Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

Patrick Chavel, Hillel Fromm, Gil Rilov, Lewi Stone and Walter Hecq

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We reveal constraints of the Cost-Benefit-Analysis (CBA), appraising the Ecosystem Services Approach (ESA) and we show the relevance of MPA's economic analysis. We analyze these challenges with respect to Israel, an affiliate MSFD country that has not yet carried such CBA on MPAs. In this case study, we compare the current MPA situation with the expected positive outcome of MPA expansion.

Our analysis shows that benefits from a marine reserve and its associated ecosystem services can largely exceed their protection costs, which should entice other organizations, from regional to governments, to follow MPA protection recommendations.

Keywords: Cost-Benefit Analysis (CBA), Environmental Policy and Economics, Good Environmental Status (GES), Integrated Nature Resources Management, Israeli Mediterranean Coast, Marine Protected Area (MPA), Marine Strategy Framework Directive (MSFD), Maximum Sustainable Yield (MSY), Program of Measures (PoMs).

JEL Classifications: Q50; Q57.
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Abstract

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¹Cost–benefit analysis (CBA) is a systematic approach to estimating the strengths and weaknesses of alternatives that may be used to compare, evaluate benefits against costs of a decision, project, or policy.
1. Introduction

1.1 Background

Fish stocks feed 70% of the population that lives along the coastline and rely on healthy ecosystems. Seas are driving the worldwide economy by producing numerous ecosystem services with great potential for sustainable growth. Marine life is not evenly distributed in the oceans and most of the world’s valuable ecosystems are found in shallow coastal waters, near the continental shelf, where the seabed is richer in nutrients and carbon. The coastal zone is also where most human activity occurs, leading to overexploitation of resources (fisheries), pollution (litter, inorganic nutrients) and habitat destruction.

The Mediterranean Sea is particularly vulnerable to anthropogenic impacts because of its relatively small water volume and limited exchange with the Atlantic Ocean through the Strait of Gibraltar in the west and with the Red Sea through the Suez Canal in the east (Galil and Rilov, 2009). Over the past few centuries, the Mediterranean coastal zone is indeed experiencing dramatic ecological changes driven by the very high population density on the coast and rapidly increasing anthropogenic activities.

Cumulative effects endanger the fragile ecological integrity of marine ecosystems (Stelzenmüller et al., 2018). This includes the negative effects of climate change (Steinberg et al., 2015), biological invasion (Rilov and Crooks, 2009), and habitat destruction leading to the loss of ecological services they provide (Bates et al., 2018). That the Israeli coast also faces growing pressure on the marine ecosystem emphasizes the need for integrated maritime spatial planning to support marine conservation and sustainable development.

1.2 Protection of the Mediterranean marine ecosystem and its legal context

The related legislation to marine protection is based on three main pillars: the Convention of Biological Biodiversity (UNEP, 1992), the Barcelona Convention (UNEP, 1995) and the Marine Strategy Framework Directive (MSFD, 2008), were MPAs appear as a keystone that respond to ecological significant criteria, and aim to increase conservation and sustainable use of marine biological diversity and ecosystem services.

1.2.1 Barcelona Convention and its implementation

The Convention on Biological Diversity (CBD) (UNEP, 1992) is a multilateral treaty for conservation of biological diversity and sustainable use of benefits from resources that emphasized the need for legal protection of natural heritage. Following the CBD, the Barcelona Convention (1995) established the plan for the protection of Mediterranean
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Seas, marine pollution assessment and sustainable management of marine resources\(^2\). This convention paved the future of conservation in the Mediterranean Sea through its ecosystem-based management approach.

In 2004, the Strategic Action Program (SAP) for the Conservation of Biological Diversity in the Mediterranean (UNEP, 1992) established coastal MPAs as part of international legislation implementation by 2020 (see § 1.3).

In 2007, the Contracting Parties of the Barcelona Convention adopted the “Ecosystem Approach process” to achieve a good environmental status in the Mediterranean, by mitigating human activities in Mediterranean waters and enforcing protection measures of marine ecosystems. Soon after, the Almeria declaration (UNEP, 2008), established ecosystem services valuation for “estimating the economic value of the products and the services provided by the marine ecosystems”\(^3\). The Barcelona Convention was adopted by Israel, and entered into force in 2010 (UNEP, 2010) with significant impact on the country’s marine and security policy. In addition, the Aichi biodiversity targets\(^4\) were added into the framework of the Strategic Plan for Biodiversity taking action for the decade (2011-2020, UNEP, 2010) that require from member states and affiliates, including Israel, that marine reserves cover at least 10% of territorial waters by 2020.

1.2.2 Marine Strategy Framework Directive (MSFD, 2008) The European Commission implemented the Barcelona Convention principles, and set up\(^5\) a global strategy and regional cooperation to be followed up by the Member States and Affiliates (MSFD, art 13) for achieving GES\(^6\) by 2020, though the creation of MPAs network in EU waters.

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\(^2\) Barcelona Convention (UNEP, 1978) objectives include environment integration in social and economic development, marine environment and coastal zones protection, natural and cultural heritage improvement; strengthen solidarity among Mediterranean coastal States and the quality of life. Affiliate Parties are: Algeria, Croatia, France, Greece, Israel, Italy, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria and Tunisia.

\(^3\) Almeria Declaration of the Contracting Parties to the Barcelona Convention (UNEP(DEPI)/MED IG.17)

\(^4\) Aichi targets 11 and 14 request sustainable uses of the oceans, seas and marine resources, ensuring effective and equitable management, and protect a wider variety of species and ecosystems for 2020, Strategic Plan for Biodiversity 2011-2020 (UNEP(DEPI)/MED IG.17/10). Decision X/2, 10\(^{th}\), Conference of the Parties (CoP), October 2010, Nagoya, and Aichi Prefecture, Japan.

\(^5\) The EU MSFD Directive, promote regional cooperation between affiliates countries and member states. MSFD aims to improve the marine ecosystem networks (art 6) by integrating the Ecosystem Approach (art. 3)… national programs should apply ecosystem-based management in order to preserve, prevent and restore marine ecosystems, by promoting sustainable and equitable use of marine areas through partnerships between coastal stakeholders, local authorities, and international programs (i.e.: PERSEUS, SESAME, Europeans programs) and assess the Program of Measures (PoMs) that consist of the expansion of marine protected areas while associated ecosystem services are assessed and analyze through their benefits vs. costs and compared to related stakeholders’ benefits and costs (Bertram and Rehdanz., 2012).

\(^6\) “all member states and affiliates countries can plan their own maritime integrated planning and use necessary tools for improving the ecosystem services and socio-economics benefits through establishment of protection measures for achieving the GES defined according ecological criteria specified for marine regions, by 2020”. EU Parliament and Council Report on MPAs establishment (MSFD, art. 21).
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1.3 Marine Protected Areas

MPA is a defined geographical maritime space, recognized by law and effectively implemented, well managed to achieve long term conservation of nature with associated ecosystem services and cultural values\(^7\).

MPAs represent only 2% of the oceans worldwide\(^8\). For less than a decade, MPAs have become part of coastal zone management in many countries worldwide through marine spatial planning (Portman and Nathan, 2014). Moreover, MPAs are included in the Program of Measures (PoMs) as mean to enhance conservation through two significant legal tools: the Integrated Coastal Zone Management\(^9\) (ICZM), and the Marine Strategy Framework EU Directive (2008/56/EC). These require the Member States to assess costs and benefits of PoMs to be implemented to reach Good Environmental Status (GES) for European waters by 2020.

In this article, after introducing the background and legal context, we propose to implement the MSFD methodology to the Mediterranean Achziv MPA and compare the costs versus benefits of its expansion. The structure of this paper is presented as follow:
- Section 2 establishes a methodology to evaluate programs of measures (PoMs).
- Section 3 analyses the implementation of legislation and recommendations.
- Section 4 puts forward the results and discussion.
- Section 5 states the conclusions of our analysis.

2. Barcelona Convention and MSFD implementation – General methodology

MSFD Parties must comply with the existing international legislations and cooperate to ensure the development of marine strategies\(^10\). Israel, as a new affiliate to the Barcelona Convention, must carry out new environmental obligation through 5 steps:
- Economic and Social Analysis (ESA) (§ 2.1);
- Environmental Targets for reaching GES\(^11\) (§ 2.2);
- Program of Measures (PoMs) (§ 2.3);
- Cost-Effectiveness Analysis (CEA) (§ 2.4);
- Environmental Impact Assessment and Cost-Benefit Analysis (CBA) (§ 2.5).

We followed this framework and provide a CBA for Achziv MPA along the Israeli coast.

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\(^7\) CBD defines MPA a "any defined area within or adjacent to the marine environment, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings".

\(^8\) United Nations targets 10% of the ocean protected by 2020 (UNEP, 2010).

\(^9\) 2nd Barcelona Convention Protocol 2008

\(^10\) For each marine region shared with third countries for developing and implementing common marine strategies “Regional cooperation and coordination of activities between Member States and third countries” (MSFD, preamble, 13, art 1-9).

\(^11\) (MSFD, art 9). Improvement MPA networks, art 13.4: Good Environmental Status - Member State must determine its GES based on associated indicators selected by Member States and associates.
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2.1 Economic and Social Analysis (ESA)

MSFD brought new requirements to improve marine management by conducting environmental-economic analysis (EC, 2010), through ecosystem approach based on ecosystem services valuation.

The MSFD requires Member States to determine and achieve Good Environmental Status (GES) based on associated indicators selected by Member States and affiliates in their waters and improve the MPA networks by 2020 (Art 1.1-9). MSFD states that Member States shall, when developing marine strategies, apply an ecosystem-based approach to assess the state of their marine area (Art. 1.3) and undertake an analysis of the predominant pressures and impacts, including human activity, on the environmental status of those waters as well as an economic and social analysis of the use of those waters and of the cost of degradation of the marine environment (Art. 8.1).

2.2 Environmental indicators

Different environmental indicators (11) are used as descriptors of the good environmental status of the EU seas, among which we selected 3 significant indicators: i) Biodiversity and richness (mainly fisheries, and algae populations); ii) Healthy and sufficient population of commercial fish stock; iii) Food web balance ensuring long-term abundance and reproduction.

In our case study, we mainly concentrated on several fish populations, mainly commercial fish stock (6 selected species), and less on macro-algae population. The bio-monitoring gave us an indication of fish and algal diversity and abundance which was sufficient for our research12.

The Good Environmental Status13 aims to attain the Maximum Sustainable Yield (fig.1) by reaching a sustainable fish stock inside the designed marine protected area. MSY, the largest average catch that can be captured from a stock under existing environmental conditions, is reached when ecosystem “carrying capacity”14 (fig.2) balances the fishing harvest, keeping fish stock at sufficient abundance with a maximum replacement rate. The various extensions of the basic model make it possible to explore the processes in more depth (Pauly et al., 2002).

12 Interactions between fish and macro-algae food-webs are being investigated (Belmaker and Rilov ecological labs).
13 The Good Environmental Status goals translate the Aichi Biodiversity Targets (The Strategic Plan for Biodiversity includes 20 time-bound, measurable targets to be met by the year 2020) into the MSFD.
14 Carrying capacity is defined as “the population of a given species that can be supported indefinitely in a given habitat without permanently damaging the ecosystem upon which it depends” (Hardin, 1991).
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Fig 1: Sustainable fisheries management target. The population growth dN/dt is plotted against population size N. MSY occurs when the growth is at a local maximum. K represents the upper asymptote of the sigmoidal or S-shaped curve produced when changing population numbers are plotted over time.

Fig 2: Carrying Capacity S Curve describes fish population as a function of time (Verhulst, 1938).

The population growth S curve is a pattern of growth in which, in a new environment, the population density of an organism (e.g. fish) increases slowly initially, in a positive acceleration phase; then increases rapidly, approaching an exponential growth rate as in the J-shaped curve; then declines in a negative acceleration phase until at zero growth rate the population stabilizes. This type of population growth is termed density-dependent, since growth rate depends on the population size. The point of stabilization, or zero growth rates, is termed the saturation value (K) or carrying capacity of the ecosystem that supports this organism (Verhulst, 1938).

\[ dN/dt = rN(1 - N/K) \]

\[ dN/dt = rN(K-N) \]

\[ K \]

Represents the upper asymptote of the sigmoidal or S-shaped curve produced when changing population numbers are plotted over time.
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There is no yield in a non-take MPA, but it is assumed that the MSY is hypothetically reached inside MPA, which occurs at approximately the half the carrying capacity (fig. 2), although the actual value is a model or system dependent.

2.3 Program of Measures (PoMs)

The PoMs is geared towards the achievement of ‘Good Environmental Status’ (MSFD, art. 13) in EU marine waters in line with the overall objective of the Directive, and covers both existing and new measures that contribute to the achievement of MSY.

2.3.1 PoMs effectiveness

The literature reveals that conservation effectiveness increases by following five key features: “no take, well enforced, old (at least a decade), large (more than 100 km²), and isolated by deep water or sand” (Edgar, 2014).

2.3.2 PoMs cost assessment

Measures of protection can vary considerably. PoMs related to marine reserves refer to the needed costs to be allocated for current management that will be used for the MPA expansion in our case study. Thereby, following costs are considered for assessment:

- Investment: equipment and infrastructures (e.g., offices).
- Operating Costs: labor, utilities (e.g., electricity, fuel, water, chemicals).
- Maintenance Costs (fixed or not): replacement materials and parts.
- Fixed Costs: annual investment costs (including taxes).
- Total Annual Costs: Sum of Operating Costs + Maintenance + Fixed Costs.

2.3.3 Costs Effectiveness Analysis (CEA)

PoMs implementation must be cost-effective and technically feasible to reach the GES prescribed by the MSFD. CEA is an optimization expressed in terms of a ratio, where the denominator is the optimal area to be reached in term of MPA expansion (km²) for aiming GES (i.e.: expecting fish stock recovery) and the numerator is the costs associated to this expansion (See Part 3).

2.4 Environmental Impact Assessment (EIA) and Cost-Benefit Analysis (CBA)

Member States must carry out environmental impact assessments which require ecological data and socio-economical information before those new measures of protection will be implemented.

In our case-study we evaluated the CBA associated to the expansion of Achziv MPA.

2.4.1 Cost Benefit Analysis of the PoMs

MSFD (art. 13-4) requires a CBA, part of the EIA prior to the introduction of any new PoMs, and evaluated in monetary terms to emphasize environmental policy choices assessed at different levels by using a CBA:

\[
\text{CEA} = \frac{\text{Cost of PoMs (€)}}{\text{MPA optimal size (km}^2\text{)}}.
\]

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16 CEA = Cost of PoMs (€)/ MPA optimal size (km²).
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(i) Full CBA, where most costs and benefits can be quantified and monetized;
(ii) Partial CBA where costs and benefits can be partly quantified or monetized;
(iii) Short CBA covering specific costs and benefits (e.g.: maintenance).

Related to our research, CBA verifies whether the benefits outweigh the costs. CBAs provide crucial information for allocating the resources most efficiently and inform the decision-makers about the relevance of type of environmental decisions. Only few CBAs have been conducted on the MPAs (Sala et al., 2012). However, MPAs can provide economic benefits (OECD, 2017) that boost coastal economies (EEA, 2015), by growing fisheries values, high income and employment as they significantly improve the fish stocks and stop destructive fishing practices. For instance, in the Mediterranean Sea, the Islas Canarias in Spain, increased catches in surrounding fisheries by about 10%/yr., generating socio-economic benefits by increasing biomass inside and outside the reserve, rebuilding its fish stocks (Sala et al., 2012).

Worldwide, MPA positive effects spill over to neighboring fisheries by increasing biodiversity, biomass abundance (Fenberg et al., 2012) and tourism (Sala et al., 2013). Total ecosystem benefits provided by less than 10% of worldwide protected territorial waters (i.e.: MPA) have been estimated around USD 800 billion over the period 2015-2050 (Brander et al., 2015, Constanza et al., 2017).

Just for EU waters, overall benefits generated by the Natura 2000 network reach approximately € 1.5 billion/yr. and is expected to reach € 3.5 billion if the marine Natura 2000 network coverage doubled.

2.4.2 Ecosystem services valuation - methods

Ecosystem services provide benefits that humans gain from the natural environment and from properly-functioning ecosystems (TEEB, 2010). Their contributions to human activities have been subdivided in both provisioning and cultural services and its valuation is expressed in physical and monetary units.

The Millennium Ecosystem Assessment (2005) defines Ecosystem services into four broad categories: provisioning, such as the production of food (fish stock); regulating, such as carbon sequestration; supporting, such as habitat for marine species and cultural.

In 2014, global ecosystems services’ value has been estimated at $ 125 trillion worldwide (Constanza et al., 2017), while about 10% of the world’s population depends directly on fisheries for their livelihoods (FAO, 2016). Therefore, healthy habitats and abundant marine biodiversity are important to protect and constitute the foundations of coastal and marine tourism as marine health improvement and creation of MPAs.

17 Seas are driving the European economy and have great potential for innovation and growth. EU Blue Growth is a long-term strategy to support sustainable growth in the maritime sectors.
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Ecosystem services valuation and the benefits assessment of protection measures (i.e. MPAs) are difficult to carry out because of the complexity of their specific interactions. Economists distinguish values in terms of ‘use’ or ‘non-use’ categories, each of which is associated with monetary valuation methods (Constanza et al., 2017) as in our study\(^\text{18}\).

2.4.2.1 Use Values have two components:

- i) Direct use values attributed to direct utilization of ecosystem services is estimated by market-based values, for instance fish sales.
- ii) Indirect use values can be assessed by indirect valuation methods such as travel cost method (TCM), a revealed preference method, revealing that the time and cost expenses that people invest to visit a site represent the true ‘price’ of access to the site.

The travel cost method (TCM) is used in a cost-benefit analysis (CBA) to calculate values that cannot be obtained directly through market prices using substitute marketable goods and services as people travel for fishing, diving or watching wildlife.

Indirect use can be estimated with stated preference methods, developed to solve the problem of valuing those resources that are not traded in any market, and for which no substitute markets exist, such as the contingent valuation method (CVM) that asks people through surveys for their willingness to pay (WTP) for nature’s indirect use.

2.4.2.2 Non-use values represent the value assigned by society to an ecological resource that does not depend on its current use:

- i) Existence value refers to the conservation of resources;
- ii) Bequest and option value refer to resource for future generations;
- iii) Altruistic value to resources which are important to others.

The Willingness to Pay (WTP) preference method is used to estimate non-use value.

3. Case study: MPA Achziv – CBA in the Israeli context

Israel’s 204 km long coastline borders the Mediterranean (190 km) and Red Sea (14 km), territorial waters cover approximately 4200 km\(^2\) and total marine state cover about 22000 km\(^2\) of Exclusive Economic Zone (EEZ).

Since the 1960’s till 2011, only seven small marine reserves have been declared along Israel’s coastline, 5 along the Mediterranean coastline (Ashkelon, Hertzelia, Dov, Kishon, Achziv MPAs) and 2 in the gulf of Eilat (Coral Beach Nature Reserve and Coral Reef Reserve), covering 10.5 km\(^2\), totalizing 0.25% of Israel’s protected territorial waters, insufficient to ensure fish stock sustainability or marine ecosystem integrity, while terrestrial reserves reach to 20 % of the area.

\(^\text{18}\) Ecosystem services valuation is challenging as marine biodiversity is not equally distributed in the oceans and most of valuable ecosystems are in coastal waters, near the continental shelf, where the seabed is more easily exploitable in entropic waters resulting from anthropogenic activities.
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In late 2011, Israel adopted a science-based marine policy within a national coastal survey project for enlarging buffer zones expanding the MPA network between off-shore gas-drilling infrastructure and the coastline. Therefore, the Israeli Nature and Park Authority (INPA) proposed the establishment and expansion of marine reserves covering 20 percent of Israel’s territorial waters, with 9 designated, and 8 others proposed marine protected areas, totaling 17 MPAs for 2020.

Among the existing Mediterranean MPAs, Achziv MPA, established in 1994 along northern of 10 km², at the northern border coastal shallow waters, contains an underground canyon within a unique ecosystem, a large variety of flora and fauna (400 plant species, some rare, endemic or protected plants), migratory birds nesting on limestone cliffs during winter and high variety of fish (endemic and invasive), crustaceans and marine mammals (dolphins and seals) and will become the wider with 100 km² and the richer in term of biodiversity after its expansion (IOLR, 2013).

3.1 Economic and Social Analysis of the MPA Achziv.

In this section, we compare economic and social significance to expand the marine reserve. We evaluate Achziv MPA provisioning and cultural services as fisheries and tourism on recreational sites.

3.1.1 Provisioning services
Fish stocks rely on healthy ecosystems. Worldwide fish stocks are under pressure, while 90% of these wild fisheries are estimated to be over-exploited (FAO, 2016), which is also the case in Israel, while Israeli fish stock is also severely impacted by oligotrophic nature of the Eastern Mediterranean Basin, and overfishing that increased dramatically last years. Israel’s small fishery industry represents less than 3 kt, representing 1% of local supply covering maybe 4% of Israeli demand, caught by trawling (middle-size boats) and artisanal (small). Fish catches are in constant diminution (fig. 3), jeopardizing fish stock regeneration for the next generations.

![Fig 3: Time-course analysis of fish catches in Israel (FAO, 2016).](image)

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19 In 2016, Israel’s fish demand reached 73.5 kt, of which about 60 percent (44.1 kt) is imported and 29.4 (40%) produced locally. Nevertheless fish farming, composed by aquaculture (land) and mariculture (sea), has grown dramatically with 27.2 kt (93%) and is the main local producer of fish in Israel.
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Provisioning services depend on inventory of MPA fish stock, this involves surveys. The surveys on which this study is based, were conducted seasonally\(^{20}\) inside and outside the MPA during the period 2013-2016 by different institutions: Rilov Marine Ecology Lab (Israeli Institute of Oceanography, IOLR), Maharag monitoring by The Tchernov lab, Leon Cheney Institute for marine sciences - Haifa University, and the National Park Authority (Bioblitz monitoring executed by volunteers and analyzed by Belmaker lab).

3.1.1.1 Fish stock in physical units as ecological evidence
During Achziv MPA bio-monitoring we observed (fig. 4) higher fish abundance, especially of carnivores inside the reserve, more notable in shallow waters (IOLR, 2013).

![Fish density: number of fish and biomass (kg) as a function of depth (m), inside vs. outside MPA. Data were collected at different depth (6, 12, 20 m) per 60 m\(^2\) density (IOLR, 2013). Fish abundance (g) inside (green) vs. outside (red) of MPA Achziv was confirmed during Bioblitz (INPA, 2017).](image)

3.1.1.2 Commercial fish stock characteristics
We selected 6 types of commercial fish (tab. 1) that have been observed and counted at different depths (6, 12, 20 m) during monitoring inside and outside of the MPA valued, according the length and weight relationship (Edelist et al., 2014).

<table>
<thead>
<tr>
<th>Fish sp. MPA (border zone)</th>
<th>Diet</th>
<th>Common weight (kg)</th>
<th>Common length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephelus sp (Grouper)</td>
<td>Carnivore</td>
<td>4-5</td>
<td>50-60</td>
</tr>
<tr>
<td>Seriola dumerili (Amberjack)</td>
<td>Carnivore</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Oblada sp (Saddled seabream)</td>
<td>Carnivore</td>
<td>0.2</td>
<td>25</td>
</tr>
<tr>
<td>Diplodus sp (Seabream)</td>
<td>Carnivore</td>
<td>0.3-0.6 - 1</td>
<td>25-35-40</td>
</tr>
<tr>
<td>Sarpa sp (Salema)</td>
<td>Carnivore (juvenile), herbivore (adult)</td>
<td>0.4</td>
<td>35</td>
</tr>
<tr>
<td>Siganus sp. (Spinefoot)</td>
<td>Herbivore</td>
<td>0.2</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 1: 6 selected commercial fish length/weight relationship (Edelist et al.2014).

\(^{20}\) We conducted 3 surveys/seasons. The collection was challenging, as the bio-monitoring was mainly executed during day while fish activity happens also during the night (INPA, 2017). The first author took part to the bio monitoring (fish stock and algae).
3.1.1.3 Extrapolation to northern fishing zone
Northern fishing zone is calculated as the length from Lebanon border till Netanya (78 km) inside the territorial waters, 20 km (12 miles) from the shore (1566 km² - tab.2).

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Fish stock (kg) outside MPA (10 km²)</th>
<th>Fish stock (kg) inside MPA (10 km²)</th>
<th>Estimated fish stock (kg) outside the MPA (1566 km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Epinephelus</em> (Grouper)</td>
<td>338</td>
<td>401</td>
<td>52853</td>
</tr>
<tr>
<td><em>Seriola dumerili</em> (Greater amberjack)</td>
<td>200</td>
<td>1840</td>
<td>31120</td>
</tr>
<tr>
<td><em>Oblada</em> (Saddled seabream)</td>
<td>121</td>
<td>428</td>
<td>19011</td>
</tr>
<tr>
<td><em>Diplodus sp.</em> (White seabream)</td>
<td>431</td>
<td>1214</td>
<td>67506</td>
</tr>
<tr>
<td><em>Sarpa salpa</em> (Salema)</td>
<td>16</td>
<td>260</td>
<td>2506</td>
</tr>
<tr>
<td><em>Siganus sp.</em> (Rabbit Fish)</td>
<td>1032</td>
<td>1113</td>
<td>161553</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2138</td>
<td>5256</td>
<td>3347482</td>
</tr>
</tbody>
</table>

Table 2: Comparison of 6 selected fish species in/outside MPA within a surface of 10 km² shows an increase of fish stock inside (Northern fishing zone 1566 km²- linear extrapolation). Data collection was conducted between 2013 – 2017 period and compared (IOLR, Maharag 2016; INPA, 2017).

3.1.1.4 Fish landing – Physical and monetary units
Until 2017, Northern total landing of 1566 km² (declared) reached about 348 t/y\(^{21}\) divided as follows (Edelist et al. 2013):

i) Professional large-scale-trawling: about 193 t/y (10 t/y for the selected species);
ii) Professional small-scale-artisanal\(^{22}\): about 128 t/y (25 t/y for selected species);
iii) Amateur fishing is estimated about 27 t/y (about 15 t/y of selected species).

Landing of the 6 selected commercial fishes is close to 50 t/y, about 15 % of total landing (333, 33 t/y). Total Catch Ratio\(^{23}\) (TCR) approximates 0.22 t/km²/y.

We assessed fish market values by visiting Israeli main ports.

<table>
<thead>
<tr>
<th>Species</th>
<th>Min €</th>
<th>Max €</th>
<th>Average €</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Epinephelus</em></td>
<td>20</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td><em>Seriola dumerili</em> (Amberjack)</td>
<td>12</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td><em>Oblada</em> sp (saddled seabream)</td>
<td>6</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td><em>Diplodus</em> sp (sea bream)</td>
<td>7</td>
<td>12</td>
<td>9.5</td>
</tr>
<tr>
<td><em>Sarpa salpa</em> (Salema porgy)</td>
<td>6</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td><em>Siganus</em> sp (Spinfoot)</td>
<td>5</td>
<td>8</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Table 3: Prices of selected commercial fish species\(^{24}\) (annual value).

---

\(^{21}\) Fish stock inventory represents about 15% of total landing. Data have been collected from 2013 to 2016. Northern Illegal catch is estimated by different sources around 75.2 t/y (six species) (Edelist et al. 2013).

\(^{22}\) Artisanal fishing activities are particularly used in northern Israel (Kishon and Akko): Gillnets (41.8 t), long-lines (16.3 t) and purse seiners (69.4 t) (Edelist, 2017).

\(^{23}\) Average catch ratio is usually used for measuring discard that turns around 30-40% in the Mediterranean countries (Edelist et al. 2013).
Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

3.1.2 Cultural Services
Cultural services are defined as the non-material benefits people obtain from ecosystems and cover recreational, aesthetic, educational and spiritual benefits (Millennium Ecosystem Assessment, 2005).

In our case study, cultural services include recreation (hostelry, marine activities), touristic travelling and education.

For this purpose, we proceeded to surveys in situ with questionnaires adapted for each activity (tourism and recreation).

We interviewed different stakeholders (public and private), tourism and recreation industry such as diving clubs, hotels and local authorities and the visitors (swimmers, divers, hikers…).

3.1.2.1 Recreational services
Recreational value of healthy reefs for recreational divers as part of their cultural services by investigating “customer’s preferences” of the public by use of surveys to estimate reef’s esthetic services, seascape beauty and nautical activities (boating, snorkeling, diving, nature tourism; leisure, and recreational fishing).

<table>
<thead>
<tr>
<th>Sites</th>
<th>Activities</th>
<th>Visitors (p/y)</th>
<th>Value (k€/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achziv national park</td>
<td>marine reserve, coffees and restaurants, beach and natural park</td>
<td>80000</td>
<td>1600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(20 €/p.)</td>
</tr>
<tr>
<td>Achziv coastline facilities,</td>
<td>Achziv field school and guesthouse (50 rooms-150 €/room), camping (50-25€),</td>
<td>55000</td>
<td>5500</td>
</tr>
<tr>
<td>resorts</td>
<td>guided trips, coffee and restaurants; hiking.</td>
<td></td>
<td>(100 € /p.)</td>
</tr>
<tr>
<td>Achziv sport clubs</td>
<td>free and scuba diving, boating, biking, hiking, fishing (out of MPA), coffee and restaurant</td>
<td>15000</td>
<td>500</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>150000</td>
<td>7600</td>
</tr>
</tbody>
</table>

Table 4: Touristic activities along Achziv MPA (survey) and economic values (2016 - constant currency)

24 We assessed fish market values by visiting ports (Jaffa, Kishon-Haifa, and Akko - average annual value). Landings are sold on the docks of Haifa and Acre ports. Prices (2016) can fluctuate dramatically.
Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

3.1.2.2 Tourism to Achziv MPA.
We applied the travel cost method to the Achziv MPA’s case study hereafter.

<table>
<thead>
<tr>
<th>Visitors Origin</th>
<th>Road (km)</th>
<th>Travel time (car/visit) (h)</th>
<th>Private car costs (€)</th>
<th>Public transport ticket prices (€)</th>
<th>Travel time (bus, train/visit) (h)</th>
<th>Public transport (€)</th>
<th>Tot. travel costs (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nahariya</td>
<td>10</td>
<td>0.16</td>
<td>15970.6</td>
<td>3</td>
<td>0.17</td>
<td>16022.1</td>
<td>31992.8</td>
</tr>
<tr>
<td>Haifa</td>
<td>78</td>
<td>0.65</td>
<td>145178.4</td>
<td>7</td>
<td>1.17</td>
<td>86017.4</td>
<td>231195.8</td>
</tr>
<tr>
<td>Akko</td>
<td>28</td>
<td>0.31</td>
<td>19152.9</td>
<td>5</td>
<td>0.33</td>
<td>14064.6</td>
<td>33217.5</td>
</tr>
<tr>
<td>Tel Aviv</td>
<td>254</td>
<td>1.58</td>
<td>91087.5</td>
<td>10</td>
<td>3.67</td>
<td>41639.7</td>
<td>132727.2</td>
</tr>
<tr>
<td>Rishon Etzion</td>
<td>282</td>
<td>1.75</td>
<td>101334.1</td>
<td>10</td>
<td>4.83</td>
<td>50995.9</td>
<td>152330.0</td>
</tr>
<tr>
<td>Rehovot</td>
<td>302</td>
<td>1.92</td>
<td>109089.4</td>
<td>10</td>
<td>5.33</td>
<td>55005.7</td>
<td>164095.1</td>
</tr>
<tr>
<td>Jerusalem</td>
<td>362</td>
<td>2.18</td>
<td>128839.5</td>
<td>12.5</td>
<td>6.5</td>
<td>67420.5</td>
<td>196260.0</td>
</tr>
<tr>
<td>Ashdod</td>
<td>330</td>
<td>2.08</td>
<td>72691.0</td>
<td>10</td>
<td>5.67</td>
<td>46143.1</td>
<td>119124.1</td>
</tr>
<tr>
<td>Ashkelon</td>
<td>360</td>
<td>2.17</td>
<td>102770.1</td>
<td>10</td>
<td>6</td>
<td>48281.7</td>
<td>151051.8</td>
</tr>
<tr>
<td>Beer Sheva</td>
<td>436</td>
<td>2.48</td>
<td>122962.0</td>
<td>12.5</td>
<td>6.5</td>
<td>53936.4</td>
<td>176898.4</td>
</tr>
<tr>
<td>Tot.</td>
<td>2442</td>
<td></td>
<td>909365.4</td>
<td>479527.5</td>
<td>1388893.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table n° 5: Yearly travel costs according to visitor’s location. (€ 2016, constant currency). Private transport: km * Number passengers (4) * number cars * fuel consumption l/km * price * time consumed (not included: insurance, maintenance and taxes). Travel time: time to reach MPA (back and forth).

3.1.2.3 Education and research
Cultural services include nature observations. Achziv field school organizes guided tours every weekend with special classes during holidays (School holidays: July-August, end of year: September, Eastern: April).

MPAs offer great opportunities for research, as not less than 9 research centers (universities or research institutes) are currently investigating marine reserves (i.e. Achziv MPA), providing sources of living (salaries, scholarships, grants) to at least 70 researchers in this area based on our last survey (INPA-Bioblitz, 2017).

We estimated that the value of the cultural services provided by education and research approximate k€ 1260 per year (2016).

In addition, many schools visit Israeli marine reserves all along the year, with a flow of hundreds of scholars per week. We evaluated their visits, partially subsidized by Ministry of Education (50% - € 25 fee), evaluated about k€ 60 (Ministry of Education).

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25 Public transport tickets: bus, train.
26 Total Visitors: 150000 visitors /yr. Travel time=time to reach the target and go back. Travel: a) private cars: 130425 visitors/y (4/car), b) public transport: 19575 visitors/y. Time cost public and private transport : 6555 €/hr. Origin: a - Northern area: 60%: local resident’s 25 km radius: Nahariya city (20% downtown), and neighborhood cities: Haifa (30%), Akko (10%); b) Centre: 25% - Tel Aviv (15%), Rishon Etzion (3%), Rehovot (2%), Jerusalem (5%); c - South: 15%: Ashdod (5 %), Ashkelon (5 %), Beersheba (5%). Rem.: Foreign visitors represent about 13% (N: 19500) of total sample coming mainly from: Tel Aviv, Jerusalem and in a less amount Haifa.
27 Therefore, we count the researchers and staff involved in the different bio-monitoring (TAU, Haifa University, IOLR) and related study in situ MPA Achziv). Data obtained INPA-Bioblitz 2017.
28 We estimated: researcher salaries: 1500 €/month, master students: 1000 €/m., PhDs, 1500 €/m.
Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

3.2 Establishment of the PoMs

Strategic Plan for Biodiversity, also implemented in Israel, aims to protect 10% of marine ecosystem for 2020 and urges the implementation of the PoMs. Therefore, Israeli Nature and Parks Authority (INPA) assiduously promoted the establishment of marine reserves, especially since the discovery of gas along the Israeli coast in 2009.

Achziv marine reserve was established in 1994 and shelters a variety of species, but is insufficient in relation with sustainable management (Edgar, 2014). Therefore, in 2009, Israel National Park Authority (INPA) formulated a policy for creating a coastal Mediterranean MPAs network\(^{30}\) from the southern border of Gaza Strip to the northern Lebanon-Israeli border, and specifically requesting the enlargement of the Achziv MPA to cover about 100 km\(^2\), becoming the first marine reserve to include a deep-sea and off-limits to fishing areas and a deep submarine canyon (1.0 km) with rich wildlife, rich endemic flora and fauna.

In August 2016, MPA the Achziv expansion\(^{31}\) plan was declared, to become the largest marine reserve in Israel by covering about 100 km\(^2\) stretched from the Rosh Hanikra cliff at the northern border; extended westward from shore for approximately 15 km.

3.3 Cost-effectiveness of PoMs implementation

Cost effectiveness of PoMs\(^{32}\) implementation involves:

i) Effectiveness of scenarios evaluates the extent to which GES can be reached.

ii) Total cost assessment covers the costs of applied measures.

iii) Cost-effectiveness analysis compares relative costs vs outcomes of PoMs.

3.3.1 Effectiveness of different scenarios. Existing marine reserves are limited to a relatively small coastal area that provides limited protection to its marine ecosystem. Without adequate enforcement and efficient protection, MPAs are just virtual wish. Nature Protection Authority considers different scenarios that correspond to MPAs. 3 hypothetical scenarios (Table 6) are considered for expansion (Binet et al., 2015):

- Basic Scenario (10 km\(^2\)) corresponds to minimal funding that meets limited requirements to sustain ecosystem functions in MPA.
- Optimal Scenario (100 km\(^2\)) covers fund for reaching effective functioning MPA corresponding to acceptable preservation goals.
- Ideal Management Scenario (150 km\(^2\)) covers the costs of effective management of existing MPAs (= opt. scenario) with management of additional MPAs.

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\(^{29}\) € 25 *100 (pupils)*4(weeks)*6 (months).

\(^{30}\) Israeli Nature Park Authorities that ultimately aims that the Israeli total marine protected area corridors will measure 400 km\(^2\) in the future.

\(^{31}\) MPA expansion will include an underwater canyon and islets that will provide substantial biodiversity. The expansion plan is currently presented to the treasury minister for final approval on the land transfer.

\(^{32}\) It exits receivable exceptions to implement measures to reach GES (Aichi Targets), justified and based on disproportionate costs that consider risks for the marine environment.
Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

<table>
<thead>
<tr>
<th>GES indicators</th>
<th>Basic</th>
<th>Optimal</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiversity and richness</td>
<td>10 km²</td>
<td>100 km²</td>
<td>150 km²</td>
</tr>
<tr>
<td>Endemic and invasive</td>
<td>Insufficient</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Sufficient population – fish stock</td>
<td>Insufficient</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Food webs elements</td>
<td>Insufficient</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Sustainability (abundance and reproduction)</td>
<td>Insufficient</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Sea floor integrity</td>
<td>Insufficient</td>
<td>Good</td>
<td>Very good</td>
</tr>
</tbody>
</table>

Table n°6: Scenarios effectiveness analysis – Overview according GES indicators following related case studies (Sala et al 2013; Edgar, 2014).

3.3.2 Total Costs Assessment

We assessed the main costs for the existing MPA by following cost categories considered (€ 2016 - Basic scenario):

1- Investments: equipment:
   - 2 Boats: Zodiac Pro-Open (650) about 40 k€ *2 for 4 years = 80 k€ +13k€ (equipment) (resale: about 37 k€ (between 32 k€ - 42 k€).
   - 2 Cars: 2017 Isuzu D-MAX LS|U Crew Cab: € 50 k *2 for 4 years: 100k€: 25 k€/yr. - (minus resale 17.5 k€*2 = 35 k€.
   - Electronics (PC, laptop…) + diving gear: 5 k€*2 (Rangers): 10k€
   - 2 Jet-ski (Sea-doo-model spark): 6-7 k€*2 = 12-14 k€ (re-sale: 2k€*2 for 4yr).
   ⇒ Total Investments: about 216 k€ for 4yr

2- Operating costs:
   - Labour: 4 k€*2* 12 (months) = 96 k€ about 100 k€/yr.
   - Utilities: gasoline, electricity, water: about 10 k€/yr.
   - Infrastructures (offices …) : about 10-15 k€/y.
   ⇒ Total: about 120 k€/yr.

3- Maintenance and monitoring costs (fixed or not):
   - Monitoring cost organized and funded by NPA (i.e.: Bioblitz): 100 k€ every two years, which means 50 k€/yr.) + Participation to other monitoring activities 10 €/yr. (i.e., Maharag, INPA Bioblitz, 2017): 60 k€/yr.
   - Possible replacement and reparations (cars, boats, boys, computing systems, cameras, sonars, diving gears: 10 k€/yr. (MPAs Centers).
   ⇒ About 70 k€/yr.

4- Fixed Costs = annual investment: about 60 k€/yr. (including discount rate 4 %) (Amortization period: 4 yr.) (Adding insurance, tax, license fees-subsidies: about 5 k€)
   ⇒ S/total: 65 k€/yr.

5- Total
   ⇒ Total budget (4yr) = 935 k€ (amortized capital) - 37 k€ - 35 k€ - 2k € =861.5 k€
   ⇒ Total annual Cost= Capital Cost (equipment cost): 60 k€ + insurances, tax, licenses: 5 k€ + Operation + maintenance and monitoring: 70 k€ = 255 k€ /yr.

We comment these figures in the Results and Discussion Section (§ 4).

33 The data were supplied by Nature Park Authority (head of marine division: Dr. Rutty Yahel and Achziv MPA rangers (Eyal Miller).
Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

3.3.3 Cost-effectiveness analysis of scenarios
The Ideal scenario (150 km$^2$) has not been approved because of security issues related to the gas drilling platform in this area (140 miles west), close to northern border. Security issues are considered as an acceptable exemption in the MSFD (Art. 13, 14). The optimal scenario (100 km$^2$) was selected as a realistic choice. Results of the cost assessment are adapted to the MPA expansion (see § 3.3.2).

3.4 Environmental Impact Assessment (EIA) including CBA

Environmental Impact Assessment\(^{34}\) considers ecological and financial risks, but, in the context of the PoMs requested by MSFD, EIA is determined by the measure that should be taken in proportion of the expected impact of the project.

Former studies (IOLR, 2013) indicated that total fish biomass has declined by about two-thirds from historical baselines because of fishing, while inside MPAs fish stock seemed to be more abundant and diversified; these findings are especially emphasized for shallow waters inside the reserve, while numerous invasive species mix with the endemic ones (INPA, 2017).

3.4.1 Potential benefits of the PoMs implementation\(^{35}\)
From the selected scenario (cost effective) of enlarging the MPAs, different types of benefits can be expected.

We investigated provisioning and cultural services through monitoring and surveys in situ to examine if the expansion increases the supporting services associated with the raise of provisioning services such as fish stock and macroalgae\(^{36}\) (Edgar, 2014).

3.4.1.1 MPA Achziv Provisioning benefits
Our study is based on surveys conducted during the period 2013-2016 by different Israeli institutions\(^{37}\).

We considered fish stock growth in the assumed expanded MPA (table 7) as inside the current MPA and compare fish landings and market values at the present situation (MPA: 10 km$^2$), vs. in expanded (MPA: 100 km$^2$).

---

\(^{34}\) PoMs requested by MSFD, EIA includes a benefit evaluation next to the costs assessment.

\(^{35}\) 1\(^{st}\) phase: MPA establishment, 2\(^{nd}\) phase: MPA Enlargement

\(^{36}\) Macroalgae species feed and support numerous slugs and crustaceans

\(^{37}\) Surveys conducted by: Rilov Ecology Lab (Institute of Oceanography), Maharag (Tchernov lab Leon Cheney Institute for marine sciences-Haifa University) and the National Park Authority (Bio-blitz expedition executed by volunteers and analyzed by Belmaker lab).
Cost-Benefit Analysis of the Achziv marine reserve expansion considering the Barcelona Convention and the EU Marine Strategy Framework Directive

1) Fish landing increase (physical units) from fishing zone (outside MPA)

<table>
<thead>
<tr>
<th>Fish species (t)</th>
<th>Current landing (t) outside MPA (10 km$^2$)</th>
<th>Expected landing (t) outside MPA (100 km$^2$)</th>
<th>Fish landing increase (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephelus sp. (Grouper)</td>
<td>6.3</td>
<td>7.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Seriola dumerili (Greater amberjack)</td>
<td>11.4</td>
<td>98.0</td>
<td>86.6</td>
</tr>
<tr>
<td>Oblada (Saddled seabream)</td>
<td>1.8</td>
<td>5.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Diplodus sp. (White seabream)</td>
<td>22.5</td>
<td>59.3</td>
<td>36.8</td>
</tr>
<tr>
<td>Sarpa salpa (Salema)</td>
<td>0.4</td>
<td>6.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Siganus sp. (Rabbit Fish)</td>
<td>7.5</td>
<td>7.6</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49.9</strong></td>
<td><strong>184.3</strong></td>
<td><strong>134.4</strong></td>
</tr>
</tbody>
</table>

Table 7: Average yearly northern fish landings$^{38}$ of 6 selected commercial fish during 4 years of study - before and after MPA expansion. Selected species represents currently about 15 % of the stock.

Expected landing representing the MSY, corresponds to the available stock inside the MPA Achziv could reach about 184.3 tons according to our linear extrapolation, while the landing represents currently about 50 tons, that means that the MPA expansion represents a gain of 134.4 tons of commercial fish, a target reachable within the decade.

ii) Fish landing benefits (table 8) from fishing zone (outside MPA)

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Price (€/kg) (2016)</th>
<th>Current landing (k€) outside current MPA (10 km$^2$). Fishing zone: 1566 km$^2$</th>
<th>Possible landing (k€) outside expanded MPA (100 km$^2$). Fishing zone: 1466 km$^2$</th>
<th>Fish landing increase (k€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephelus sp. (Grouper)</td>
<td>25 (20-30)</td>
<td>157.2</td>
<td>174.7</td>
<td>17.4</td>
</tr>
<tr>
<td>Seriola dumerili (Greater amberjack)</td>
<td>16 (12-20)</td>
<td>182.1</td>
<td>1568.1</td>
<td>1386.1</td>
</tr>
<tr>
<td>Oblada (Saddled seabream)</td>
<td>8 (6-10)</td>
<td>14.4</td>
<td>47.6</td>
<td>33.2</td>
</tr>
<tr>
<td>Diplodus sp. (White seabream)</td>
<td>9.5 (7-12)</td>
<td>213.7</td>
<td>563.1</td>
<td>349.5</td>
</tr>
<tr>
<td>Sarpa salpa (Salema)</td>
<td>7 (6-8)</td>
<td>3.0</td>
<td>45.7</td>
<td>42.7</td>
</tr>
<tr>
<td>Siganus sp. (Rabbit Fish)</td>
<td>6.5 (5-8)</td>
<td>48.8</td>
<td>49.3</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>619.2</strong></td>
<td><strong>2448.6</strong></td>
<td><strong>1829.4</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Northern Fish landing market values before and after MPA expansion and resulting benefits.

---

$^{38}$ We estimate the expected fish landing growth and the potential provisioning benefits by extrapolating collected data inside vs outside the MPA for a 10 -fold increase of surface area, under the same conditions. Landing grows proportionally with the fish stock as mentioned in the literature (OECD, 2017), while landing of our selected species represents currently about 15 % of their stock.
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3.4.1.2 Cultural Benefits

i) Physical units: Tourism stakeholders (ministry of tourism, hostelries, and nautical sport centers) agree that MPA establishment is an important magnet for tourists (See § 3.1.2), even if tourism professionals consider that MPA expansion (voted in June 2016) do not substantially change visitor habits (Sources: Putsker nautical club, Achziv field school, Gesher, Hotels: Hearth Place, Balcony, Sea life, Mermaid Hotels).

ii) Monetary unit: We used a Travel Cost Method (table 9) for measuring cultural benefits in monetary terms assessment by evaluating all expenses for traveling to MPA.

<table>
<thead>
<tr>
<th>Visitors Origin</th>
<th>BAU: Travel Cost current MPA (10 km²)</th>
<th>Travel Cost (k€) MPA expansion (100 km²)</th>
<th>Benefit (k€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitors (n.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nahariya</td>
<td>150000</td>
<td>157950</td>
<td>0.6</td>
</tr>
<tr>
<td>Haifa</td>
<td>32</td>
<td>32.6</td>
<td></td>
</tr>
<tr>
<td>Akko</td>
<td>231.2</td>
<td>251.5</td>
<td>20.3</td>
</tr>
<tr>
<td>Tel Aviv</td>
<td>33.2</td>
<td>34.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Rishon Etzion</td>
<td>116.3</td>
<td>156.4</td>
<td>40.1</td>
</tr>
<tr>
<td>Rehovot</td>
<td>164.1</td>
<td>168.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Jerusalem</td>
<td>196.3</td>
<td>203.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Ashdod</td>
<td>119.1</td>
<td>123.0</td>
<td>3.9</td>
</tr>
<tr>
<td>Ashkelon</td>
<td>151.1</td>
<td>156.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Beer Sheva</td>
<td>176.9</td>
<td>183.4</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td>1389.0</td>
<td>1454.5</td>
<td>65.5</td>
</tr>
</tbody>
</table>

Table n° 9: MPA Achziv visitor’s frequentation: BAU in current situation: Travel cost to current MPA. According TCM, tourism attendance increase with MPA expansion of about 5, 3%. The growth rate per 10 km² is 0.4% (n: 130500) for locals and 1.4% foreign visitors (n: 19500) following Onagri & Nunes assumption (Onagri & Nunes, 2013).

3.4.1.3 Existence values

Achziv MPA existence value is estimated by using Willingness to Pay (WTP) questionnaire that provides opinion of tourists about MPA expansion (See § 2). 250 people were interviewed (population age: 18-86) and answered as follows:

i. 34% do not want to pay per visit and think it should be free for all;
ii. 23% are willing to pay between € 1-5 per visit;
iii. 14% are willing to pay between € 6-10 per visit;
iv. 8 % are willing to pay between € 11-15 per visit;
v. 4% are willing to pay between € 16-20 per visit;
vi. 17% did not answer.

Conclusions regarding the WTP:
- More than half of the tourists interviewed agreed to pay MPA entrance fee.
- Achziv marine reserve existence is estimated around 535.5 (k€/y). This value ranges from k€ 388.5 to k€ 682.5.

39 Survey conducted in situ (Achziv shore) from 2013-2016.
4. **Results and Discussion**

4.1 **GES indicators**

We assumed to reach the MSY inside the MPA considering the following indicators:

i) Biodiversity and richness: fisheries and algae population: inside the MPA, fish stock is about 3-fold higher inside the reserve than outside (7-20m depth) with larger differences in shallow waters (1-12 m) compared to outside.

ii) Endemic and invasive species balance (idem): slightly less invasive species inside the reserve (comparison facts) supporting the hypothesis that pristine state reserve protects endemic fish species against invasive ones (Otero, 2013).

iii) Healthy and sufficient population of commercial fish (idem): all commercial species are larger, on average, inside the reserve, mostly in the shallower waters (1-12 m) compared to those outside (see fig. 5).

iv) Food web: balance ensuring long-term abundance and reproduction. Macroalgae\(^40\) coverage looks higher inside the MPA, suggesting higher predators (carnivores) population inside the MPA (INPA, 2017).

v) Sea floor integrity, ensuring ecosystem function: trawlers are devastating sea floors; MPA could regenerate the sea bottom including benthic and demersal species.

4.2 **CBA for implementing the PoMs**

Benefit Analysis is required for implementing the Program of Measures (PoMs). We compare the policy measures (current state vs. expansion) and we calculate their relevance in terms of benefits vs. costs.

<table>
<thead>
<tr>
<th>CBA</th>
<th>Method</th>
<th>MPA current (10 km(^2))</th>
<th>MPA expansion (100 km(^2))</th>
<th>Increase (k€/y)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoMs</td>
<td>Market</td>
<td>255</td>
<td>280</td>
<td>25</td>
<td>10</td>
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<tr>
<td>Services</td>
<td>Market</td>
<td>11463.7</td>
<td>13789.8</td>
<td>2325.8</td>
<td>20</td>
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<tr>
<td>Provisioning</td>
<td>Market</td>
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<td>2448.6</td>
<td>1829.4</td>
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<tr>
<td>Cultural</td>
<td>Market</td>
<td>10309.3</td>
<td>10777.3</td>
<td>468</td>
<td>4.5</td>
</tr>
<tr>
<td>Recreational</td>
<td>Market</td>
<td>7600.3</td>
<td>8002.8</td>
<td>402.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Tourism</td>
<td>TC</td>
<td>1389.0</td>
<td>1454.5</td>
<td>65.5</td>
<td>4.7</td>
</tr>
<tr>
<td>Education</td>
<td>Survey</td>
<td>60</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Research</td>
<td>Survey</td>
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<td>1260</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Existence Value</td>
<td>WTP</td>
<td>535.5</td>
<td>563.9</td>
<td>28.4</td>
<td>5.3</td>
</tr>
<tr>
<td>NET BENEFITS</td>
<td></td>
<td></td>
<td>2300.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10: CBA of the MPA comparing current situation vs expansion (€ 2016, constant currency). Benefits are related to the increase of services, costs are related to the PoMs implementation.

\(^{40}\) Macroalgae mainly composed of native flashy brown (Saragassum sp., Gracilariae sp…) and green (Ulva sp., Codium sp…).
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4.2.1 Costs
Total PoMs costs do not significantly increase with the MPA expansion, with a slight augmentation related mainly to fuel use (25 k€ /yr.). (Oral communication NPA 2017). Same existing costs (surveillance techniques, labor, gear) stay valid for both scenarios (basic -10 km², and optimal – 100 km²).

4.2.2 Benefits

4.2.2.1 Provisioning services
i) Physical values: monitoring in situ revealed that the fish stock inside the reserve is more abundant and diversified than outside (Fig. 5); higher biomass and longevity of all species, especially predators with a remarkable difference in shallow water, while invasive species compete with endemics⁴¹ (Edelist et al. 2013). Selected commercial fish species inside is higher than outside (IOLR, 2013).

![Size differences in protected vs. unprotected areas](image)

Fig 5: Biomass comparison inside vs outside MPA – Weight (g) = f (Size (cm)) (IOLR, 2013).

After six years, commercial fish biomass is expected to increase significantly inside the MPA (about 3 folds BAU) and in adjacent fishing grounds, leading to a general support for the expansion of the MPA (WWF, 2005, OECD, 2017) tending to the MSY.

Results follow the same trend observed during different monitoring⁴². MPA seems to provide complex and healthier food-web if well well-managed (Edgar, 2014) and supply more fish (Tab.8). MPA abundance is more significant in spring in shallow waters.

ii) Monetary values: provisioning services amount to 620 k€/y at current situation (BAU, Tab. 4). MPA Achziv expansion could improve the expecting fish stock and reach about 2450 k€/y, revealing a fish stock increase of about 1830 k€ (4 folds BAU, tab.4).

4.2.2.2 Cultural services. Recreation and tourism, education and research (tab.10).
   i) Physical values: cultural services are massive in comparison with the provisioning goods (fisheries) but the first one has an impact on the second as the rich community attracts also a recreation activity inside the reserve. MPA expansion doesn’t affect significantly these services, with a slightly augmentation of nautical recreation, and with an even smaller extent, the tourism in the region.

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⁴¹ This information has been confirmed by other surveys (IOLR, 2013; Maharag, 2014; Bioblitz, 2017).
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Education and Research do not seem to be affected by the MPA expansion.

ii) Monetary values: services from tourism and recreation contribute highly to local economy, estimated about € 8 million (Ministry of Tourism).
At the current situation, total cultural services rise less than 5% with the MPA expansion.

4.2.2.3 Existence value
Benefits in terms of Existence values, calculated by WTP method, amount to 28.4 k€/y (increase of 5% from current state).

4.3 Overall Costs-Benefits Analysis of implementing the PoMs
Total expected net benefits would reach about 2,326 k€/y with the MPA expansion, showing a significant increase of the provisioning services (5 folds) followed by the expected increase in cultural services (4.5%).

Benefits outweigh largely MPA’s creation and operation costs estimated to be 255 k€/y, these do not rise dramatically (same facilities, labor …) with the expansion.

5. Conclusion

Worldwide, environmentalists, ecologists and economists investigate how to improve the wildlife management and marine biodiversity through local implementation of international conventions (Turner, 2011). For that purpose, we must consider the significance of ecosystem services and their valuation (Nunes et al., 2001, Cordier et al., 2014) that allows to support natural resources management (Sala et al., 2013).

In the MSFD, PoMs complies with economic and ecological considerations, by using Ecosystem Based Management for ensuring GES of EU marine ecosystems, through various conservation efforts measures such as the creation of MPA networks. MSFD considers MPAs collectively and not individually, while a single MPA big enough (>100km²) and well managed can make a significant contribution (Edgar, 2014).

In our case study, fish stock increase inside the MPA improving biodiversity and abundance spilling out beyond its borders.

Moreover, our literature overview shows that benefits coming out from MPAs worldwide and its associated ecosystem services exceed their protection costs only if big enough, well managed and strictly implemented (Edgar, 2014).

MPA acts as “Fish Banks”, ensuring fish stock sustainability and producing other cultural valuable benefits such as tourism and recreation. Achziv MPA benefits that we could valuate partially (fish stock production, tourism and recreation) offset its costs. This conclusion is in line with other MPAs in the Mediterranean (Sala, 2013).
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The decision-making process that gauged the pertinence of the creation and then the MPA expansion requires a better EIA within a better information and collaboration between stakeholders (authorities, NGO, research institutions, agencies…).

Our research reveals the methodological difficulties in the CBA implementation, such as the lack of knowledge\(^{43}\) and data availability, that lead to simplifications and limitations and other several constraints such as the need of significant financial means. Therefore, for the feasibility of the study, we had to select a few of ecosystem services\(^{44}\) at the detriment of others, making our research partially elusive, while we could not consider other ecosystem services\(^{45}\) provided by crustaceans, bivalves, seaweeds and planktons for filtering water that could not be evaluated because of lack of data\(^{46}\) and means.

From a managerial point of view, there is an unfortunate insufficiency of collaboration between research centers, governmental organizations, environmental agencies and a lack of coordination between local, national authorities\(^{47}\) and the private stakeholders.

To fill the gap, a system of incentives might improve such collaboration between the different stakeholders we believe. Also, public consultation, as prescribed by the PoMs under the MSFD, has been partially executed and not really followed by the authorities, without real consideration for the fishermen, especially the trawlers, real victims of the northern fishing ban that has been decided without a long-term job relocation program.

Our case study confirms that benefits of protecting a marine reserve (Achziv MPA) and its associated ecosystem services exceed largely its protection costs (TEEB, 2010).

Israel is implementing rapidly environmental legislation and with this attempt, we may expect that it will reach European level of conservation awareness and liability in the coming years.

With MPA well managed and deeper methodological implementation, results can be improved. It is a first useful step.

In that framework, our methodology can be expanded to other ecosystem services and be conducted in other places for achieving conservation goals for providing a general framework to conduct CBA on potential creation and expansion of reserves.

\(^{43}\) In most of the ecosystems, the state of many species remains unknown

\(^{44}\) Such as other local provisioning services macroalgae (feed for fish stock), local sponges and corals (drugs and food) were not taken in account.

\(^{45}\) I.e. regulating services such as water filtering by planktons.

\(^{46}\) Some missing data such as tourist employment, cost elements (i.e.: vehicle depreciation) must be also mentioned.

\(^{47}\) The treasury minister did not transfer the funds needed for expanding the MPA to 100 km\(^2\), while the local committee approved the MPA expansion that the National Park Authority already validated.
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