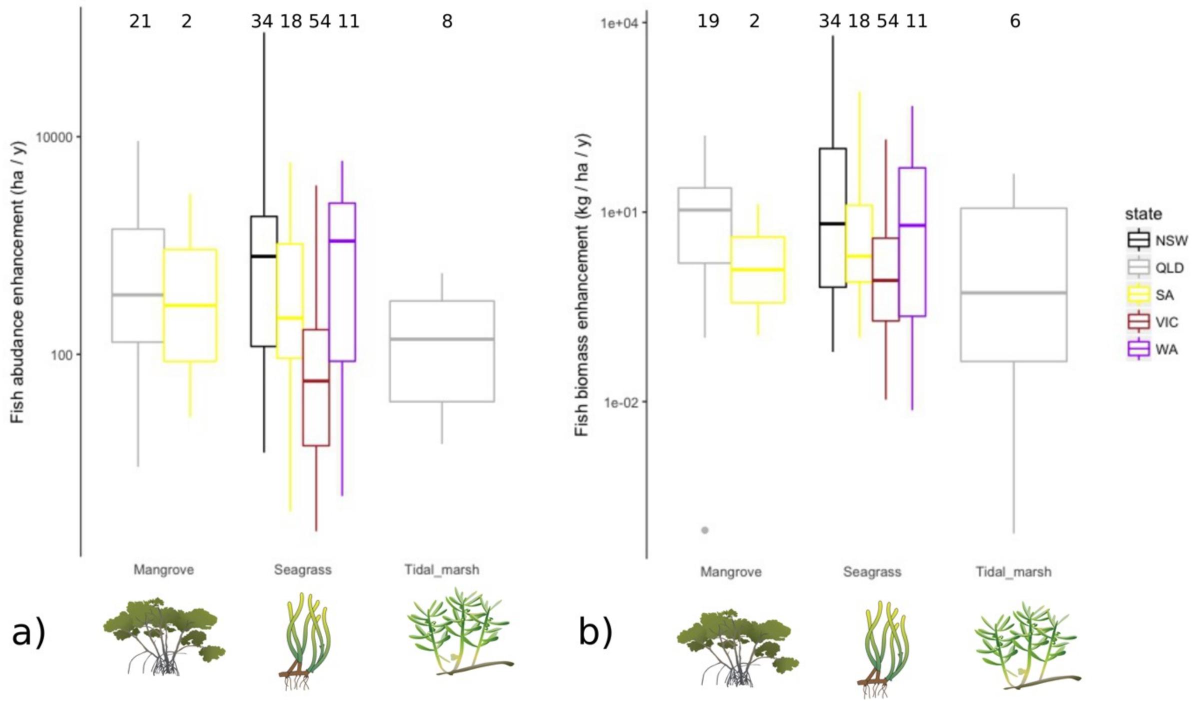

Figure 2: Boxplot of fish-specific (a) abundance (ha^{-1} y^{-1}) and (b) biomass (kg ha^{-1} y^{-1}) enhancement from mangrove, seagrass and tidal marsh ecosystems compared to unvegetated seabed across five Australian states. Numbers above each box show the number

of individual fish species enhanced by coastal ecosystems for each state. See Figure 1 for state abbreviations.

Across Australia, average abundance enhancement of fish on seagrass beds was 55,589 individuals ha^{-1} y^{-1} (equal to 4,064 kg), compared to an equivalent area of unvegetated seabed (Figure 2a, b). In contrast, the average abundance enhancement from mangroves was 19,234 (equal to 265 kg) and tidal marshes contributed on average 1,712 individual fish (equal to 64 kg) per one hectare (Figure 2a, b).

The overall nursery function of coastal ecosystems varied greatly between Australian states (Figure 2a, b). For example, seagrasses in New South Wales displayed the highest combined increase in fish biomass (13,789 kg ha^{-1} y^{-1}) which was 85% of the total biomass enhanced by seagrass ecosystems and 81.8% of the overall total biomass increase supported by coastal ecosystems (Figure 2 b). Large differences between the mean and median abundance and biomass enhancements of fish suggest that some species have strong relationships with coastal ecosystems and thus create large disparities between mean and median values.

The five highest average fish-specific abundance enhancements in Australia all originated from seagrasses in New South Wales (Table 1). The highest fish-specific abundance enhancement was displayed by Port Jackson Glassfish, *Ambassis jacksoniensis* (90,987 individuals ha^{-1} y^{-1}), contributing 35% of the overall abundance enhancements (Table 1). With 9,600 individuals ha^{-1} y^{-1}, Sea mullet (*Mugil cephalus*) was the only economically relevant species amongst the top five with the highest abundance enhancements (Table 1).

Four out of the top five biomass enhancements originated from seagrass ecosystems in New South Wales and one from South Australia (Table 1). The highest biomass enhancement was shown by Tarwhine, *Rhabdosargus sarba*, 6,227 kg^{-1} ha^{-1} y^{-1}, contributing 37% of the total biomass enhanced by seagrass across all states (Table 1). Top five species contributed a combined 13,325 kg^{-1} biomass ha^{-1} per year which was 79% of the total enhancement of fish biomass (Table 1).

Table 1. Abundance and biomass (kg) enhancements ha^{-1} y^{-1} of top five highest contributing fish species across ecosystem types and states. Economically important species are marked in bold. See Figure 1 for state abbreviations.

Abundance enhancement ha^{-1} y^{-1}			
Species	**Mean**	**State**	**Ecosystem**
Port Jackson glassfish (*Ambassis jacksoniensis*)	59,337		
Largemouth goby (*Redigobius macrostoma*)	19,379		
Bluespot goby (*Pseudogobius olorum*)	15,203	NSW	Seagrass
Eastern Striped Gunter (*Pelates sexlineatus*)	10,595		
Sea mullet (*Mugil cephalus*)	9,600		
Biomass enhancement kg^{-1} ha^{-1} y^{-1}			

Tarwhine (*Rhabdosargus sarba*)	6,227		
Sea mullet (*Mugil cephalus*)	3,976	NSW	
Yellowfin bream (*Acanthopagrus australis*)	1,735		Seagrass
King George whiting (*Sillaginodes punctatus*)	809	SA	
Port Jackson glassfish (*Ambassis jacksoniensis*)	576	NSW	

Economic valuation

Of the 148 fish species identified in this dataset as using coastal ecosystems as nursery areas, 25 were of commercial relevance and provided a combined biomass of 14,675 kg ha^{-1} y^{-1} and value of AUD 62,150 ha^{-1} y^{-1} for coastal ecosystems (Figure 3a, b). 23 commercially relevant species were supported by seagrass and two by tidal marshes (see supplementary material table_3 for full data file). 99% of the economic enhancement identified originated from seagrass ecosystems which were valued at AUD 62,136 ha^{-1} y^{-1} in New South Wales; AUD 1,542 ha^{-1} y^{-1} in Victoria; and AUD 150 ha^{-1} y^{-1} in South Australia. Thus, an average value for seagrass beds in Australia is estimated at 21,276 ha^{-1} y^{-1}. Two species enhanced by tidal marshes in Queensland contributed a modest AUD 14 ha^{-1} y^{-1}.

State-specific median biomass enhancements of commercially relevant fish ranged from 4410 kg ha^{-1} y^{-1} and economic enhancements ranged from AUD 7–765 ha^{-1} y^{-1} (Figure 3a, b). However, some fish showing strong relationships with coastal ecosystems as well as high market values contributed notably more than other species. Tarwhine in New South Wales was the highest contributor to economic value, with AUD 43,700 ha^{-1} y^{-1} making up 69% of the overall dollar value assigned to coastal ecosystems based on our data. Dollar value linked to Tarwhine (*Rhabdosargus sarba*) was six-fold greater than the second highest contributing fish, Yellowfin bream (*Acanthopagrus australis*) with AUD 8,025 ha^{-1} y^{-1} (Table 2). The top five economically enhanced species contributed AUD 59,709 ha^{-1} y^{-1} making up 96% of current dollar value estimates assigned to coastal ecosystems.

Table 2. Mean value in AUD ha^{-1} y^{-1} of the five most economically enhanced fish species across ecosystem types and states. Dollar values are expressed according to 2019 standards. See Figure 1 for state abbreviations.

Economic value enhancement AUD ha^{-1} y^{-1}			
Species	**Mean**	**State**	**Ecosystem**
Tarwhine (*Rhabdosargus sarba*)	43,704	NSW	Seagrass
Yellowfin bream (*Acanthopagrus australis*)	8,025		
Sea mullet (*Mugil cephalus*)	6,435		

Luderick (Girella tricuspidata)	780
Yellowfin leatherjacket (*Meuschenia trachylepis*)	765

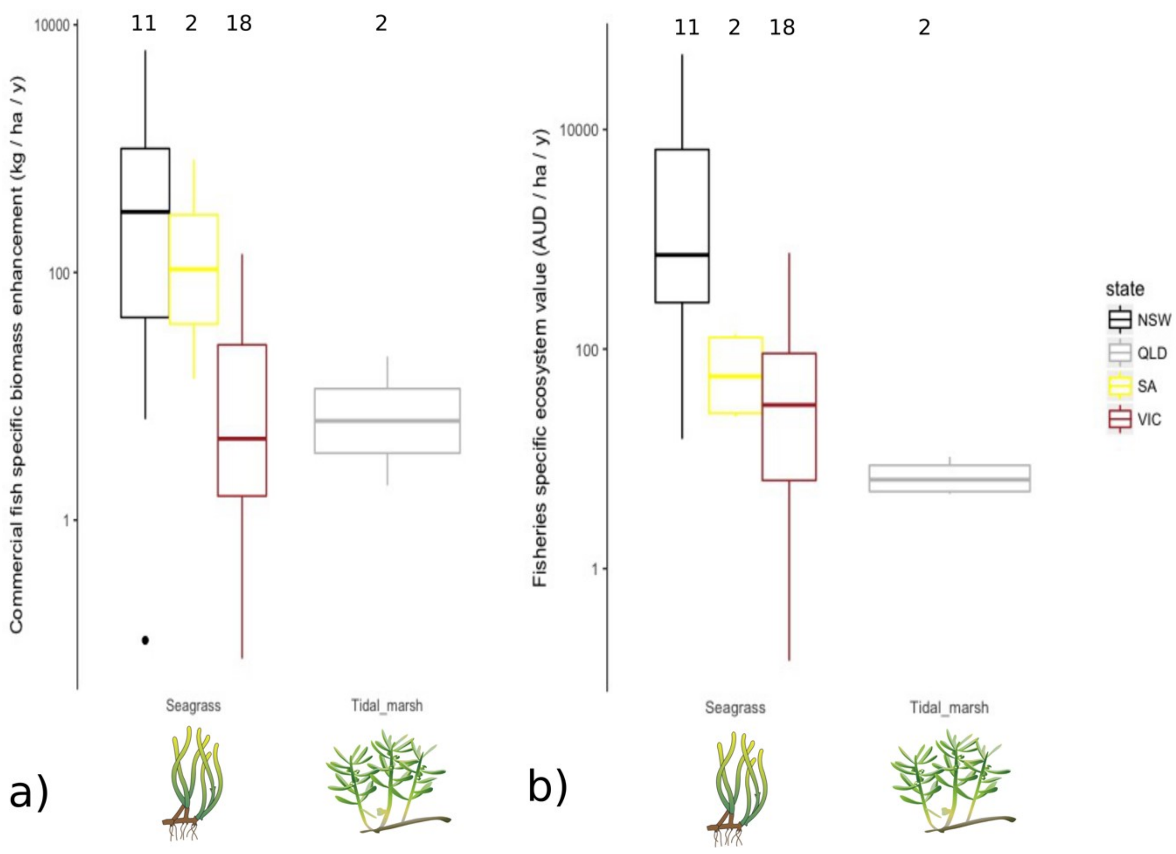

Figure 3: Boxplot of (a) biomass of economically relevant fish (kg ha^{-1} y^{-1}); and (b) value (AUD ha^{-1} y^{-1}) enhancement from mangrove, seagrass and tidal marsh ecosystems compared to unvegetated seabed across five Australian states. Numbers above each box show the number of individual fish species with positive biomass and value enhancement by coastal ecosystems at each state. See Figure 1 for state abbreviations.

Discussion

Seagrasses across Australian states yielded the highest per-hectare increase in juvenile fish abundance (222,318 ha^{-1} y^{-1}), biomass (16,254 kg ha^{-1} y^{-1}), and dollar value (62,136 AUD ha^{-1} y^{-1}) of the three ecosystems examined. The most abundant juvenile fish across all ecosystems were small, non-commercial species, but the highest biomass and economic value originated from larger longer-lived fish that are regularly targeted by fisheries (e.g. breams, mullets and leatherjackets). Of the 148 fish species positively enhanced as juveniles by coastal ecosystems, 25 were of commercial relevance. Twenty-three of these species were enhanced by seagrass ecosystems, thus, 99% of the total increase in economic value calculated in this study was attributed to seagrass ecosystems.

Nevertheless, several fold differences emerged between the capacity of coastal ecosystems to support fish production across Australian states that cover a wide spatial range. This might be as fish could more easily enter seagrass ecosystems as they are located lower in the intertidal or subtidal zones compared to tidal marshes and mangroves. Australia has one of the largest and most diverse seagrass communities globally (Butler, Jernakoff, & Entry, 1999; Short, Carruthers, Dennison, & Waycott, 2007) - thus, it is likely that such a vast area of underwater primary producers translates into fish production. In comparison, tidal marshes in

Australia are located high in the intertidal zone and are infrequently inundated (Hollingsworth & Connolly, 2006) and fish have very limited access to tidal marshes. It is reasonable to assume that seagrass beds have been exposed to higher sampling effort due to easier access and easily quantifiable linkages to fisheries.

A recent review by Blandon and Zu Ermgassen (2014) from southern Australia provided a significant contribution to our understanding of seagrass-fishery relationships, as it is the only known attempt in the region to combine quantifiable, large-scale ecological data with economic analysis. Similarly to our study, they modelled adult fish biomass from juvenile abundances and combined results with market values of commercially harvested fish sought from state authorities. However, Blandon and Zu Ermgassen (2014) focussed solely on seagrass ecosystems and provided an average annual dollar value per hectare of seagrass, whereas we also reviewed the importance of mangroves and tidal marshes to fish production. They estimated an average per-hectare seagrass value in southern Australia at AUD 31,650 ha^{-1} y^{-1} (Blandon and Zu Ermgassen, 2014b), which is similar to our average Australia-wide estimation of AUD 21,276 ha^{-1} y^{-1}. Our results, however, illustrate that seagrass value is highly variable between states, ranging from AUD 150 in South Australia to AUD 60,500 (ha^{-1} y^{-1}) in New South Wales. This finding has demonstrable management relevance, as Australian states are managed as separate fisheries management units.

We note that, despite the relatively low value of enhanced fish production identified for tidal marshes and mangroves in this study, there is significant evidence that these habitats are widely understood to be important and productive fish habitats (Barbier et al., 2011; Ley and Rolls, 2018; Pantallano et al., 2018; Ronnback, 1999). This difference between our results and previous findings is likely the result of two main factors. Firstly, our method only accounts for enhanced fish production resulting from increased fish abundance and biomass. In the case of tidal marshes in particular, there is much emphasis on the value of transported organic material from these ecosystems for supporting the wider fish communities that was not accounted for here (Jänes et al., 2019). Secondly, one key criterion for a study to be included in our analysis was that it allowed the quantification of fish data per unit area. However, commonly used nets for sampling mangroves and tidal marshes in Australia are gill nets or fyke nets (Payne and Gillanders, 2009; Smith and Hindell, 2005; White and Potter, 2004). These do not provide a per-unit-area estimate of juvenile fish densities, and therefore were not included.

Quantifying juvenile fish enhancement and biomass from ecosystems provides a partial understanding about the relationships between fish and coastal ecosystems. Additionally, it is also important to consider the movement of individuals throughout various life history stages (e.g. from juvenile ecosystems, and successful recruitment to adult populations). Recent work by Raoult, Gaston and Taylor (2018) in the estuaries of northern New South Wales demonstrated that a significant dietary contribution for adult Yellowfin bream, Luderick and Sea mullet originated from tidal marshes. The same fish were amongst the top five species in our dataset, with the highest per-hectare enhancement of biomass from seagrass ecosystems, but were not enhanced as juveniles by tidal marshes. This illustrates the importance of considering all habitats at a landscape scale, and across the entire life history of the species, if the full importance of coastal habitats to fisheries is to be understood or quantified. Focusing only on selected parts of fish life cycle might result in partial answers about ecosystem-fish relationships.

The majority of global societies and economies are built on ever-increasing annual consumption and growth in any given industry, which violates the simple principles of population ecology about space and time limitations, and are thus unsustainable form a long-term perspective (Bastian et al., 2012; Seidl and Tisdell, 1999). Despite the potential wider applicability of monetary valuations as a tool for communication with various stakeholders, it should not be forgotten that money is something that can be easily devalued (Patro et al., 2014; Upadhyaya, 1999) and is subject to political pressures and conflict (Frieden, 2015). It is important to bear in mind that prices of goods and services (e.g. fish prices) can significantly vary around the world while fundamentally providing the same service - which is to feed people. Thus, value estimates of coastal ecosystems derived from fisheries can be affected and often vary depending on the scale and the location of a study. For example, mangrove-related fish and crab species account for 32% of the small-scale fisheries landings in the Gulf of California, with an estimated annual value of USD 37,500 per hectare of mangrove fringe (Aburto-Oropeza et al., 2008). Sundarban Mangrove Reserve and its impact zone in Bangladesh is home to 3.5 million people, from which 79% of surveyed households rely on various mangrove-supported fisheries as part of their year-round income, providing an estimated habitat value of USD 976 ha^{-1} (Rahman et al., 2018). Whereas Raoult et al. (2018) estimated economic values from fisheries for saltmarshes in two Australian estuaries which ranged between AUD 2500–25,000 ha^{-1} y^{-1}.

Economists tend to value the benefits rising from nature and not the nature itself. However, more focus should be also placed on effective communication of actual quantities of goods and services obtained from natural resources and how this is positively linked to the livelihoods of people. Furthermore, estimated values for coastal ecosystems in this manuscript are based on the additional biomass of fish theoretically available to the fishery per unit area of coastal ecosystem. This contrasts common approach to ecosystem service valuations where someone has to benefit from the service for it to have value i.e. total fisheries catch from annual biomass production. Being unable to determine the proportion of fisheries catch from total biomass enhancement means that valuation here is therefore based on the theoretical biomass enhancement by the system and not what is caught.

The benefit of large-scale syntheses and reviews in any given discipline relies on the ability to draw broad conclusions and comparisons relevant on a national or international level. Furthermore, abundance and biomass estimates provided in our study could be combined with environmental and human-mediated factors that could potentially explain why differences within and between ecosystems emerged. Seagrass characteristics (Rubin et al., 2018), study location (Jenkins et al., 1999), latitudinal differences (Perry et al., 2017), current speed and direction (Jenkins et al., 2000), rainfall patterns (Rodrigues et al., 2019), and average temperatures (Jenkins and King, 2006) are only some of the factors that likely affect community composition in aquatic ecosystems.

Conclusion

We effectively summarized how juvenile fish abundance, biomass, and dollar values of commercially targeted species can be combined to provide an overview of how the value of recruitment enhancement by coastal ecosystems can be viewed. In light of continued degradation and loss of coastal ecosystems globally, there is an urgent need for decision makers to understand the benefits humans derive from the natural world, and the impact of careless human actions. Our results are broadly applicable to both regional and global decision makers and managers, to better understand the fisheries benefits provided by seagrass, mangrove and tidal marsh ecosystems. Abundance, biomass and monetary values assigned to coastal ecosystems can help decision makers prioritize conservation and restoration actions.

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Data accessibility

All required data is accessible in supplementary materials.

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