DRAFT PAPER

ECONOMIC VALUATION OF THE ECOSYSTEM SERVICES IN THE ISRAELI MEDITERRANEAN

Shiri Zemah Shamir, Yoav Peled, Mordechai Shechter, Alvaro Israel

abstract

While many current and potential uses of the Israeli Mediterranean have clearly defined economic value and apparent benefits to various stakeholders (e.g. energy and raw materials extraction, maritime traffic), the marine ecosystem's benefits are severely underexplored and are not manifested in economic terms. Coupled with increasingly changing environmental conditions (e.g. climate change, biological invasion), the need for performing both monetary valuations and spatial analyses to the benefits derived from this ecosystem, is clearly evident.

In this paper we performed an evaluation of marine and coastal ecosystem services in order to better quantify and map their importance to society. By employing various economic valuation methods, the benefits of the assessed ecosystem services were monetized. In addition, the study performed spatial analyses to the ecosystem service in order to map distribution of values, identify critical areas of ecosystem services' supply, and provide predicative supply trends given expected scenarios. Our main tool for applying the spatial analysis was ARtifical Intelligence for Ecosystem Services (ARIES), a modelling platform which enables the construction of Ad-hoc deterministic or probabilistic models, suited to given case studies and local conditions while at the same time acknowledges missing or uncertain data.

Keywords: marine ecosystem services, economic valuation, mapping, Mediterranean

1. Introduction

The marine ecosystem of the Israeli Mediterranean coast, located within the Levantine Sea in the Eastern part of the Mediterranean basin, has undergone significant changes in recent decades caused primarily by species invasion, fishing activity, river damming and climate change. The Levantine basin has the hottest, saltiest and most nutrient poor waters in the Mediterranean Sea, as a result of high evaporation rates, very low riverine inputs and limited vertical mixing. It has been stated that multiple empty niches that can be used by invasive species exist in the Levant ecosystem. This may be due to the low biodiversity in the region and the apparent existence of the native species in a habitat which is thought to be at the limits of their tolerance levels (Corrales et al. 2017). In addition, the opening of the Suez Canal in 1869, its continuous enlargement and the similarity between the Levantine Sea and the Red Sea in terms of temperature and salinity allowed for the progressive introduction of many species of Indo-Pacific origin into the Eastern Mediterranean Sea (known as Lessepsian immigrants). This phenomenon is almost entirely unidirectional, i.e. into the Mediterranean rather than out of it. These introductions accelerated during the second half of the 20th century and the first decade of the 21th century.

Development pressures, overfishing and regional and global phenomena (such as climate change) have, over the last few decades, resulted in a 50% worldwide decline in fish catch. Increased fishing activity (of all kinds) has put a growing strain on the environment, both globally and in the Mediterranean Sea. Israel has experienced a 45% decline in fish catch, along with a significant increase in the bycatch. Currently, Israeli fishing provides only 2,600 tons per year, amounting to just a very small percentage of the country's food fish consumption.

Given the aforementioned stressors and threats and the interconnectedness between species populations, environment and human activities, a shift towards a more comprehensive analysis and management of human activities, such as ecosystem-based management (EBM), is required. Within this context, ecosystem modelling tools are particularly useful because they allow the study of marine ecosystems as a whole, integrating available information to study direct and indirect interactions among ecosystem compartments, i.e. trophic interactions and the impact of fishing activity on marine resources. Economic valuation of ecosystem services complements such tools by providing a common measure, aiding decision and policy makers to understand the possible effects of marine development on ecosystems and the welfare of stakeholders which are associated with these ecosystems.

Our assessment of the total economic value of the marine ecosystem relies on the classification of ecosystem services presented by TEEB (2010) in order to avoid double-counting of supporting services (which are regarded as ecosystem functions) and incorporate "habitat services" into the valuation. We also adopt the approach presented by Admiraal et al. (2013) which acknowledges the importance of the "insurance value" as an indirect value of biodiversity which contributes to the resilience and functions of ecosystems. Although valuation methods of ecosystem resilience and insurance values are still rudimentary, we incorporate it in our assessment as an ecosystem service and will try to determine its effect on other flows of marine ecosystem services through the use of portfolio theory (Figge 2004, Koellner and Schmitz 2006).

To date, only several ecosystem services' assessments have been carried out in the Israeli Mediterranean. UNEP Mediterranean Action Plan (UNEP/MAP) is, currently, the most comprehensive study on the benefits rendered by marine and coastal ecosystem services in the Mediterranean Sea. The study encompasses all countries bordering the Mediterranean and valuates six ecosystem services: provision of food resources, amenities, support for recreational activities, climate regulation, mitigation of natural hazards (coastal erosion) and waste processing. The benefits of these ecosystem services were valued at 1.109 billion Euros per year for the Israeli Mediterranean. The results, however, represent only a crude and often overestimated values of the benefits for the inspected ecosystem services. Although this publication serves as an important assessment and raises awareness among decision makers, it does not address future scenarios or the conditions that exist in Israel. In addition, only several local studies, focusing on marine ecosystem service within Israeli waters, have been conducted. The dearth of such detailed studies is mainly due to an acute lack of biological and ecological data regarding this marine environment, which imposes many research difficulties. Moreover, ecosystem services' indicators which were used in other studies of marine ecosystem services usually do not fit the local context and applying the benefit transfer valuation method (i.e. applying values obtained in other regions to Israeli context) might lead to erroneous results.

While previous attempts to estimate the total economic value of marine ecosystem in the Mediterranean (Mangos et al. 2010) focused on a limited number of ecosystem services, the proposed TEV will address a fuller spectrum of ecosystem services, estimating both use and non-use values. In addition, the valuation will take into account spatial heterogeneity and stochastic variances of relevant ecosystem services (Barbier 2012). Where applicable, a spatially explicit meta-modelling approach (Villa et al. 2009, Bagstad et al. 2012) will be used in order to assess changes in ecosystem services flows given the proposed scenarios (oceanic acidification and climate change).

2. Methodology

Ecosystem services included in this study are specified in table 1. Each chosen ecosystem services was monetarily valuated using appropriate valuation methods. Next, where applicable, spatial data was used in designated models, designed to produce either qualitative or quantitative (physical and/or monetary) evaluations of the different ecosystem services with spatio-temporal attributes.

Table 1. List of ecosystem services included in the study.

Ecosystem service type	Ecosystem service	Description
Provisioning	Food provisioning	Ecosystem's ability to provide consumable biomass (fisheries and mariculture)
Regulating	Climate regulation	Absorption and deposition of climate-changing substances in the seabed
	Wastewater treatment	Absorption and decontamination of effluents in the coastal and marine environment
	Coastal protection	Provide physical protection against coastal damages (storms and waves)
	Biological control	Ecosystem's inherent abilities to buffer against detrimental phase shifts (invasive species)

3. Economic valuation

Depending on the nature of the ecosystem service in question, specific on-site conditions and data availability, a suitable valuation method was applied. In the case of direct use values, e.g. from food provisioning, the most preferred and straightforward approach is the Market Price

Method, in which the market price of consumptive goods represent people's willingness to pay (WTP), usually a marginal value. Other types of values, e.g. indirect usage of ecosystem benefits in the form of waste treatment by biological organisms, can be inferred using methods such as replacement cost, which estimates the benefits of the ecosystem based on the cost of their artificial replacement (wastewater treatment costs in the case of waste treatment, for example). In the case of indirect use values, a broader spectrum of methods is available, and each ecosystem service can be valuated using different methods, depending not only on the type of service, but also its beneficiary and the nature of its usage. Such methods include revealed preferences, in which economic value is attained by observing individuals' behaviour and resulting expenses, or stated preferences where individuals are questioned directly on their economic preferences regarding certain ecosystem services' benefits.

Spatio-temporal modelling and mapping

In cases where knowledge gaps were encountered, probability-based models were used in order to cope with uncertainty related to ecosystem services' supply. Bayesian Belief Networks (BBN; also called probability networks) are customized, statistical instruments designed to project the influence of predictor variables on response variables and are highly suitable for ecological modeling. In Bayesian models, predictor variables feed into predicted variables through causative relationships. The possible states of each variable are chosen and the different probabilities of outcomes are set according to prior knowledge or expert advice. These probabilities are listed in Conditional Probability Tables (CPTs), in which the magnitude and impact of the different variables cascade through the model, ultimately determining the state of the predicted variable. The ARtifical Intelligence for Ecosystem Service (ARIES) modelling platform uses Bayesian modeling to assess and explore ecosystem services' supply. The ARIES platform uses spatial data sets as inputs to the BBN and models changes in the flow of ecosystem services. The main advantage of ARIES is its use of probability-based models as opposed to deterministic ecological models, enabling it to acknowledge missing or uncertain data and to extrapolate expected results with varying confidence levels. Another advantage of the ARIES platform is the ability to construct predictive models tailored to specific conditions and contexts. These attributes, together with the ability to update and train the different models with new data, provide the flexibility needed to address current knowledge gaps and uncertainties of marine ecosystems.

4. Ecosystem services valuation

Climate regulation

Our methodology taking into account the temporal aspect of carbon once it is removed from the atmosphere via the biological pump. Previous studies usually regarded only the fraction of sequestered carbon that was removed from the atmosphere for periods exceeding 100 years (Beaumont et al. 2008; Costanza et al. 2014; Murillas-Maza et al. 2011). However, the amount of carbon which remains within the ocean for shorter periods in effect contributes to the temporary reduction of greenhouse gasses and delays climate change phenomena. Thus, for each given period, we partitioned the flux of carbon into permanent and impermanent compartments.

Using this revised methodology and updated SCC values, taking into account future carbon values, we also expanded our historic data observations in order to detect interannual trends. Historic data from 1998-2015, coupled with the new methodology, revealed a decreasing trend of carbon sequestration (loss of 97 tons of sequestered carbon for the entire EEZ per year). In order to account for a possible range of values, different SCC values were chosen, reflecting possible social preferences towards tradeoffs between present and future values (Interagency Working Group on Social Cost of Greenhouse Gases 2016). Mapping of the spatial distribution of average annual carbon sequestration for the years 1998-2015 shows that most sequestered carbon is located near the shoreline (Figure 1). Depending on the chosen SCC value and discount rate, the valuation ranges between 25.53 and 122.34 million ILS per year (Table 2). The expected change in the value of climate regulation under different social discount rates and growth path of SCC values until 2050 shows a steady increase due to rising SCC values (figure 2).

Table 2. Annual average economic values of the climate regulation ecosystem service for the Israeli EEZ (1998-2015).

Discount rate	**Value (ILS/ton C)**	**Climate regulation value (Mill. ILS/year)**
5.0%	134	25.53
3.0%	477	84.28
2.5%	725	122.34

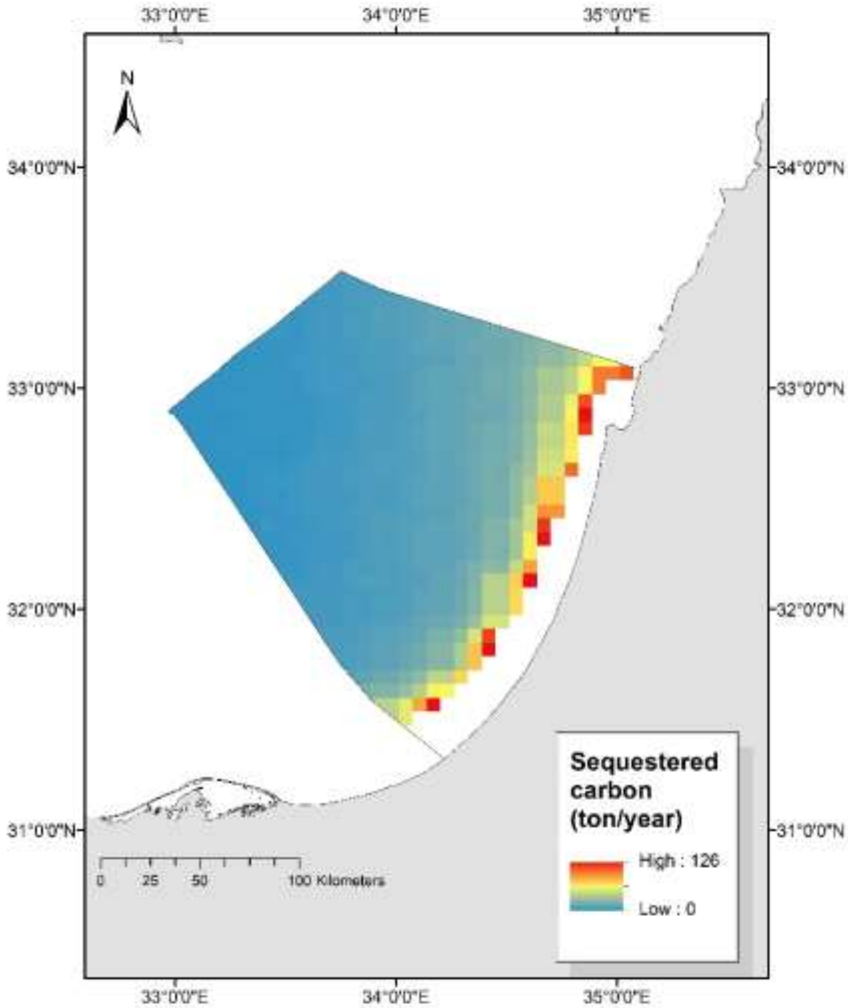


Figure 1.Spatial distribution of sequestered carbon (1998-2015). Each pixel has an area of ~3.5 km2.

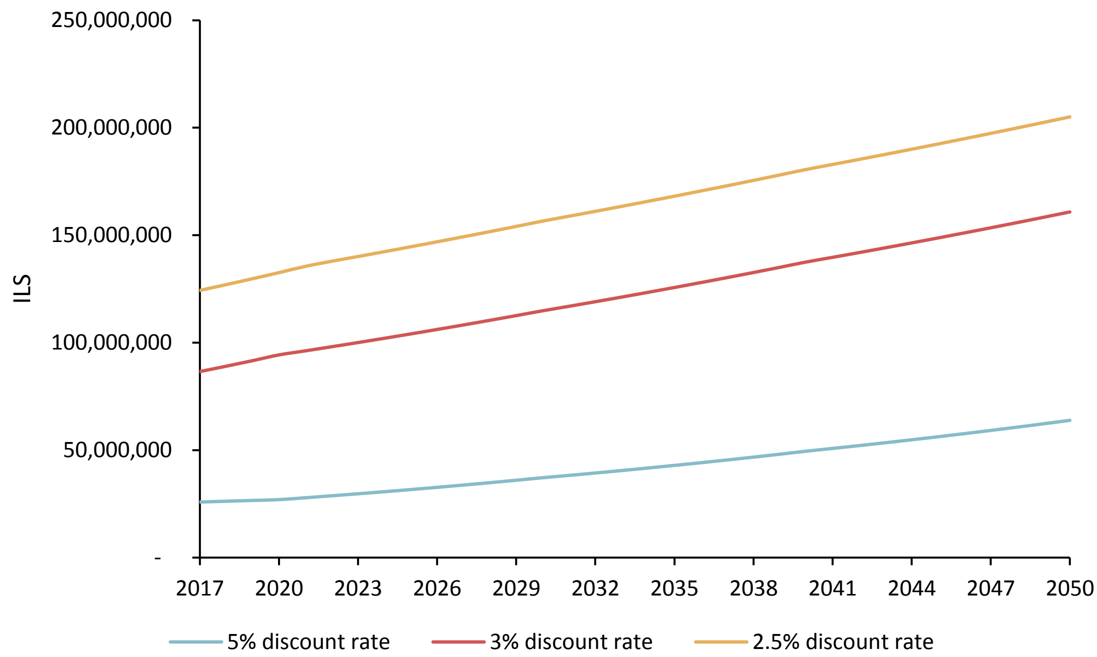


Figure 2. Projected climate regulation values until 2050 using different social discount rates.

Wastewater treatment

In this study, we defined the waste treatment ecosystem service as the ecosystem's ability to provide mitigation benefits to emitters through capture of eutrophication inducing pollutants, such as nitrogen and phosphorus. The marine environment thus functions as a virtual waste treatment plant, negating the users' need for effluent treatment and associated costs. The ecosystem treats excess nutrients until eutrophication conditions are achieved, in which point, its economic value is completely nullified. The analysis was comprised of an economic valuation of waste treatment and a probabilistic model designed to specify marine areas where excess inflow of nutrients may lead to eutrophication.

The economic valuation was based on the replacement cost method, in which the cost of replacing an ecosystem service serve as an estimate of its value. Nutrient treatment cost were derived from existing wastewater treatment plants and were multiplied by calculated nutrient emissions into the Mediterranean and the ecosystem's efficiency of treating these nutrients. The valuation was computed for three distinct periods: 2004, 2008 and 2012, yielding an average annual value between 52.3 - 178.2 million NIS, depending on the type of pollutant in question (table 3).

Table 3. Valuation results for the waste treatment ecosystem service

Pollutant	Cost of removal from wastewater (NIS/ton)	Discharged pollutants (tons)			Ecosystem removal efficiency	Total benefit (Million NIS.)		
		2004	2008	2012		2004	2008	2012
Nitrogen	33,594	7,711	7,299	4,887	80%	207.2	196.2	131.3
Phosphorus	168,654	1,179	2,275	1,196	20%	39.8	76.7	40.3

Figure 3 presents the results of the probabilistic model, which assessed the probability of the development of eutrophic conditions given additional input of nutrients into the marine environment. This analysis serves as a spatio-temporal mapping of areas where the waste treatment ecosystem service might become a dis-service given certain environmental conditions.

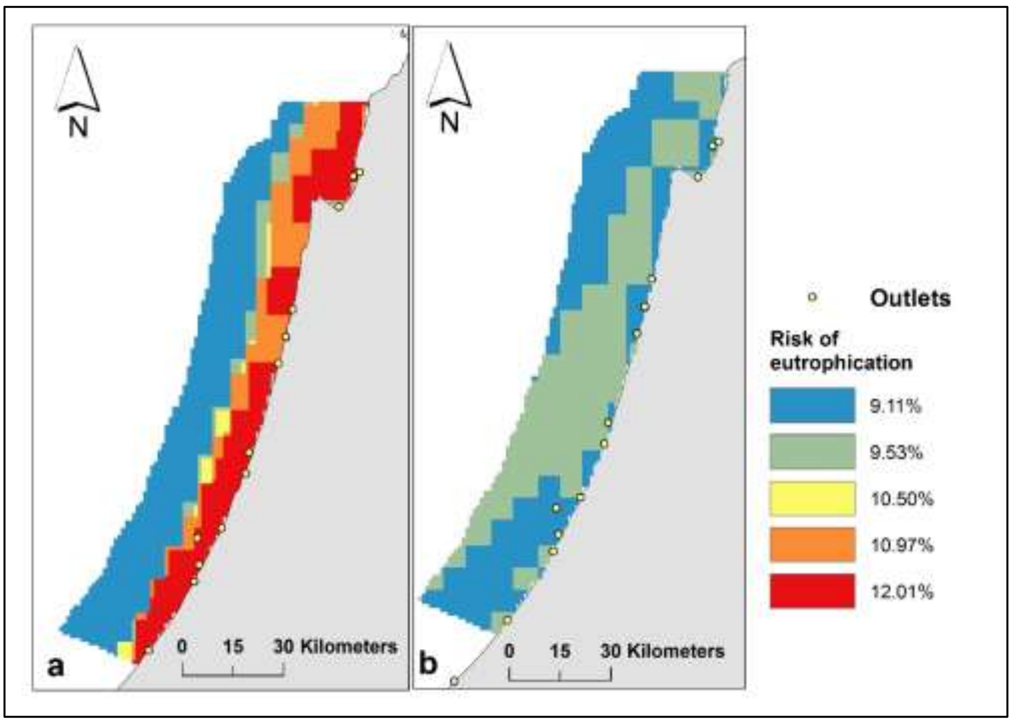


Figure 3. Eutrophication probability due to increased nutrient concentrations for July (a) and January (b).

Coastal protection

About 10% of Israeli coasts are home to vermetids, which form unique biogenic habitats upon abrasion platforms. These habitats, known as vermetid reefs, provide coastal protection against coastal erosion and inundation. However, in recent years, environmental pressures threaten the future existence of the organism (*Dendropoma petraeum*) responsible for maintaining this unique habitat. There exist a considerable knowledge gap regarding vermetid reefs and their current and future functioning are still unknown. Given the high uncertainty and lack of data, our valuation of the coastal protection provided by this habitat relied on the replacement cost method. By valuating suggested artificial means to preserve the functionality of this habitat, we calculated the benefits of coastal protection associated with the vermetid reefs (table 4). The annual economic value of this ecosystem was based on ongoing maintenance costs coupled with discounted construction costs (30 year period).

Table 4. Economic valuation of artificial replacement costs of vermetid reefs

	% replacement of vermetid reefs	Construction costs (million NIS)	maintenance costs (million NIS/year)
Low estimate	1%	38.69	2.81
High estimate	3%	154.78	13.13

In addition, spatial analysis was performed for areas adjacent to vermetid reefs in order to map protected areas and their importance. Areas susceptible to flooding due to increased sea-levels or coastal surges were also mapped. Figure 4 presents an analysis for Dor beach, along the Israeli coast.

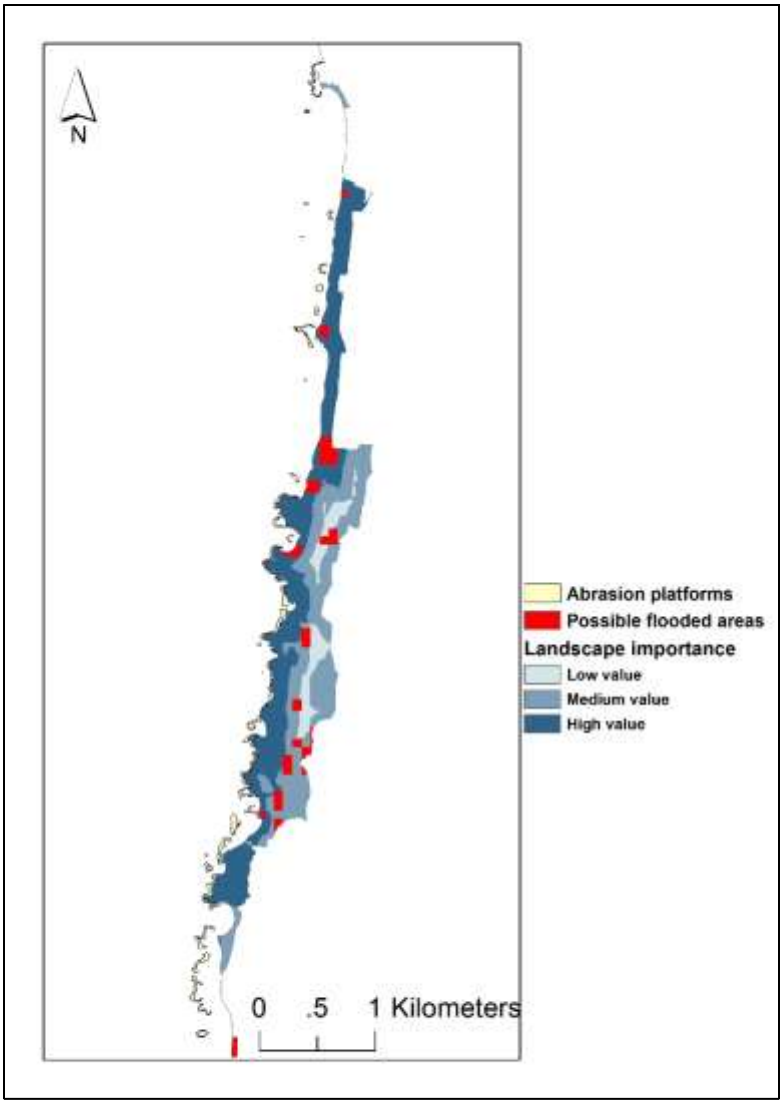


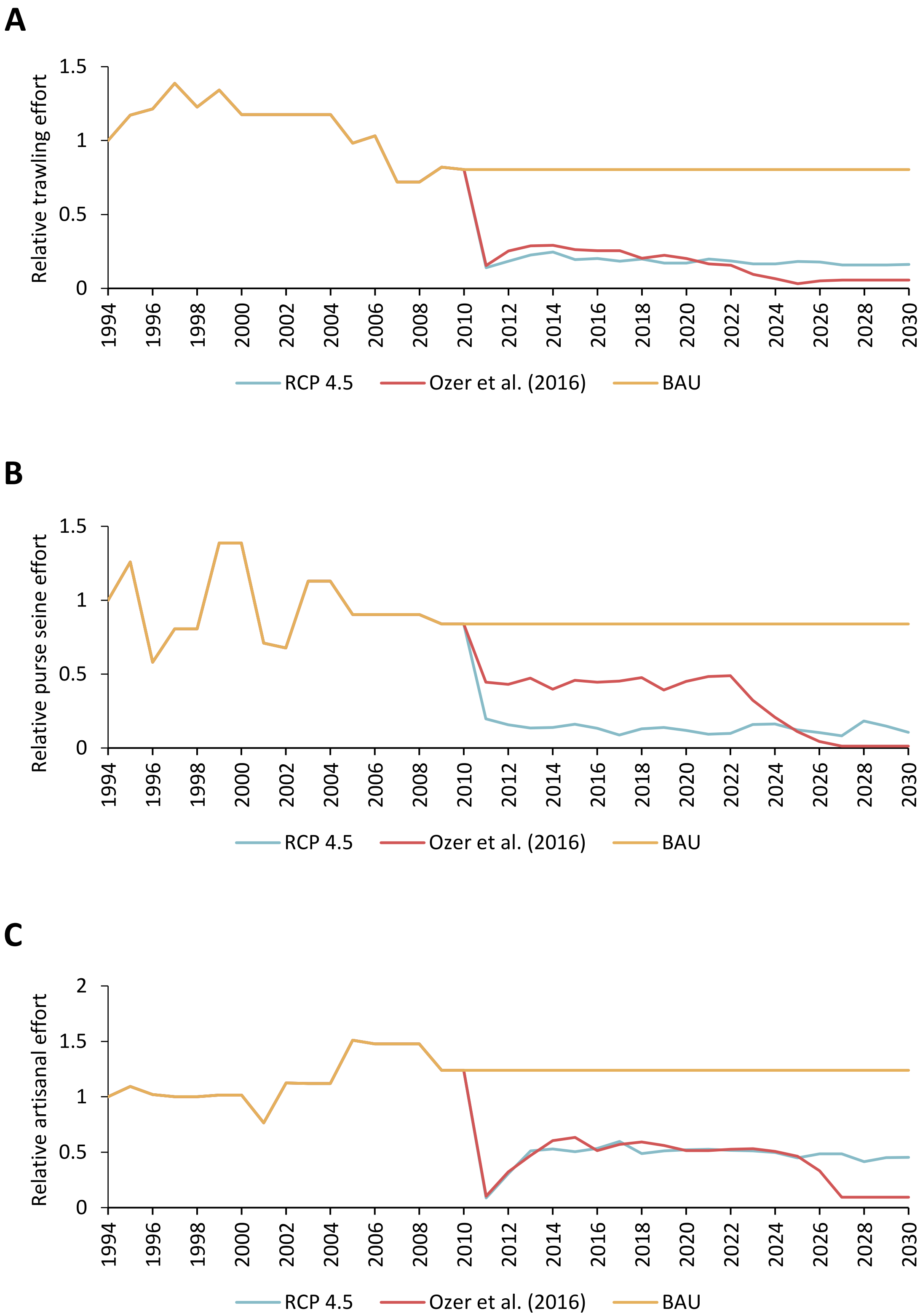
Figure 4. Areas protected by vermetid reefs, classified by their landscape importance and areas where inundation might occur.

Food provisioning

The food provisioning ecosystem service was analyzed in order to explore sustainable management of the fishing effort in the Israeli Mediterranean, under different climate change scenarios. Sustainable fishing was defined under the concept of Maximum Economic Yield (MEY), i.e. attaining catch levels that maximize fishing revenues and costs, while maintaining renewable biomass stocks. The non-selective nature of the various commercial fishing methods employed in Israel (trawling, purse seine, artisanal fishing) necessitate the need for achieving Multi-species MEY (MMEY), i.e. setting general fishing effort levels that results in overall MEY of the entire fished biomass.

In order to discover recommended effort levels for MMEY, the Ecopath with Ecosim (EwE) model for the Israeli Mediterranean, coupled with the Management Strategy Evaluation (MSE) module within the EwE platform were applied. Our bioeconomic approach explored the dynamics of different fishing efforts on the various fished groups represented in the model, and how their biomass might change as a result. In addition, expected trends in fishing costs (due to rising fuel prices) and fish prices were used to derive a possible range for the model to operate in. Using Monte Carlo simulations, multiple runs of the bioeconomic model were carried out, resulting in mean recommended effort levels. These effort levels were then used as input to the original EwE model, resulting in expected changes in biomass, catch and revenue in the Israeli fishing sector and underlying ecosystem. The methodology was applied under two climate change scenarios: the first, a general Intergovernmental Panel on Climate Change (IPCC) model for the Eastern Mediterranean (named RCP 4.5) predicting an annual increase of 0.05°C. The second, based on historically measured temperature trends in the Israeli Mediterranean (Ozer et al. 2016) representing an annual increase of 0.12°C. MMEY effort was then compared to Business as Usual (BAU) effort levels, under the two climate change scenarios, resulting in four scenarios in total (BAU and MMEY under RCP4.5 and Ozer et al. (2016)).

The bioeconomic model resulted in different effort recommendations, depending on the climate scenario (figure 4). Under each fishing method and climate scenario, the model recommends a significant reduction in effort. The effort reduction is expected to lead to changes in fishery profits. Under the two climate change scenarios, the model predicts an economic loss of 185.06-262.98 million ILS in fishery profits due to reduced catch caused by reducing effort levels (figure 5). It is important to note that for while artisanal effort levels are reduced, the overall profit levels for this fishery sector are expected to increase. There is a tradeoff between reduced profits and ecological gains. Under the recommended effort levels in both climate change scenarios, the overall biomass levels of both local and invasive species' groups represented in the model are expected to increase (figure 6). However, in the case of the invasive species, the increase in biomass under the recommended effort is more moderate than BAU scenarios, hinting at a possible control of invasive species by local species. This finding is only relevant in the case of no expected change in invasion rates, which is the model's basic settings. In addition, under the Ozer et al. (2016) climate change scenario, recommended effort levels induce an increase in local species' trophic level (Pane C) while in terms of invasive species, under the two climate scenarios, the model's recommended effort levels result in lower trophic levels, suggesting another form of control over invasive species (Pane D).



A
Relative trawling effort
1.5
1
0.5
0
B
Relative purse seine effort
1.5
1
0.5
0
C
Relative artisanal effort
2
1.5
1
0.5
0
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
RCP 4.5
Ozer et al. (2016)
BAU

Figure 4. Business As Usual and recommended effort (relative to 1994 effort levels) according to the bioeconomic model for the two climate scenarios (RCP 4.5 and Ozer et al. (2016)). Pane A: trawling effort. Pane B: purse seine effort. Pane C: Artisanal effort.

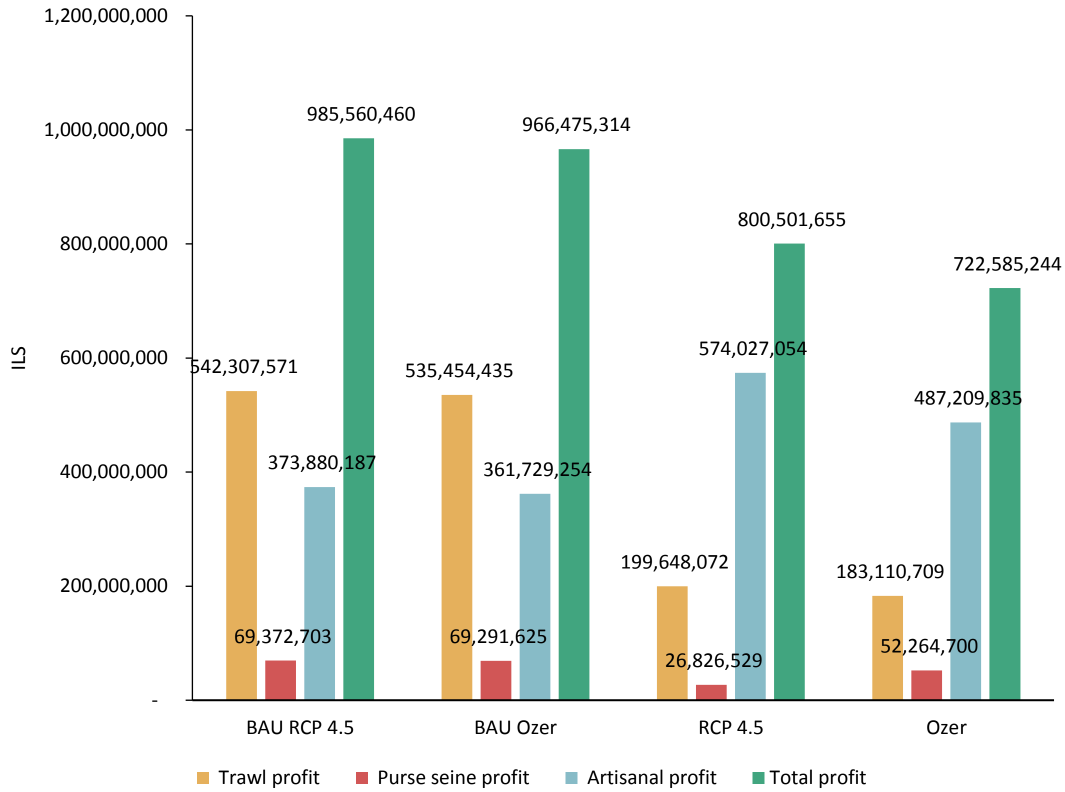
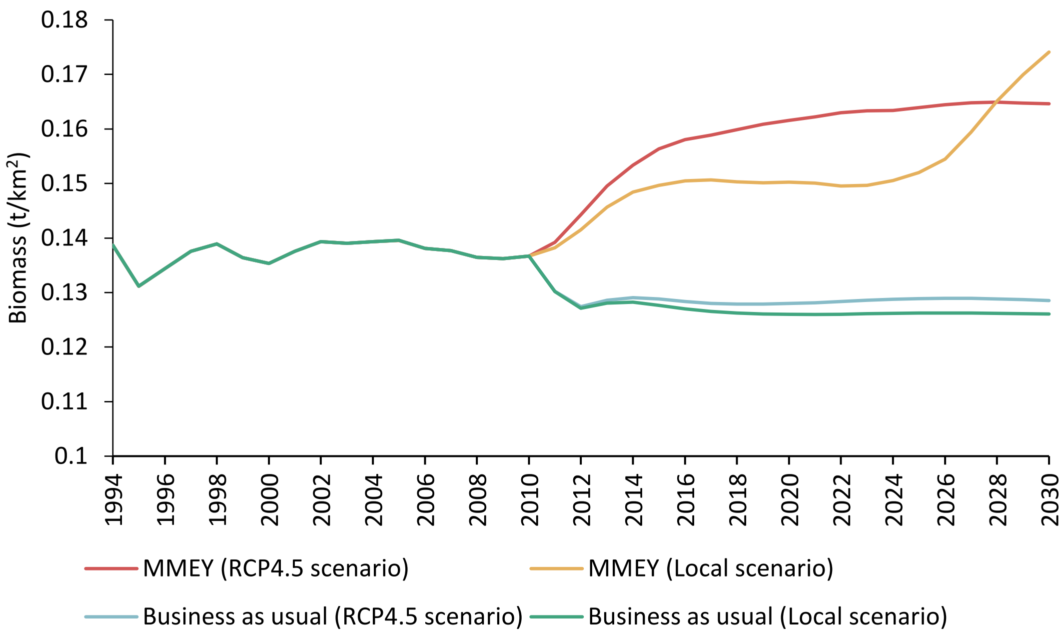


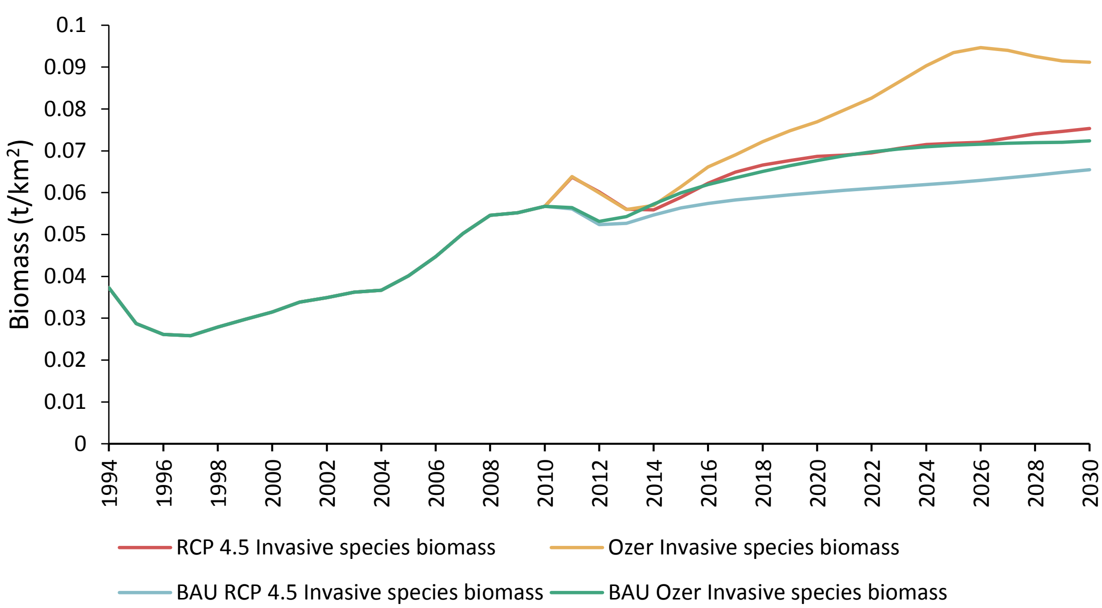
Figure 5. Fishery sector Net Present Value (at 3% rate discount rate) of profits (years 2011-2030) under the different scenarios.

A



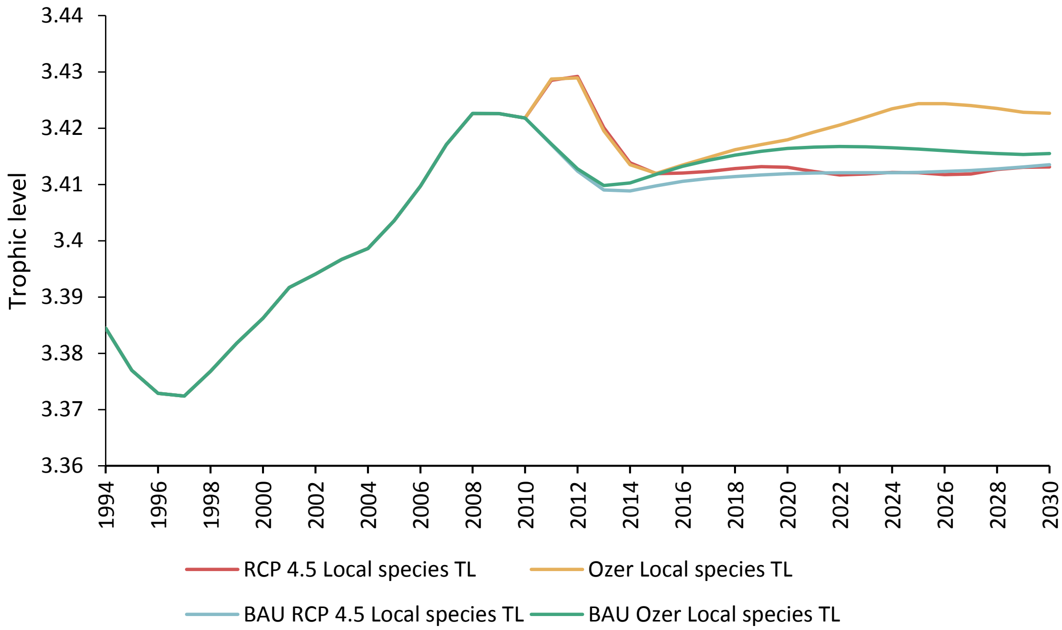
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
Biomass (t/km^2)
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
MMEY (RCP4.5 scenario)
MMEY (Local scenario)
Business as usual (RCP4.5 scenario)
Business as usual (Local scenario)

B



0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Biomass (t/km^2)
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
RCP 4.5 Invasive species biomass
Ozer Invasive species biomass
BAU RCP 4.5 Invasive species biomass
BAU Ozer Invasive species biomass

C



D

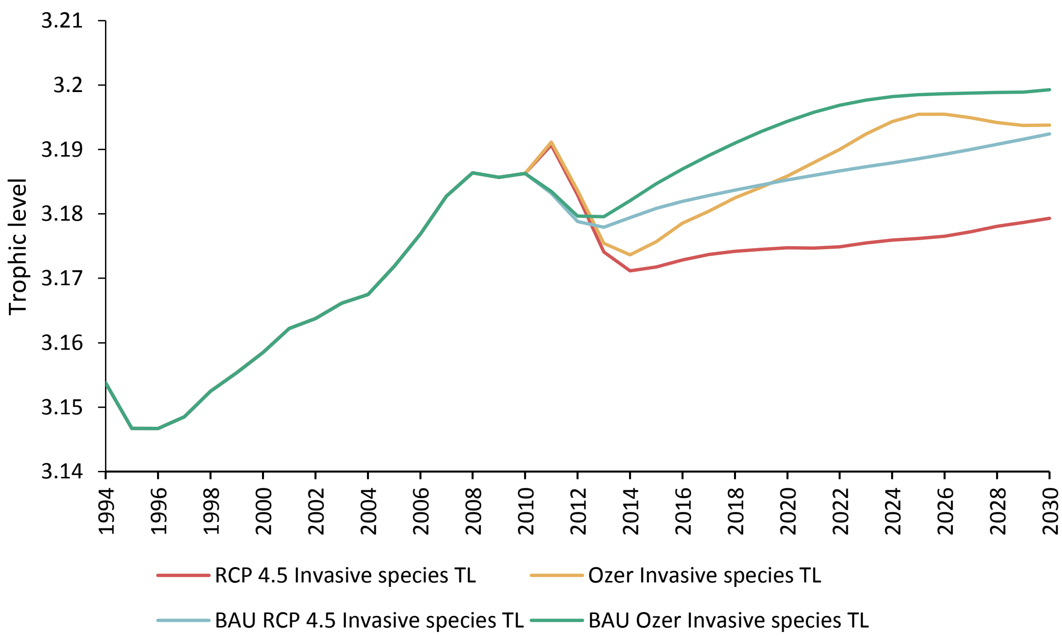


Figure 6. Biomass (in t/km2) and trophic levels under the four scenarios. Pane A: Local fish species' biomass. Pane B: Invasive fish species' biomass. Pane C: Local species' trophic level. Pane D: Invasive species' trophic level.

Biological control

Biological control is the attenuation of adverse economic losses to different stakeholders due to increased presence of harmful invasive species in the Israeli Mediterranean. Potentially increasing biomass levels of marine biodiversity functioning as potential predators to jellyfish and increases in local species, competing with invasive species, might reduce future income losses associated with invasive species. The biological control model is based on valuating the effect a marginal increase in ecosystem resilience (e.g. increase in potential jellyfish predators) on stakeholders' welfare. The model computes the reduced possibility of income loss due to increase in ecosystem resilience by taking into account parameters associated with the ecosystem's tendency to move into a new ecological regime, in which the effects of invasive species are more prevalent. The biological model includes stakeholders: 1) fisheries (trawlers and longliners), which experience declines in revenues due to decrease local catch (which is more valuable than invasive catch); 2) powerplants, which suffer from periodic decreases in production levels associated with infrastructure clogging due to jellyfish blooms; 3) beach recreationalists, which suffer from jellyfish stings during summer months. The biological control model attempts to predict the economic losses that will be spared from these stakeholders if marine policy actions will be undertaken to improve the existing ecosystem ability to counter the harmful effects of invasive species. In the case of the updated model, the policy was defined as a 5% biomass increase in jellyfish larva predators and a 5% increase in biomass-weighted-mean trophic level of local species. The total expected economic loss for the different sectors is detailed in table 5. Due to present knowledge gaps and poor understanding of various aspects associated with invasive species (jellyfish in particular), a probabilistic model, able to take into account existing uncertainty, was constructed using scientific literature and expert opinion. The probabilistic model then feeds into a final model, computing the biological control values of existing biodiversity in the Mediterranean (Baumgärtner and Strunz 2014). The results indicate that increased biodiversity levels (jellyfish predator biomass and biomass-weighted trophic levels) in rocky areas, close to the shoreline, deliver most of the biological control (Figure 7). Biological control hotspots include Haifa bay, the Carmel area and kurkar ridges in central and southern Israel.

Table 5. Stakeholders' potential income loss due to invasive species

Stakeholder	**Potential economic losses (ILS/year)**
Power plants	640,246
Trawlers	2,321,712
Longliners	1,730,632
Recreationalists	49,411,725

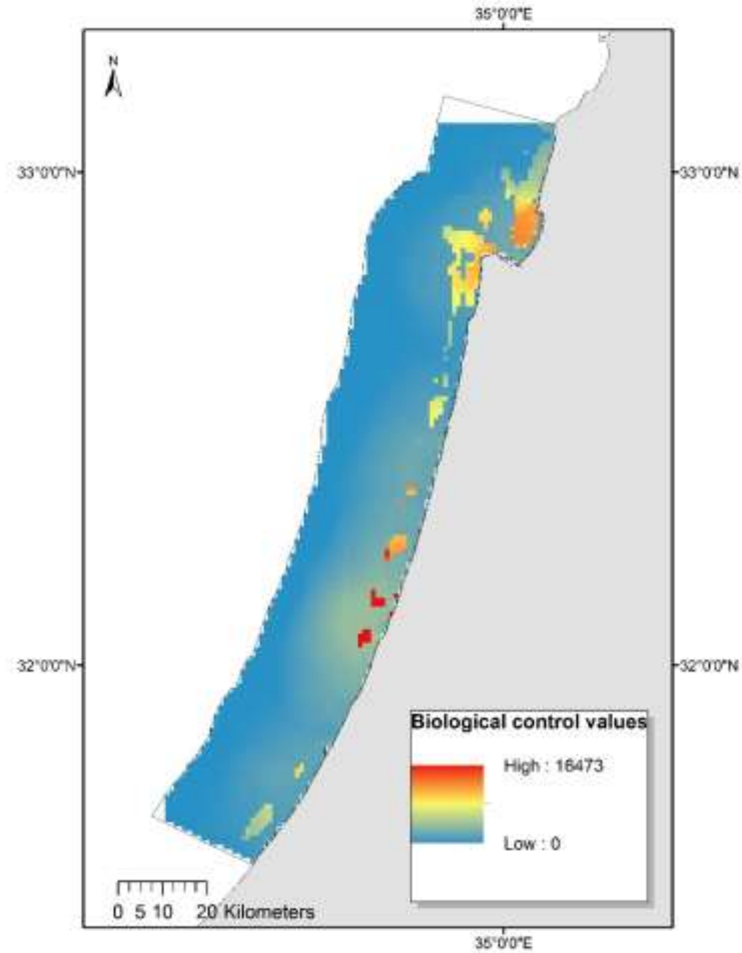


Figure 7. Biological control values for the Israeli Mediterranean. Each pixel with an area of ~0.75 square kilometers. Values in ILS/year.

5. Conclusion and discussion

The spatial analyses carried out in this study can provide, for the first time, decision makers and stakeholders with tools and insights regarding the crucial areas, within the Israeli Mediterranean, from which they receive benefits. The results clearly show that for the surveyed ecosystem services, most economic values tend to be concentrated along the continental shelf, most likely because of the high primary productivity, which acts as a supporting infrastructure to most of the ecosystem processes and their services.

Due to considerable lack of data regarding all ecosystem services, the assessments carried in this study relied on conservative estimations for the parameters used in the valuation in order to avoid overestimated values. Therefore, the economic magnitude of the investigated ecosystem services can be regarded as baseline for future valuations.

Given the results obtained in this study, several difficulties were observed during the study:

1. The main hindrance detected in this study is the acute lack of ecological and physical data in the Israeli Mediterranean. As the Israeli marine environment been scantily explored over the years, our knowledge base for conducting valuations is often incomplete and rudimentary. In order to counter this problem, we employed probabilistic modelling. However, further understanding of the processes that govern this environment will grant us with valuable information necessary for better management of the marine ecosystem.

2. The spatial analyses carried out in this study relied on remotely-sensed data. Based on these data, the constructed models for analyzing ecosystem services can provide us a coherent picture of value trends. However, spatial resolution plays a key role in understanding the impact of ecosystem services on beneficiaries, especially when considering small scale areas of interest (such as beaches or specific mariculture infrastructure). Thus, obtaining data with high resolution is crucial for obtaining results with the closest match to conditions on site.

3. For the biological control ecosystem service, key components of the assessment (such as ecosystem resilience and elasticity) relied on indicators which can successfully emulate the components' magnitude of influence within the model. The indicators that were used, however, proved to be fairly generalized and as a result, the model outcomes exhibited similar generality. Further research and understanding of the appropriate and desirable indicators will surely hone future model analyses.

4. For the waste treatment ecosystem service, the need for a baseline nutrient balance (with distinction between various nutrient input sources) is clearly apparent. By providing models relying on observed data with initial conditions of the nutrient budget of the Israeli Mediterranean, a spatial valuation of the benefits of this ecosystem service can be achieved. In addition, continued studies of anthropogenic nutrient emissions to the Israeli Mediterranean will provided ongoing understanding of the magnitude of benefits obtained by the marine environment over time.

5. For the climate regulation ecosystem service, several generalizing assumptions were had to be made in order to provide the evaluation. Given *in-situ* measurements of relevant parameters, the results of the model will provide a fuller picture of the magnitude of the ecosystem service.

6. For the coastal protection ecosystem service, the almost complete lack of data regarding the habitat which is responsible for supplying this ecosystem service proved to be a major difficulty. Ecological research and understanding of future threats to vermetid reefs is essential for future valuations.

Conclusions

The overall results clearly show that, from an economic viewpoint, the Israeli Mediterranean benefits a wide array of stakeholders and that accounting for the total economic value of its ecosystems gives policy makers and institutions a better understanding of possible trade-offs between various economic gains associated with marine and coastal development. The ability to locate high-value areas is manifested in the project's spatial mapping and analysis of the different ecosystem services.

The implementation of our research also enabled us to update existing literature and scientific methods related to ecosystem services in a global scale. The methodology developed for the climate regulation aided in criticizing previous works and valuation carried out in other contexts and resulted in a scientific publication (Peled et al. 2018).

2. References

Assif, Shamay, Michelle E. Portman, Yuval Cohen, Ellik Adler, Idan Porat, Yael Teff-Seker, Varda Spier, et al. 2015. "The Israel Marine Plan." Technion - Israel Institute of Technology.

Baumgärtner, Stefan, and Sebastian Strunz. 2014. "The Economic Insurance Value of Ecosystem Resilience." *Ecological Economics* 101 (May): 21–32. https://doi.org/10.1016/j.ecolecon.2014.02.012.

Beaumont, N.J., M.C. Austen, S.C. Mangi, and M. Townsend. 2008. "Economic Valuation for the Conservation of Marine Biodiversity." *Marine Pollution Bulletin* 56 (3): 386–96. https://doi.org/10.1016/j.marpolbul.2007.11.013.

Corrales, X., E. Ofir, M. Coll, M. Goren, D. Edelist, J.J. Heymans, and G. Gal. 2017. "Modeling the Role and Impact of Alien Species and Fisheries on the Israeli Marine Continental Shelf Ecosystem." *Journal of Marine Systems* 170 (June): 88–102. https://doi.org/10.1016/j.jmarsys.2017.02.004.

Costanza, Robert, Rudolf de Groot, Paul Sutton, Sander van der Ploeg, Sharolyn J. Anderson, Ida Kubiszewski, Stephen Farber, and R. Kerry Turner. 2014. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26 (May): 152–58. https://doi.org/10.1016/j.gloenvcha.2014.04.002.

Interagency Working Group on Social Cost of Greenhouse Gases. 2016. "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866."

Murillas-Maza, Arantza, Jorge Virto, María Carmen Gallastegui, Pilar González, and Javier Fernández-Macho. 2011. "The Value of Open Ocean Ecosystems: A Case Study for the Spanish Exclusive Economic Zone." In *Natural Resources Forum*, 35:122–133. Wiley Online Library. http://onlinelibrary.wiley.com/doi/10.1111/j.1477-8947.2011.01383.x/full.

Ozer, Tal, Isaac Gertman, Nurit Kress, Jacob Silverman, and Barak Herut. 2016. "Interannual Thermohaline (1979–2014) and Nutrient (2002–2014) Dynamics in the Levantine Surface and

Intermediate Water Masses, SE Mediterranean Sea." *Global and Planetary Change*, April. https://doi.org/10.1016/j.gloplacha.2016.04.001.

Peled, Yoav, Shiri Zemah Shamir, Mordechai Shechter, Eyal Rahav, and Alvaro Israel. 2018. "A New Perspective on Valuating Marine Climate Regulation: The Israeli Mediterranean as a Case Study." *Ecosystem Services* 29 (February): 83–90. https://doi.org/10.1016/j.ecoser.2017.12.001.