Valuing Ecosystem-Based Fisheries Management in Malta: A Discrete Choice Experiment to Elicit Preferences and Willingness to Pay

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Introduction

Background and Motivation

- The ocean, covering over 70% of the Earth's surface, plays a pivotal role in delivering ecosystem goods and services that sustain life and contribute to the wellbeing of billions of people across the globe.
- Over the years, anthropogenic pressures on marine ecosystems have intensified:
  - Overfishing (e.g., FAO, 2024).
  - Pollution from multiple sources (e.g., Jambeck et al., 2015).
  - Loss of biodiversity (e.g., Lotze et al., 2006).
  - Climate change (e.g., Gaines et al., 2019).
- Such pressures are reducing the continued ability of marine ecosystems to sustain our lives across a number of dimensions, including health, economic activities and social interactions.
- There is a historical legacy of piecemeal management that has focused on single sectors of activity and failed to consider marine ecosystems as interconnected wholes, leading to negative consequences.

Background and Motivation

- One classic example of the resulting negative consequences where this has happened is in fisheries management.
- Why? Through the lens of an Economist:
  - Absence of Property Rights (i.e., common-pool resources) which are Rival and Non-Excludable.
  - Inability to internalise externalities

    $\rightarrow$ Tragedy of the Commons (Hardin, 1963)
- This is manifested as overfishing and illegal, unreported, and underregulated fishing (Ba et al., 2018; Lopez-Rivas & Cardenas, 2024).

Objective

This study undertakes an economic valuation of the potential implementation of Ecosystem-Based Fisheries Management(EBFM), using a stated preference approach and leveraging Malta — a country that currently does not employ EBFM — as the case study.

Key Contributions

1. By adopting a more comprehensive definition of EBFM (see for example Long et al., 2015; Trochta et al., 2018), it advances the field of economic valuation of EBFM by employing a DCE to elicit respondents' preferences, WTP, and the trade-offs in preferences related to EBFM, an area that has been underexplored.

2. Highlights the importance of non-use values in marine ecosystems.

3. It is the first empirical valuation of EBFM within the Mediterranean context of Malta, offering critical insights for fisheries managers and policymakers.

4. The findings are not only relevant to Malta, a small island state with a high reliance on the fisheries sector and vulnerability to marine ecosystem stressors but are also likely applicable to other small island states facing similar challenges.

5. Contributes to the achievement of the 2030 Agenda for Sustainable Development, particularly Sustainable Development Goal (SDG) 14, which addresses "life below water" alongside interconnected goals, such as "decent work and economic growth"(SDG 8), and "climate action"(SDG 13).

Preview of Results

- Four out of every five people in Malta are willing to pay a premium for fish which carry one or more EBFM labels.
- The premiums range between 125.9% and 163.1% for fish carrying EBFM labels compared to the original price of an unlabeled alternative.

Literature

Ecosystem-based Fisheries Management

- EBFM is widely acknowledged as a promising solution for mitigating anthropogenic pressures on marine ecosystem services as it aims to holistically integrate ecological, economic and social considerations into fisheries management (see for example Scotti et al., 2022).
- The effective application of EBFM hinges on the value of marine ecosystem services.
  - Provisioning services: physical outputs derived from marine environments, such as fish.
  - Regulating services: benefits arising from ecosystem-mediated processes, including climate regulation and carbon sequestration.
  - Cultural services: intangible values ecosystems provide, such as aesthetic appreciation and spiritual fulfillment.
  - Supporting services: underpin all other ecosystem functions, such as nutrient cycling and the maintenance of biodiversity and marine habitats. (Millenium Ecosystem Assessment, 2003)

Valuing Non-Market Services

- Recognize marine ecosystems as critical natural capital fundamental to sustaining public goods and delivering a wide range of direct and indirect ecosystem services (Fenichel et al., 2023).
- While some of these services are associated with implicit markets, others do not. The challenge, therefore, lies in understanding how people value these non-market services and how such valuations can inform trade-offs in policy and practice (Murillas-Maza et al., 2011).
- Revealed preference methods are inapplicable as such methods are limited to use values (Börger et al., 2018).

→ For this reason, stated preference methods, in particular, *Discrete Choice Experiments* (DCE), are usually preferred (Hoyos, 2010; Johnson & Geisendorf, 2022).

Discrete Choice Experiments

- DCEs involve the generation and analysis of choice data through hypothetical scenarios using a survey.
- Respondents are presented with multiple choice sets, each comprising mutually exclusive hypothetical alternatives, and are asked to select their preferred choice.
- Alternatives are characterized by a set of attributes, each of which has varying levels. The choices made by individuals reflect implicit trade-offs among these attribute levels in the different alternatives included in the choice set.
- By including cost or price as one of the attributes, marginal utility estimates can be converted to willingness-to-pay (WTP) estimates for changes in attribute levels.
- Experimental designs are employed to construct choice sets with uncorrelated attributes, ensuring robust and unbiased parameter estimates (Hoyos, 2010).

Discrete Choice Experiments on EBFM

- Despite the increased popularity of DCE in many environmental-based studies, applications in marine contexts remain underrepresented in the literature compared to terrestrial counterparts (Börger et al., 2018; Lopez-Rivas & Cardenas, 2024).
- Indeed, a recent study by Lopez-Rivas and Cardenas (2024), which undertook a systematic literature review combined with a meta-analysis to investigate the economic valuation of coastal and marine ecosystem services, identified only 10 studies that utilized choice experiments (CEs) as their principal valuation methodology.
- Despite their importance, CEs for evaluating the adoption of EBFM emerge as an even more elusive area within the existing body of literature (Wattage et al., 2011).

Labelling outcomes

- While several studies claim to use employ choice experiments to value the application of EBFM, the authors observe that, although the concept of EBFM continues to evolve, the lacking a of universally accepted definition or standardised application, the resulted with studies reviewed adopting a narrowly defined interpretation of EBFM, thereby overlooking important criteria on the EBFM checklist (Long et al., 2015; Trochta et al., 2018).
  - For example Ankamah-Yeboah et al. (2021) and Mulatu et al. (2018) neglect the key principles of inclusive and adaptive management.
  - Fernández-Polanco et al. (2013) and Fonner and Sylvia (2015) report WTP values of €4.98/kg and €5.20/kg for the sustainability attribute.
  - Rudd et al. (2011) estimate a WTP of €3.59 for reduced local environmental impact and €3.02 for reduced global environmental impact.

Research Area

Small island State situated in the heart of the Mediterranean

- The maritime space of Malta constitutes a much larger geographic area than its terrestrial counterpart.
- Fisheries & aquaculture contributed €348M in turnover (2022), 5.9% of Malta's exports. Highest GVA share in EU from the sector at 0.5%, ahead of Greece (0.45%) & Portugal (0.23%). Over 4x growth in turnover and value-added since early 2000s.
- Malta is particularly vulnerable to current and projected climate change impacts, making the preservation of functioning marine ecosystems a necessity. Indeed, The Mediterranean Sea exemplifies how the cumulative effects of multiple anthropogenic stressors can degrade marine ecosystem services, particularly in food provision. Indeed, widespread overfishing, leading to the depletion of fish stocks beyond sustainable biological limits, remains a pressing issue in the Mediterranean (Froese et al., 2018).

Choice Experiment

EcoScope

- The CE employed in this study was embedded as part of a large-scale socio-economic survey conducted for the EcoScope project.
- The survey aimed to assess public perceptions, preferences, and expectations regarding current fisheries management and EBFM in Europe and estimate the economic value associated with key EBFM attributes.
- Respondents were asked to envision purchasing the same fish species (dolphinfish - Ecoscope consortium) from their usual retailer, labelled to reflect distinct EBFM attributes. Each label corresponded to specific characteristics of EBFM, with detailed descriptions provided to facilitate informed decision-making.
- Respondents were presented with fish of the same species and size but harvested by different fisheries, each bearing a unique label(s) representing EBFM attributes set at varying levels. Each option featured distinct prices and attributes.

Choice of attributes and attributes level

- Following an extant literature review and stakeholder consultations, the following attributes and levels were identified:

Attribute	**Description attribute**	**Levels**
Sustainably Harvested-No overfishing	When dolphinfish has this label, it means that management ensures that no overfishing occurs. Dolphinfish stocks remain productive and healthy enough to allow the same fishing outtake to continue in future. However, this cannot be guaranteed when the dolphinfish has no such label.	No label (blank)
		Sustainable Stocks
	A "High" performance level ALSO allows for a safety buffer so that if conditions in the marine environment change, dolphinfish stocks still remain productive and healthy in future.	Sustainable Stocks (High)

Choice of attributes and attributes level

Attribute	Description attribute	Levels
Protects Marine Life - Minimised impact on habitats and species	When dolphinfish has this label, this indicates that the fishery ensures that any impact on sensitive marine habitats and vulnerable species is minimised. But when the dolphinfish has no such label, this cannot be guaranteed.	No label (blank)
		Protects Marine Life
	A "High" performance level means that any impact on ALL marine habitats and other species is minimised.	Protects Marine Life (High)

Choice of attributes and attributes level

Attribute	Description attribute	Levels
Climate Friendly - Low Carbon Dioxide (CO2) emissions per kg	When dolphinfish has this label, this means that the carbon dioxide (CO2) emissions from vessel operations are capped at 1.5 kg per kg of dolphinfish. When dolphinfish has no such label, low emissions cannot be guaranteed.	No label (blank)
		Climate Friendly
	A "High" performance level means that the (CO2) emissions from vessel operations are kept at 0.5 kg per kg of dolphinfish. (By way of comparison, 2.3 kg of CO2 are generated from a litre of gasoline).	Climate Friendly (High)

Choice of attributes and attributes level

Attribute	Description attribute	Levels
Inclusive Management - Information and stakeholder involvement in decision-making	When dolphinfish has this label, this means that fishery's management publicly provides comprehensive information on management decisions. When dolphinfish do not have such a label, this cannot be guaranteed.	No label (blank)
	A "High" performance level means that management publicly provides comprehensive information and involves community stakeholders in management decisions.	Inclusive Management (High)
Price	Price per kilogram of dolphinfish	€9 per kg €10.35 per kg €12.60 per kg €14.27 per kg

Design Properties

- To construct the choice sets, a Bayesian D-efficient design was employed.
- A pilot study was undertaken (both in English and in Maltese) to ensure the survey's validity and reliability. This stage assessed whether the questions were clear, comprehensible, and free from ambiguity, with any identified issues addressed before full implementation (de Leeuw et al., 2012).
- Pre-testing was conducted with approximately 10% of the targeted sample size, serving as an important step in confirming the feasibility of estimating the selected choice model before starting the primary data collection.
- A heterogeneous design of 36 different choice cards was eventually designed. Ngene was instructed to group the choice cards (scenarios) into four blocks. Respondents were randomly split into these four blocks, with each respondent answering a total of nine choice cards.

Example of a Choice Card

Q9.2. Which of these 3 options would you buy, A, B, or C?

EcoScope Questionnaire

- Beyond the choice experiment, the survey included a wide array of questions addressing demographic information, self-reported well-being, lifestyle, exposure to marine ecosystem services, fish consumption habits, food security concerns, perceptions of fishery impacts, general and fishery-specific policy preferences, and willingness to engage in reporting illegal or hazardous marine activities (Briguglio et al., 2024).

Data Collection

- A self-administered online survey was conducted between July 5 and August 18, 2023, using quota-based sampling to ensure national representativeness by age, gender, region, and education. Participants were recruited and compensated by a professional survey company, with informed consent obtained and anonymity preserved throughout.
- Randomisation techniques ensured balanced sub-samples, and daily quota monitoring enhanced representativeness. After rigorous data cleaning, including exclusion of low-quality responses, the final sample consisted of 503 respondents completing nine choice tasks each—yielding 4,500 valid observations with a margin of error below 5%.

Choice Modelling

Multinomial Logit Model (MNL)

Building on Lancaster's (1966) theory of demand, we assume that respondents derive utility from the attributes of a good rather than the good itself. Their decisions are influenced by these attributes and are modelled within the random utility model framework (McFadden, 1973).

$$U_{ij} = V_{ij}(X_{ij}) + e_{ij} = \beta_{ij} X_{ij} + \epsilon_{ij}$$

- Where X_{ij} is the vector of the attributes comprising the alternative j consumed by participant i,
- β_i is the vector of random preferences specific to i, and
- ϵ_{ij} is the random error factor specific to the participant and the alternative.

Mixed Logit Model (MXL)

The MNL suffers from two limitations:

- IIA property - the relative likelihood of choosing from A from B won't change if a third choice is placed into the mix.
- limited ability to explicitly account for preference heterogeneity by allowing parameters to vary randomly across the sample population, capturing each individual's unique preferences.

$\rightarrow$ The MXL model addresses the above.

Results

Descriptive Statistics

Variable	Description	Mean	St. Dev.
Demographics			
Gender	Male/Other = 0, Female = 1	0.5	0.5
Age	Increasing from 18 years	44.9	15.8
Education	Education (ISCED bands, no schooling [1] to Doctoral [8])	4.9	1.5
Employment Status	Employed = 0, Unemployed/inactive = 1	0.0	0.1
Personal Income	Income brackets [1 = <€5,001, 12 = €55,000–€60,000)	6.1	1.8
Marital Status	Not married = 0, Married = 1	0.6	0.5
Household Size	Number of people in household	2.9	1.2
Food Habits			
Fish Consumption at Home	Scale: 0 (Never) to 5 (Daily)	3.1	1.2

Descriptive Statistics

Variable	Description	Mean	St. Dev.
Attitudes & Awareness			
Trust in Government	Scale: 1 (Strongly disagree) to 5 (Strongly agree)	2.3	1.2
Trust in EU	Scale: 1 (Strongly disagree) to 5 (Strongly agree)	2.9	1.0
Pro-environment	Agreement with pro-environmental statements (1–5)	3.9	0.8
Worry Climate	Agreement with climate worry (1–5)	4.1	0.8

Descriptive Statistics

Variable	Description	Mean	St. Dev.
Fishery Policy Preferences			
Impact Stock	Impact on Fish Stock (1–5)	2.4	0.9
Impact Marine Life	Impact on Marine Life (1–5)	2.3	0.8
Impact Coast	Impact on Coastal Communities (1–5)	2.4	0.9
Impact Economy	Impact on Local Economy (1–5)	3.4	0.8
Impact Climate	Impact on Global Climate (1–5)	2.4	0.8
Fishery Policy Preferences	PCA Factor Variable (= 0.91, loadings = 0.70–0.84)		

Descriptive Statistics

Variable	Description	Mean	St. Dev.
Marine Exposure			
Marine Distance	Residence distance from sea (1 = <1km, 2 = 1–3km, 3 = >3km)	2.1	0.8
Visit Gap Length	Visits to the sea (1 = daily to 5 = never)	2.8	1.2
Owns Boat	Household member owns a boat (Yes = 1)	0.1	0.3
Marine Work	Household member works in marine sector (Yes = 1)	0.2	0.4
Knowledge of EBFM	1 = Yes and know, 2 = Yes but don't know, 3 = No	2.6	0.7

MXL Results - Model 3

Variable	Description	Robust s.e.
Main Effects		
Sustainable Stocks	2.697***	0.267
Sustainable Stocks (HIGH)	2.918***	0.287
Protects Marine Life	2.750***	0.303
Protects Marine Life (HIGH)	3.169***	0.282
Climate Friendly	2.470***	0.285
Climate Friendly (HIGH)	2.427***	0.318
Inclusive Management	1.498***	0.222
Inclusive Management (HIGH)	1.301***	0.212
Price	-0.558***	0.053
Alternative Specific Constant[b]	38.310***	3.718
Individual-level Interactions		
Age (continuous)[a]	0.132**	0.058
SD of Random Parameters		
Sustainable Stocks (HIGH)	4.408***	0.760
Protects Marine Life (HIGH)	0.003	0.130
Inclusive Management (HIGH)	3.990***	0.505
Climate Friendly	2.021***	0.452
Price	0.003	0.004

MXL Results – Model 3: Model Fit Criteria

Variable	Statistic
Log-likelihood-null	-6340.04
Log likelihood	-1891.97
AIC	3823.95
BIC	3971.73
Number of observations	11,961
Prob > chi^2	0.00
McFadden Pseudo-R^2	0.702

Notes:
Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
[a] Interacted with ASC variable.
[b] The results remain broadly the same if the Alternative Specific Constant is assumed to be random rather than a fixed parameter.
Coeff. = coefficient, s.e. = standard error.

Average willingness to pay (own elaborations) (Euros/kg)

Variable (base = no label)	MXL
Sustainable Stocks	4.83
	(3.84 – 5.82)
Sustainable Stocks (HIGH)	5.23
	(4.23 – 6.22)
Protects Marine Life	4.93
	(4.15 – 5.71)
Protects Marine Life (HIGH)	5.68
	(4.89 – 6.46)
Climate Friendly	4.42
	(3.56 – 5.29)
Climate Friendly (HIGH)	4.35
	(3.44 – 5.25)
Inclusive Management	2.68
	(2.03 – 3.33)
Inclusive Management (HIGH)	2.33
	(1.64 – 3.02)

Notes: 95% confidence interval in parenthesis

Conclusion

Key Takeaways

- Respondents are significantly willing to pay above and beyond market prices to support the adoption and implementation of EBFM, providing important insights to policymakers on the economic value of EBFM and how different attributes compare in relative importance.
- More than 80% of respondents preferred fish with EBFM labels despite the associated price premium, indicating broad national support for adopting EBFM principles.
- This finding underscores the importance of integrating EBFM into national fisheries management strategies, as its implementation has the potential to generate environmental, social, and economic benefits for Malta.

Caveats

1. While precautionary measures were implemented to mitigate potential status quo selection bias, further research is necessary to confirm that the positive coefficient of the ASC is due to habit formation.
2. Enhancing the sample's representativeness, particularly in terms of age and educational attainment, could strengthen the robustness and generalisability of the findings. Nonetheless, it is noteworthy that the model was also estimated without the age variable, and the results remained consistent.

Future Research

- Establish a more direct benchmark against which the findings of this study may be compared, thereby refining the interpretation and applicability of the inferred estimates.
- Given that the findings are context-specific to Malta, there is a clear opportunity for future research to expand this analysis to other geographic regions, particularly in small island states that exhibit a greater reliance on the fisheries sector and marine ecosystems.
- The study underscores the necessity for broader valuation research that embraces a comprehensive definition of EBFM, taking into account both use and non-use services.

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EcoScope

Thank you for your attention.

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